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Abbreviations and acronyms

Partner Acronyms:

ASCAMM Fundaciò Privada ASCAMM, Spain
REDINN Rete Europea dell'Innovazione, Italy
ION Institute of Nanotechnology, UK
MTV Malsch TechnoValuation, Netherlands
ZSI Zentrum für Soziale Innovation, Austria
VTT Technical Research Centre of Finland, Finland
RELANS Latin American Nanotechnology and Society Network, Brazil
MINCyT Ministry of Science, Technology and Productive Innovation, Argentina
CIMAV-CONACYT Centro de Investigación en Materiales Avanzados, S.C, Mexico
MEC Ministry of Education and Culture, Uruguay
EUROCHILE Eurochile Business Foundation, Chile

Abbreviations and acronyms used in this report

MCT Ministry of Science and Technology
SISNANO National System of Nanotechnology Laboratories
LAC: Latin American Countries
MCTI Ministry of Science, Technology and Innovation
FAN Argentinean Foundation for Nanotechnology
FS-NANO Nano Sectorial Funds
R&D Research and Development
LA Latin America
EU European Union
ASJC All Science Journal Classification
FINEP Funding Agency for Studies and Projects
CNPq National Council for Scientific and Technological Development
NIST National Institutes of Science and Technology
NANOSUS Nanobiotechnology Laboratory for the National Health System
FIOCRUZ Osvaldo Cruz Foundation
LNN Nanomedicine and Nanotoxicology Laboratory
SUS National Health System
N&N Nanoscience and nanotechnology
S&T Science and technology
RNyN National Nanotechnology Research Network
CONACYT National Council of Science and Technology
ANPECYT National Agency for Scientific and Technological Promotion
CONICYT National Commission for Science and Technolgy
IEEE Institute of Electric and Electronic Engineers
COLCIENCIAS Administrative Department of Science, Technology and Innovation
ANII National Agency of Research and Innovation

Objective

The objective of Work Package 2 is to pool knowledge on the deployment of advanced materials to meet social challenges of specific regions (in healthcare, clean energy and environment). Here, local expertise and expertise from different levels of knowledge carriers will be brought together for further analysis. A scheme will be developed to evaluate projects and initiatives that have the described objectives and to assess those projects' impacts on social indicator developments. This goes along with a review of scientific outputs in the field of "AM for society" publications. By involving experts and local stakeholders (including NGOs and civil society), a participatory process will be implemented to identify good practices (especially with regard to involvement of local knowledge innovation capacity) and to identify niches for future collaborations and engagement. Quantitative and qualitative results will be analyzed with regard to policy preferences (as flexible as possible) and feed into tailor-made recommendations and policy briefs and fact sheets for WP3 and WP4 events.

The goal of this deliverable is to provide a map of the status of research and development on nanotechnology for health, energy and water. The map synthetizes bibliometric information on nano research selected topics in Latin America, as well as qualitative information on policy initiatives, ongoing research projects, main research groups and institutions in six Latin American Countries. This map will allow the identification of stakeholders and experts to be invited to events under WP3 and WP4 and support the pooling of knowledge in the field. It will also support the identification of niches for international and regional cooperation.

1 Executive summary

Several Latin American countries have endorsed the development of nanotechnology in the last decade. This novel techno–scientific field has been identified as strategic in Science, Technology and Innovation Plans of various countries in Latin America. The process has been led by Brazil, Mexico and Argentina.

Two research protocols were applied to detect the R&D nano–related activities in three areas of interest: health, energy, water. One was the analysis of the publication output by conducting bibliometric studies using the two major international citation databases available (Web of Science and Scopus). A second one implied the use of a qualitative/quantitative approach oriented to identify the main research institutions, research groups and research projects. Data is given for the whole region and for the six countries that were subject to in deep analysis: Brazil, Mexico, Argentina, Chile, Colombia and Uruguay.

Most research and development (R&D) in nanotechnology in the region has been in public science and technology institutions. In this context, private enterprises play a marginal role, with some initial presence mainly in Brazil.

Brazil leads nanotechnology R&D in the three areas of interest, followed by Mexico in second place, and Argentina in third. Some institutions were more visible than others and were present in all three case studies. For instance, the Universidade de São Paulo (USP) and the Universidade Estadual de Campinas (UNICAMP), from Brazil, and the Universidad Nacional Autónoma de México, were always between the first five.

Regarding the main areas, health and energy stand out in terms of scientific publications and research groups. Nanomedicine articles have around 950 and nanoenergy around 800 articles over the 12 first years of the century. Water is the less developed area of the three, in terms of nanotechnology related research, with around 500 scientific publications.[1] Within health, drugs & therapies is the main area of interest. In the case of energy, solar energy captures most researcher´s attention. The topic of water remediation is, within nano-water related research, the only one present in all the countries analysed.

The United States (US) is the main presence in inter–country collaborations. For the case of the European Union, France and Spain lead the cooperative efforts with the region. Within Latin America, the collaboration between Argentina and Brazil is persistent, regardless of the topic.

[1] These figures are very broad numbers, since different sources offer quite different amounts; but they give an idea of how far is nano-water regarding to nano-energy and nano-health topics.

There is considerable nanotechnology R&D in health -drugs & therapies- and energy -solar/photovoltaic, and less in water -remediation. Nevertheless it is not easy to identify the social relevance of this research to Latin American countries, as most of it is still basic research. The potential applications are still in an infant stage and are very difficult to estimate. More theoretical discussion is needed on this regard.

The data collected shall contribute to provide an overview of activities and to identify the most important stakeholders in the region for the following topics:

- **Health.** Various aspects of the application of advance materials, especially for therapeutic and diagnostic purposes.
- **Energy.** Advanced materials for all types of nano-energy related areas, with a special focus on solar energy.
- **Water.** Advanced materials for water remediation and drinking water (potabilization).

2 Nanotechnologies in Latin America. General overview

Several Latin American countries started promoting nanotechnology over the last decade. This new techno scientific field has been defined as strategic in the Science, Technology and Innovation Plans of various countries in the region. The process has been headed by Brazil, Mexico and Argentina, not only the largest economies in the region, but also the countries that have historically accumulated the more advanced scientific capabilities. Later on, several other medium-size and small countries followed.

The Brazilian Ministry of Science and Technology (MCT) started a systematic support for the area in 2001, with the creation of the first research networks in nanotechnology. In 2004 it was launched the National Program for the Development of Nanoscience and Nanotechnology, the first of its kind in the region. Re-launched in 2005 as the National Nanotechnology Program, this plan directed efforts for development of qualified human resources, the modernization of infrastructure and the promotion of university-industry cooperation. At the same time, industrial policy reinforced the strategic status attributed to nanotechnology and its role to enhance the countries' competitiveness (Invernizzi, Korbes, & Fuck, 2012). Recently, the MCT promoted and funded the SisNANO, a system of multi-users nanotechnology laboratories with a view to facilitate researchers´ and companies´ access to research infrastructure (MCTI, 2012).

In 2001, the Mexican Science and Technology Special Program 2001-2006 highlighted the strategic importance of nanotechnology for the first time in official documents. Currently, nanotechnology is one of the nine priority areas for scientific and technological development contained in the Science, Technology and Innovation Special Program 2008-2012. Differently from Brazil, Mexico does not have a centrally coordinated nanotechnology plan and the advance of the field has been driven by different research groups, which have succeeded in implementing a well-developed research infrastructure, making use of a variety of public research funds, of university-business cooperation, and international cooperation. In 2009 the National Council on Science and Technology contributed to the creation of a national network in Nano Science and Technology with the purpose of connecting researchers and their facilities (Záyago & Foladori, 2012; Záyago, Foladori, & Arteaga, 2012)

In Argentina, the Science and Technology Secretariat placed nanotechnology within the priority areas in 2003 and started organizing research networks in the field. In 2005, the Argentina Foundation for Nanotechnology (FAN) was created by the Economy and Production Ministry, with the aim of stimulating the training of human resources and the development of technical infrastructure to advance nanotechnology and its adoption by industry. While the preceding programs distinguished funding for the public sector on the one hand (essentially the research networks) and the private sector on the other (projects of the FAN), the nano sectorial funds (FS-NANO) launched in 2010 provided funding for the projects that were dedicated to basic and applied science via public-private partnerships (García, Lugones, & Reising, 2012; Spivak L´Hoste, Hubert, Figueroa, & Andrini, 2012).

Nanotechnology was also encouraged by ST&I policies in various middle and small Latin American countries, such as Colombia, Chile, Venezuela, Uruguay and some Central American and Caribbean countries. In Colombia, it has been defined as a strategic area for the competitive development of the country since 2004 and is associated with a program of development of centers of excellence (Pérez Marteló & Vinck, 2012). In Chile, science and technology policies have driven the formation of nanotechnology research centers since 2004, although the topic had already been the focus of that country's Millennium Institute created some years before (Cortés-Lobos, 2012). In Venezuela, the National Science, Technology and Innovation Plan (2005-2030) highlighted the need to incorporate cutting-edge technologies in the country, among them nanotechnology, but had not implemented any specific plan. Recently, in 2010, the Venezuelan Nanotechnology Network (RedVNano) was established, with members from the productive sector, universities and some State bodies (López, Hasmy, & Vessuri, 2012). Uruguayan researchers created the Uruguay Nanotechnology Group in 2006, and later, in 2010, nanotechnology was included as a transversal priority area in the National Strategic Plan for Science, Technology and Innovation (Chiancone, 2012). In Central America, Costa Rica is notable for the Lanotec facility, a laboratory dedicated to nanomaterials created in 2004, which receives support from the Ministry of Science and Technology, universities, high-technology industries and the U.S. space agency NASA (Vega-Baudrit & Campos, 2012). In the Dominican Republic, the Strategic Plan for Science, Technology and Innovation 2008-2018 has a sub-chapter on nanosciences within its priority areas (Piazza, 2012). The following table, organized in chronological sequence, shows the incorporation of nanotechnology in the policy agendas of most Latin American countries.

Year	Country	Institution
2001	Brazil	Ministry of Science and Technology
2001	Mexico	National Council for Science and Technology
2003	Argentina	Science and Technology Secretariat
2004	Colombia	Administrative Department for Science, Technology and Innovation
2004	Costa Rica	National Council for Scientific and Technological Research
2005	Guatemala	National Council for Science and Technology

2005	Ecuador	National Secretariat for Science and Technology
2006	El Salvador	National Council for Science and Technology
2006	Peru	National Council for Science, Technology and Innovation Technology
2008	Dominican Rep.	State Secretariat for Higher Education, Science and Technology
2009	Uruguay	Ministerial Advisory Office for Innovation
2010	Panama	National Secretariat for Science, Technology and Innovation

Source: (Foladori, Figueroa, Záyago, & Invernizzi, 2012)

Table 0-1 Incorporation of nanotechnology in the public agendas of selected Latin American countries

2.1 Framework for analysis

Two approaches were used to identify the R&D nano-topic activities (health, energy, water) in the Latin American countries.One was the analysis of the quantitative publication output by conducting bibliometric studies using the two major international citation databases available (Web of Science and Scopus).

The second approach was searching the public databases on R&D groups and on public funds allocated by topics in each country, as well as personal knowledge of nanotechnology programs by research members.

2.1.1 Mapping of Projects targeting societal challenges: Bibliometric Analysis

The ReLANS team used Thomson Reuter's *Web of Science* as a data source. ZSI consulted Elsevier's *Scopus* database alternatively.

The bibliometric approach allows quantifying scientific articles from different perspectives. The two study threads are also woven together.

2.1.2 Mapping of Projects targeting societal challenges: Country Analyses

A detailed qualitative analysis and collection of contact data was conducted for those countries that were identified as remarkably productivte by the predecessing bibliometric studies.

Due to the different amount of information available and the different criteria and regularity of information in and within each country, the information is not easily comparable. Also, and in most of the cases, a hand research by investigator had to be done in order to identify main research topics and contact information. Details on this methodology are included in the analysis of each country and case. It is important to notice that whenever personal emails or addresses are included is because they were taken from the public institutional Web pages.

3 Health Sector

3.1 Bibliometric Analysis: Web of Science

The following analysis was done by ReLANS. We present the results of scientific publications in the field of health - mainly nanomedicine - published by researchers belonging to academic and research institutions in the region of Latin America and the Caribbean. This work uncovered some indicators through a bibliometric and scientometric study.

In the section that follows, we clarify some of the methodological points regarding the tools employed in this study. Later, the results of the study are expounded upon.

3.1.1 Methodology

In bibliometric and scientometric studies and in scientific and technological monitoring, there are a variety of tools and methods employed in the identification of themes that develop from the production of new knowledge. In this study, scientific articles published in the field of nanomedicine that have been identified in an earlier stage of the study are analyzed; they account for some 950 scientific articles published until 2012 in which at least one researcher belonging to an academic or research institution from a Latin American or Caribbean country was involved. The points of reference employed have been identified through the terms used in the search strategy proposed by Wagner and collaborators (2008), which include a series of keywords and compound terms put through the Web of Science search engine in the Science Citation Index, Social Science Citation Index and the Arts & Humanities Science Citation Index databases. The search of these databases was carried out on November 15th, 2013. Additionally, the search added the word "nanomedicine" to identify academic texts mainly in the latter two databases, since we were also interested in this study to identify social science research and the ethical and social aspects relating to the development of this emerging area in Latin America. With the aim of identifying references from Latin American and Caribbean countries, the names of those countries were introduced into the "CU" field of the search engine (see list of countries in Table 3.11-2).

In the analysis of Wagner and collaborators, the authors identified seven areas in the field of nanomedicine, among which was found the area of cosmetics. This selection was made because "the cosmetic industry sometimes appears as an early user of new technology, and innovative products are first introduced in the cosmetic market before they enter clinical use" (Wagner et al., 2008, p. 33). In this study we have eliminated that area since the fieldwork in the area of cosmetics studies do not necessarily imply studies in the field of nanomedicine. For example, the strategy employed by Wagner and collaborators used the term *liposomes* in the cosmetics area as well as other terms about creams and solar protectors that make use of liposomes and that are not necessarily technically put to use at the nanometric scale.

InTable 3.11-1the search equations employed in the WoS search are shown, for each of the six areas in the field of nanomedicine that Wagner and collaborators identified, and the results when the word “nanomedicine” was used.

The use of the bibliometric databases was made with the help of the Access informatics tool. The tables and graphics were created with Excel and the images of maps and networks were derived from MapPoint, Pajek and VOSviewer.

3.1.2 Results

The seven topics proposed in the study carried out by Wagner and his collaborators and the results of the articles identified in the search of the databases are shown inTable 3.1-1. The results show that the area of Drug Administration within nanomedicine in Latin America and the Caribbean is the term that arises most often in published articles with a total of 616 articles, the equivalent of 64.84% of the total articles identified. Much lower in the results one finds the area of Medical Imaging with 203 articles, or 21.37% of the total, and the area of Medical Biosensors with 78 articles, or 8.21%. The remaining areas account for less than 5% of the total.[2]

Área	Artículos	% de 950
Suministro de fármacos	616	64.84%
Imagenología in vivo	203	21.37%
Biosensores medicos	78	8.21%
Biomateriales	41	4.32%
Nanomedicina	34	3.58%
Fármacos y terapía	26	2.74%
Implantes inteligentes / Protesis neurales	0	0.00%

Table 3.1-1 Areas in the field of nanomedicine proposed by Wagner and colleagues for Latin America and the Caribbean

The first indicator that interests us concerns the evolution of each of these areas. In Figure 3.1-1 the curves show the evolution of the articles published in Latin America and the Caribbean. The first articles identified were published in 1988 in the area of Medical Imaging, however, these were sporadic publications. From the year 2000 the publication of articles in the field of nanomedicine in Latin America and the Caribbean began to increase. The results in Figure 3.1-1 show that the area of greatest

[2] Since some articles could cover more than one topic the sum up does not equal 100%.

development in the region is the Supply of drugs that has seen exponential growth since 2005.

These results show that the development of this emerging field has been increasing steadily since the middle of the last decade. However, we see that the growth is not the same between different areas of nanomedicine and that some of these areas are still found to be in an early stage of their development.

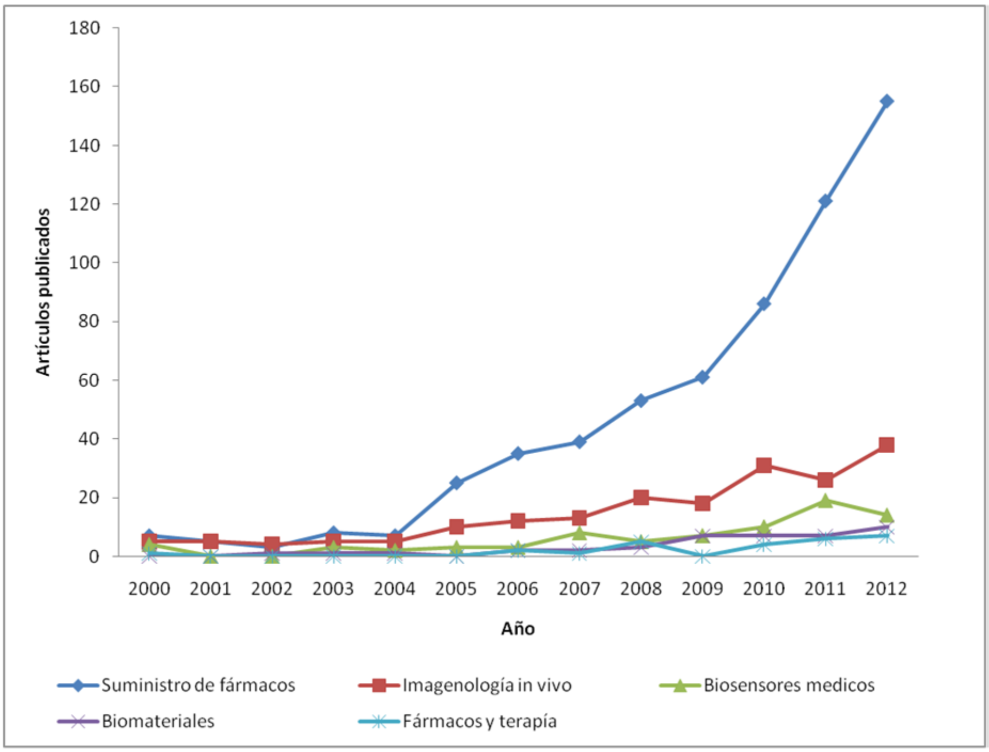

Figure 3.1-1 Evolution of the publications in the different areas in the field of nanomedicine in Latin America and the Caribbean during the period 2000-2012

The production of these scientific articles in the field of nanomedicine originated among 13 countries from the Latin American and Caribbean region. The leader is Brazil, with a total of 630 articles, representing 66.32% of the total. The second country with the most articles published is Mexico, which accounts for 161 published articles (16.95% of the total). This is followed by Argentina with 87 published articles. Later comes Chile (38 articles), Cuba (22 articles), Colombia (14 articles) and Uruguay (13 articles). The remaining countries of the region have produced less than 1% of the total articles published, according to our findings (Table 3.1-2).

Furthermore, in Table 3.1-2 the frequency with which articles were published with co-authors from countries outside of the Latin American and Caribbean region is shown.

The top collaborators are the United States (8% of published articles), France (7.47%), Spain (7.37%) and Germany (3.89%). These results confirm that collaborations with the member countries of the European Union and with countries of other regions are mostly insignificant. In a departure from the principle that the publication of scientific articles reflects scientific activity in a given scientific area,Figure 3.1-2shows the scientific distribution of those activities in the field of nanomedicine in Latin America and the Caribbean.

País	Artículos	% de 950
Brazil	**630**	**66.32%**
Mexico	**161**	**16.95%**
Argentina	**87**	**9.16%**
USA	76	8.00%
France	71	7.47%
Spain	70	7.37%
Chile	**38**	**4.00%**
Germany	37	3.89%
Cuba	**22**	**2.32%**
Portugal	20	2.11%
England	17	1.79%
Colombia	**14**	**1.47%**
Canada	14	1.47%
Uruguay	**13**	**1.37%**
Italy	11	1.16%
Czech_Republic	8	0.84%
Poland	7	0.74%
Venezuela	**7**	**0.74%**
Australia	6	0.63%
China	5	0.53%
Denmark	5	0.53%
Japan	5	0.53%
Sweden	5	0.53%
Scotland	4	0.42%
Uzbekistan	4	0.42%
Peru	**4**	**0.42%**
India	4	0.42%
Belgium	4	0.42%

País	Artículos	% de 950
Netherlands	3	0.32%
Switzerland	3	0.32%
Russia	3	0.32%
Austria	3	0.32%
Egypt	3	0.32%
Costa_Rica	**2**	**0.21%**
Turkey	2	0.21%
Norway	2	0.21%
Singapore	2	0.21%
Taiwan	2	0.21%
Bangladesh	2	0.21%
Israel	2	0.21%
Panama	**2**	**0.21%**
Greece	2	0.21%
Byelarus	1	0.11%
Trinid_&_Tobago	**1**	**0.11%**
Ukraine	1	0.11%
Thailand	1	0.11%
Croatia	1	0.11%
Malaysia	1	0.11%
Slovenia	1	0.11%
Slovakia	1	0.11%
Guatemala	**1**	**0.11%**
Ireland	1	0.11%
Algeria	1	0.11%
Morocco	1	0.11%
South_Africa	1	0.11%

Table 3.1-2 Countries and frequency of articles published in the field of nanomedicine in Latin America and the Caribbean during up to year 2012

Figure 3.1-2 Geographical distribution of the scientific activities in the field of nanomedicine in Latin America up to year 2012.

In terms of institutions that have produced articles in the field of nanomedicine in the region of Latin America and the Caribbean,Table 3.1-3 shows the institutions where researchers have published more than 10 articles. The list is dominated by Brazilian institutions, followed by those in Mexico and Argentina. With respect to European institutions, the list contains two institutions from France and two from Spain. One institution from the United States also stands out. It is interesting to note the presence of these institutions as co-authors in the field of nanomedicine, since this gives us an indication of the position of those institutions in scientific collaborations with their counterparts in Latin America and the Caribbean.

Institución	País	Artículos	% de 950
Univ Sao Paulo,	Brasil	253	26.63%
Univ Fed Rio Grande do Sul,	Brasil	221	23.26%
Univ Estadual Campinas,	Brasil	123	12.95%
Univ Nacl Autonoma Mexico,	Mexico	94	9.89%
Univ Fed Minas Gerais,	Brasil	76	8.00%
Univ Brasilia,	Brasil	71	7.47%
Univ Fed Rio de Janeiro,	Brasil	54	5.68%
Univ Fed Santa Catarina,	Brasil	47	4.95%
Univ Fed Pernambuco,	Brasil	44	4.63%
Univ Fed Santa Maria,	Brasil	43	4.53%
Univ Estadual Paulista,	Brasil	39	4.11%
Univ Estadual Sao Paulo,	Brasil	36	3.79%
Univ Buenos Aires,	Argentina	34	3.58%
Univ Fed Rio Grande do Norte,	Brasil	33	3.47%
Univ Fed Goias,	Brasil	29	3.05%
Ctr Invest & Estud Avanzados,	Mexico	28	2.95%
Univ La Habana,	Cuba	25	2.63%
Univ Nacl La Plata,	Argentina	24	2.53%
Inst Politecn Nacl,	Mexico	24	2.53%
Univ Autonoma Metropolitana,	Mexico	24	2.53%
Univ Barcelona,	España	23	2.42%
CSIC,	España	22	2.32%
Univ Fed Ceara,	Brasil	22	2.32%
Fundacao Oswaldo Cruz,	Brasil	21	2.21%
Univ Estadual Maringa,	Brasil	21	2.21%
Univ Chile,	Chile	20	2.11%
Univ Fed Sao Paulo,	Brasil	20	2.11%
Consejo Nacl Invest Cient & Tecn,	Argentina	18	1.89%
Univ Fed Uberlandia,	Brasil	18	1.89%
Univ Nacl Cordoba,	Argentina	17	1.79%
Univ Paris Sud,	Francia	17	1.79%
Univ Fed ABC,	Brasil	16	1.68%
Inst Nacl Neurol & Neurocirugia MVS,	Mexico	16	1.68%
Univ Fed Ouro Preto,	Brasil	13	1.37%
Univ Fed Sao Carlos,	Brasil	13	1.37%
Inst Butantan,	Brasil	13	1.37%
Univ Utah,	Estados Unidos	12	1.26%
Inst Tecnol & Estudios Super Monterrey,	Mexico	12	1.26%
Univ Autonoma Nuevo Leon,	Mexico	12	1.26%
Univ Fed Sergipe,	Brasil	11	1.16%
Univ Concepcion,	Chile	11	1.16%
CNRS,	Francia	11	1.16%
Comis Nacl Energia Atom,	Argentina	11	1.16%
Univ Nacl Rio Cuarto,	Argentina	10	1.05%

Table 3.1-3 Institutions with more than 10 published articles in the field of nanomedicine in Latin America and the Caribbean up to year 2012

Scientific collaboration is an interesting point to explore in this kind of study. In the following three images, we show the scientific collaborations in co-authored articles identified in the field of nanomedicine in Latin America and the Caribbean. The nodes represent various countries, the lines are the scientific collaboration relationships and the thickness of the lines is determined by the frequency of co-authorship. Figure 3.1-3 shows the networks of collaboration between countries of the Latin American and Caribbean region, where the most significant of those collaborations are between Mexico and Cuba, Brazil and Cuba, and Argentina and Brazil. It also shows that five Latin American countries in this region do not collaborate.

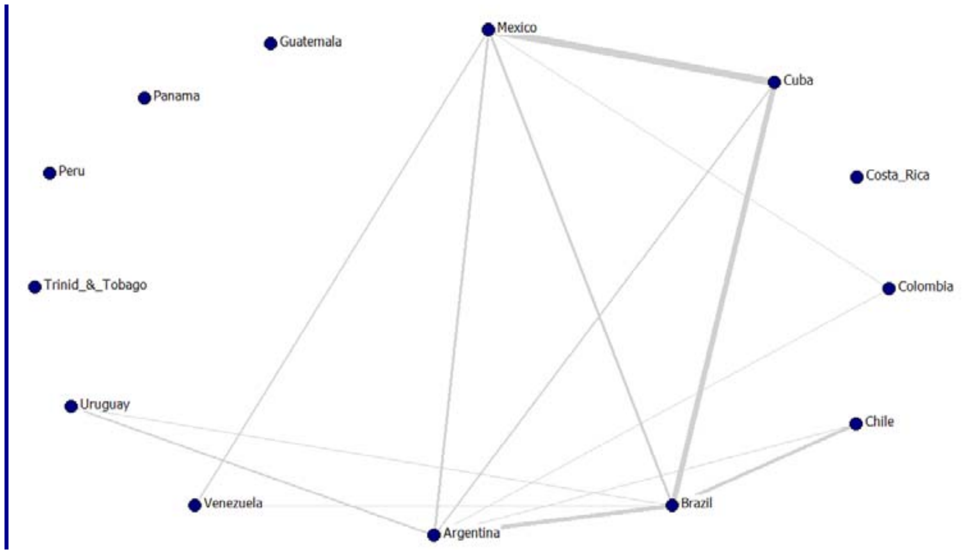

Figure 3.1-3 Scientific collaboration networks in in the field of nanomedicine in Latin America and the Caribbean up to year 2012

In Figure 3.1-4, the networks of scientific collaboration among the countries of Latin America and the Caribbean with the European Union are shown. In these networks, the most significant partnerships are with France and Spain: they collaborate with various countries in the region. The most significant collaborations are Brazil with France, Portugal and Poland. Also of note are the collaborations between Chile and Spain, as well as the latter and Cuba, Argentina, Mexico and Uruguay.

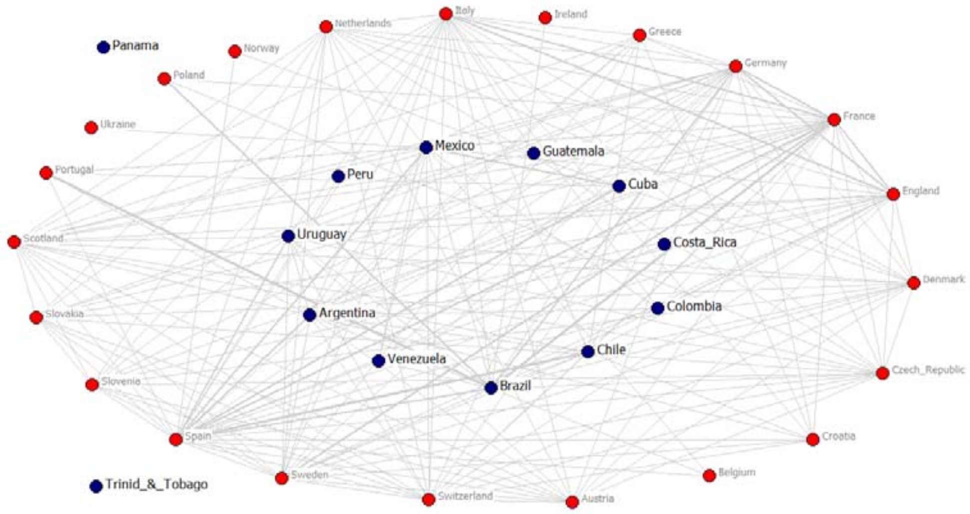

Figure 3.1-4 Scientific collaboration networks in the field of nanomedicine between Latin America and the Caribbean and Europe up to year 2012

The collaboration networks that researchers in Latin America and the Caribbean have maintained with researchers located in countries that are not members of the European Union are shown inFigure 3.1-5 In those results the collaborations between Mexico and Brazil with the United States are notable, while the latter also has considerable collaboration with Israel and Canada, with these results showing that in the collaborations between the United States and the various countries of Latin America and the Caribbean, Israel and Canada also participate.

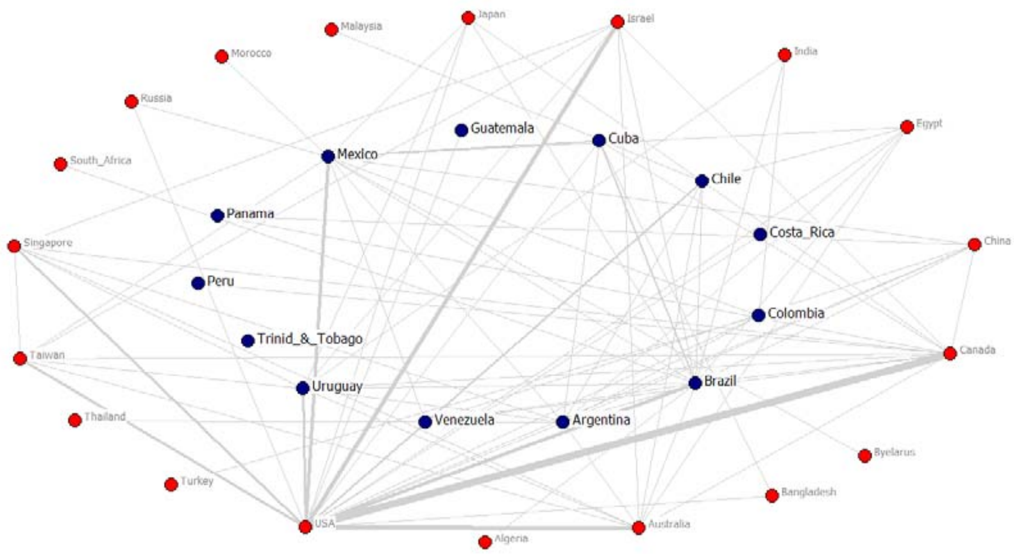

Figure 3.1-5 Scientific collaboration networks in the field of nanomedicine between Latin America and the Caribbean and the world except Europe up to year 2012

Following we concentrate on identifying the key scientific authors of the articles in each of the four areas of the field of nanomedicine in Latin America that is the focus of this study. This involves identifying the most productive authors in each of the four areas of nanomedicine, since we can assume that the scientists with the greatest productivity are leaders in their collaboration groups. The following tables provide lists of the researchers with the greatest production of articles in each of the four areas under study. It is worth alerting the reader that the authorship of the articles has not been standardized since to do so would require significant investment of time and effort that has not been possible within the parameters of the current study.

Autores	Artículos	Institución	País
Guterres, SS	75	Univ Fed Rio Grande do Sul	Brasil
Pohlmann, AR	69	Univ Fed Rio Grande do Sul	Brasil
Morais, PC	36	Univ Brasilia	Brasil
Tedesco, AC	32	Univ Sao Paulo	Brasil
Beck, RCR	27	Univ Fed Rio Grande do Sul	Brasil
Fraceto, LF	19	Univ Estadual Paulista	Brasil
Lacava, ZGM	19	Univ Brasilia	Brasil
Duran, N	19	Univ Estadual Campinas	Brasil
da Silveira, NP	15	Univ Fed Rio Grande do Sul	Brasil
Lopez, T	14	Univ Autonoma Metropolitana	México
Rosa, AH	14	Univ Estadual Paulista	Brasil
Jager, E	14	Univ Fed Rio Grande do Sul	Brasil
Simioni, AR	13	Univ Sao Paulo	Brasil
Primo, FL	13	Univ Sao Paulo	Brasil
Azevedo, RB	13	Univ Brasilia	Brasil
de Melo, NFS	12	Univ Estadual Sao Paulo	Brasil
Grillo, R	12	Univ Estadual Campinas	Brasil
de Paula, E	11	Univ Estadual Campinas	Brasil
Gamarra, LF	11	Univ Sao Paulo / IIEPAE	Brasil
Amaro, E	11	Univ Sao Paulo / IIEPAE	Brasil
Santana, MHA	11	Univ Estadual Campinas	Brasil
Lima, ECD	10	Univ Fed Goias	Brasil
Jager, A	10	Univ Fed Rio Grande do Sul	Brasil
Lemos-Senna, E	10	Univ Fed Santa Catarina	Brasil

Table 3.1-4 Researchers that have published at least 10 articles in the area of drug delivery in Latin America and the Caribbean up to year 2012

Autores	Artículos	Institución	País
Gamarra, LF	11	Univ Sao Paulo / IIEPAE	Brasil
Amaro, E	11	Univ Sao Paulo / IIEPAE	Brasil
Pontuschka, WM	8	Univ Sao Paulo	Brasil
Mamani, JB	7	Univ Sao Paulo / IIEPAE	Brasil
Knobel, M	6	Univ Estadual Campinas	Brasil
Fabris, JD	6	Univ Fed Minas Gerais	Brasil
Jose-Yacaman, M	5	Univ Texas San Antonio	Estados Unidos /México
Goya, GF	5	Univ Sao Paulo	Brasil
Weissleder, R	5	Massachusetts Gen Hosp	Estados Unidos
Dantas, NO	5	Univ Fed Uberlandia	Brasil
Elizondo, G	5	Hosp univ Monterrey	México
Pavon, LF	5	IIEPAE	Brasil

Note: In Table 3.1-5 we have included two researchers located in the United States with the aim of showing the presence of foreign researchers within the scientific community in Latin America and the Caribbean. That presence caught our attention since these could be core scientific actors in the collaboration networks that could have considerable influence on the research agendas of their collaborators. This is what has happened with other researchers who have signed on to the articles affiliated with countries outside the region (see Table 3.1-6).

Table 3.1-5 Researchers that have published at least 5 articles in the area of in-vivo imaging in Latin America and the Caribbean up to year 2012.

Autores	Artículos	Institución	País
Kubota, LT	5	Univ Estadual Campinas	Brasil
Lapizco-Encinas, BH	5	Ctr Invest & Estud Avanzados	Mexico
Ferreira, J	4	Univ Fed Pelotas	Brasil
Alles, AB	3	Univ Republica	Uruguay
Azzaroni, O	3	Univ Nacl La Plata	Argentina
Baptista, MS	3	Univ Sao Paulo	Brasil
Brynda, E	3	Acad Sci Czech Republic	Republica Checa
Calvo, EJ	3	Univ Buenos Aires	Argentina
Girotto, EM	3	Univ Estadual Maringa	Brasil
Rodriguez-Emmenegger, C	3	Univ Republica / Acad Sci Czech Republic	Uruguay /Republica Checa
Santos, MJL	3	Univ Fed Rio Grande do Sul	Brasil

Table 3.1-6 Researchers that have published at least 3 articles in the area of medical biosensors in Latin America and the Caribbean up to year 2012

Autores	Artículos	Institución	País
Oliver, A	8	Univ Nacl Autonoma Mexico	México
Rodriguez-Fernandez, L	7	Univ Nacl Autonoma Mexico	México
Cheang-Wong, JC	6	Univ Nacl Autonoma Mexico	México
Crespo-Sosa, A	6	Univ Nacl Autonoma Mexico	México
Reyes-Esqueda, JA	5	Univ Nacl Autonoma Mexico	México
Costa, HS	4	Univ Fed Minas Gerais	Brasil
Mansur, HS	4	Univ Fed Minas Gerais	Brasil
Mansur, AAP	3	Univ Fed Minas Gerais	Brasil

Table 3.1-7 Researchers that have published at least 3 articles in the area of medical biomaterials in Latin America and the Caribbean up to year 2012

Autores	Artículos	Institución	País
Jalbout, AF	5	Univ Nacl Autonoma Mexico	México
Fernandez, L	3	Univ Nacl Rio Cuarto	Argentina
Santo, M	3	Univ Nacl Rio Cuarto	Argentina
Basiuk, VA	3	Univ Nacl Autonoma Mexico	México
Silber, JJ	3	Univ Nacl Rio Cuarto	Argentina
De Leon, A	3	Univ Nacl Autonoma Mexico	México
Zucolotto, V	3	Univ Sao Paulo	Brasil

Table 3.1-8 Researchers that have published at least 3 articles in the area of drugs and therapies in Latin America and the Caribbean up to year 2012.

In addition to visualizing the networks of scientific collaboration that show us a vision of the structure of science in the field of nanomedicine, it is also interesting to consider another kind of visualization of that science. One of these ways of looking at the science concerns the disciplines that converge in the emerging fields of science and technology. On this point we analyze the indicated categories in which the identified articles from Web of Science were discovered. The articles and other scientific documents were published in scientific publications (scientific journals) covering a total of 279 categories of specialized disciplines. In the Web of Science databases, the journals can be indexed in at least one category and the articles published in journals are then classified in one or more categories. The analysis we have performed applied the method of visualization of similarities with the support of the Pajek and VOSviewer programs (Waltman & Van Ech, 2012), which is based upon an analysis of social networks and grouped by similarities applied to the categories, the result being a visualization of the structure of scientific knowledge in terms of disciplines. These visualizations can be interpreted as a reflection of the profile of scientific knowledge.

The articles identified in the field of nanomedicine in Latin America and the Caribbean have been indexed in 64 categorical disciplines in the Web of Science. Figure 3.1-6 shows the result of this analysis, which gives us a total of 20 groupings, which indicates that a considerable wide grouping exists in this field. In the resultant visualization we see that the principal disciplines according to the size of the node is identified through the frequency of the disciplines, which are Chemistry, Material Sciences, Physics and other topics of science and technology.

Regarding the groupings created through similarities in the disciplines, we see the discipline of Pharmacology and Pharmacy that make up part of the same grouping as Biotechnology, Dermatology and Ophthalmology, among others. Also of importance is the grouping of Molecular Biology and Biochemistry.

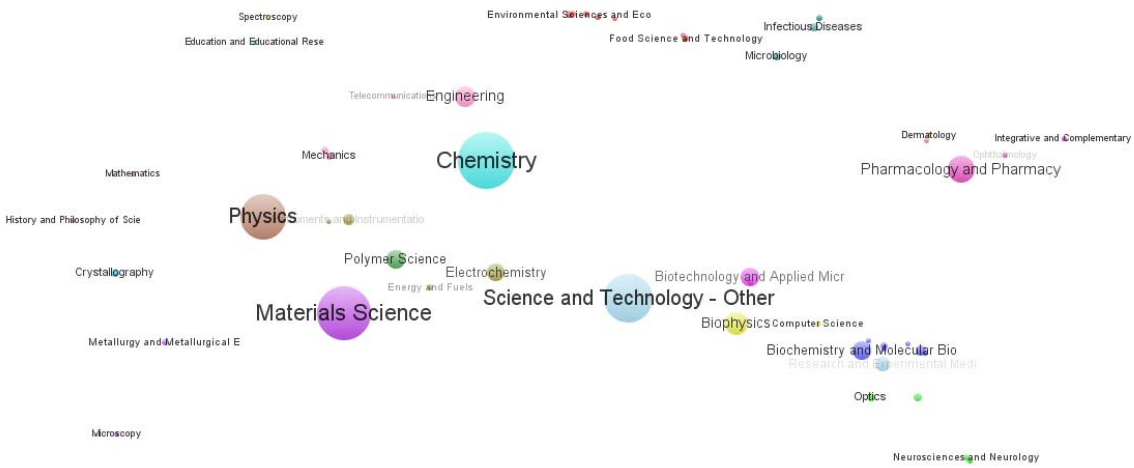

Figure 3.1-6 Profile of the field of nanomedicine in the region of Latin America and the Caribbean regarding scientific disciplines up to year 2012.

3.2 Bibliometric Analysis: Scopus

The present study has been carried out by ZSI and covers co-publication activity between the regions LA (3.12.4) and EU in the thematic fields of nanotechnologies and health. It identifies the quantity of (co-)publications in and between these regions as well as key institutions and individual researchers in EU-LA nano-research with focus on health topics. The main data source was Elsevier's *Scopus* database. Data was retrieved in October 2013 and reaches publications of all years tracked by *Scopus*. As the goal of the study is to get an overview of research activity in the selected field, data as complete as possible was collected, thus not discriminating records by document type.

Analysis follows the main research question: What institutions and individuals are key players in EU-LA nano-research with focus on health topics? The data were analysed according to the following dimensions:

- total numbers for the areas in focus
- relevant institutions (operationalized as the top 40 "affiliations" =Institution-author relations according to Scopus)
- relevant authors (operationalized as the top 40 authors according to Scopus)
- developments over the last decade for LA-EU collaborations in terms of the importance of key-words in nanotechnologies
- This report is structured as follows: At first we commit ourselves to a brief description of the methodological framework used for the present study in terms of data retrieval and analysis. The subsequent and core chapter shows the analysis results regarding the different dimensions. This is followed by some data visualisation to understand developments in keyword usage. Finally, we offer an outlook and attach further details on definitions, queries and keyword-lists in 3.12.1, 3.12.2 and 3.12.3.

3.2.1 Methodology

For this second approach on bibliometric analysis a slightly different scope is being covered – on the one hand, because another major citation database was consulted (*Elsevier Scopus*) and because focus was laid on the sub set of Latin-American and European collaboration.

3.2.2 Data source

The data set for the extraction of data on co-authorship are publications indexed in Elsevier's *Scopus* scientific citation database, as retrieved through keyword-based queries (no time-limit as the development of the field as such is of interest), with at least one author affiliated to an EU or LA-region based institution.

The selection of *Scopus* as the main source of raw and citation data (as opposed to e.g. Thomson Reuter's *Web of Science*) is justified for the following reasons:

- *Scopus'* coverage is more comprehensive than *Web of Science's*, especially post-1996, which is the period of interest for this study. While *Scopus* indexes

20 500 source titles, out of which 19 500 are journals and 360 book series[3], *Web of Sciences* reports coverage of 12 000 journals[4]. Partly, this difference is due to *Web of Science's* stricter criteria for indexing journals. This approach, however, is counterproductive to the present study as this study aims at a comprehensive coverage (particularly also regarding non-English speaking journals) rather than a selective one. Analyses with a selective focus on high-impact journals could be performed in addition using the *Scopus* source data.

- *Scopus'* coverage of non-English language journals is more comprehensive than *Web of Science's*[5]. *Scopus* also works with regions like Southeast Asia to improve the coverage of local journal content.
- *Scopus'* coverage of the social sciences is more comprehensive than *Web of Science's*[6]. Social sciences are nowadays being considered as elementary for tackling societal challenges.
- Our own experience from previous studies shows that the *Scopus* database might not contain the "cleanest" data, but institutions or organisations are better indexed and unified and there is a faster reaction to recent developments in the rise of emerging research fields (regarding coverage, journal classification, etc) than in other database systems. Nanotechnologies as comparably young discipline is therefore better outlined in *Scopus*.
- Particularly, HEALTH-related journals are better and more comprehensively indexed in Scopus

However, limitations due to the general validity of bibliometric data (publications and co-publications only account for parts of research activity) and limitations inherent to the data source (with regards to the amount and coverage of journals and the quality of the source data, e.g. misspellings, ambiguity in subject classification, etc.) apply and have to be accepted.

Data and results presented unfold their full potential by triangulating them with additional qualitative data and complementary analyses, such as expert consultations or other activities outlined in task 2.1.

3.2.3 Geographical coverage and time frame

This bibliometric analysis covers co-publications of the region Latin America with the region Europe (countries in and associated with ERA)[7] as well as publications in each

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[3] Scopus website, accessed: 11 June 2013
[4] Thomson Reuters website, access: 11 June 2013
[5] Moya-Anegón et al. 2009; Scimago 2010
[6] Linköping University Library (2013), online: www.bibl.liu.se/bibliometri/citbas?l=en

geographic region in the area of nanotechnologies (keyword based query). The study covers every scientific output in these areas listed in *Scopus*, which includes all document types for all years covered by *Scopus*.

3.2.4 Thematic classifications

Taking into account *Scopus* as the major data source, the database's own All Science Journal Classification (ASJC) system with its 27 thematic clusters is the basis for thematic classification and analysis. Each publication (and journal) is attached to at least one ASJC, but multiple allocations are possible. In addition to this journal classification system, keyword sets are used to determine and analyse co-authored output between LA region and EU-based researchers in the field of Health and nanotechnologies.

For this study, the thematic classification was achieved as follows:

"Health" was determined as a combination of the seven health related ASJCs defined by *Scopus*: Medicine; Biochemistry, Genetics and Molecular Biology; Pharmacology, Toxicology and Pharmaceutics; Health Professions; Immunology and Microbiology; Nursing; Dentistry.

"Nano" was defined by an expert-vetted set of keywords developed by a study lead by Peter Haddawy (UNU) in 2011 (list of author keywords attached).

3.2.5 Restrictions and Issues

There are a few things to be kept in mind when interpreting the results and data presented:

- The sample of records relevant to this study is comparably small. Therefore, drawing conclusions for wider co-publication patterns is not possible with the results from this study.
- It should be kept in mind that journals can be assigned more than one ASJC and publications within this journal carry all categories, ignoring their exact focus. Therefore, the numbers of co-publications per subject area cannot simply be summated and certain blurriness of categorisation is inherent to any database.
- Although the *Scopus* database is one of the most elaborate in indexing authors by assigning Author IDs, any tracking of individuals is extremely error-prone, especially when it comes to very common names in certain language groups or authors changing institutions etc. The top 40 authors and their publication values presented

[7] For the list of countries included to this study please see 3.12.4. The list of LAC countries was decided in accordance with the task leader. The list of ERA countries includes all EU members, associate and candidate states.

in this study are therefore not to be taken as definite and the list cannot be interpreted as a ranking. It gives a good picture of some of the most active authors in a given field, but cannot give a definite list of the more active authors.

3.2.6 Results

3.2.6.1 Total Publication Counts in Nanotechnologies

According to the nano-related keyword query, there are 63 578 publications in this area in the European Research Area (ERA) and 6 549 publications in the LA-region in all years tracked by *Scopus*. Thus, ERA's output in nano-science has been so far almost 10 times higher than the output in Latin American countries. Limiting these results to health-related publications, an amount of 11 603 records in the European Research Area and 908 publications in the region of Latin America could be retrieved. These sums do not enable conclusions on these regions' *productivity* (in the sense of the relation of output by input), as there is for example no reliable way to find out how many individual scientists are dedicated to nano-research in either of the regions that eventually create this output.

Together, the two regions were collaborating on 181 co-publications for "nano" and health within networks that consist at least of one Latin-America and one Europe-based author (but that might also include authors from or affiliated in third countries). This means, that Latin American countries collaborate in more than one quarter of their health-related nano-publications with countries in Europe.

Health-related publications make almost 14 % of total output in nano-sciences in Latin America, whereas in Europe 18 % of the nano-publications deal (also) with medical issues. In the co-publications of the two regions, close to 14% of the jointly published nano-studies are dedicated to human health.

With a sum of more than 115 000 co-publications between ERA and LAC, the share of nano-research in this collaboration is almost 1,2 %. Looking at the total output in these regions and comparing it to each region's output in nano-research, these shares differ between the two regions: ERA (> 14 Mio publications) and LAC (> ½ Mio publications) have a share of nano-related research of approximately 0,4% and 1,1% respectively.

3.2.6.2 Most active Institutions and Authors in EU-LA co-publications

Each set of publications and co-publications were analysed for the top 40 "affiliations" and "Authors" as indexed by *Scopus*. The record counts for the affiliations are not exactly counts for the underlying institution or organisation, but refer to an author-institution link (=affiliation).

Please note that the two tables are positioned beside each other for space reasons, not to suggest a relation between author and affiliation that appear in one line. Furthermore it is not possible to identify the authors' location within the context of this study, resulting from various difficulties in unification, career tracking and data quality.

There are affiliation and author references to third countries. This is due to the fact that e.g.: some USA-based authors are very active (in the sense of "productive") in networks where Latin-American and European authors are part – even more than those authors themselves. The decision was made to keep those authors and institutions in the list of the most active players in order to create a picture as close as possible to the reality of the dynamics in LA-EU collaboration networks – that of course includes partners from third countries.

Affiliations	**Records**		**Authors**	**Records**
Consiglio Nazionale delle Ricerche	1191		Bimberg D.	178
CNRS Centre National de la Recherche Scientifique	1161		Cingolani R.	159
University of Cambridge	1008		Couvreur P.	141
Eidgenossische Technische Hochschule Zurich	930		Muller R.H.	137
Ecole Polytechnique Federale de Lausanne	831		Kreuter J.	125
Universite Paris-Sud XI	562		Schmuki P.	124
Imperial College London	557		Forchel A.	116
University of Oxford	547		Potschke P.	102
Universite Pierre et Marie Curie	518		Hopkinson M.	100
Danmarks Tekniske Universitet	507		Irache J.M.	86
Delft University of Technology	504		Pratsinis S.E.	83
Universität Erlangen-Nürnberg	497		Landfester K.	82
Katholieke Universiteit Leuven	489		Ledentsov N.N.	81
The Royal Institute of Technology KTH	472		Prato M.	80
Technische Universität Dresden	469		Fritzsche W.	79
Technische Universität Berlin	462		Schmidt O.G.	78
CEA Grenoble	420		Compton R.G.	77
Università degli Studi di Padova	418		Roth S.	75
University of Sheffield	416		Chen Y.	75
Polish Academy of Sciences	415		Dubois P.	75
University of Nottingham	412		Ritchie D.A.	75
Aalto University	396		Kenny J.M.	75
Chalmers Tekniska Högskola	390		Liz-Marzan L.M.	74
Politecnico di Torino	390		Konya Z.	74
Universitat de Barcelona	387		Karczewski G.	73
Technische Universiteit Eindhoven	386		Chaudret B.	72

University of Manchester	385		Sokmen I.	72
Lunds Universitet	379		Kauppinen E.I.	69
UCL	378		Abstreiter G.	68
Rheinisch-Westfälische Technische Hochschule Aachen	371		Milne W.I.	68
Technische Universität München	369		Mondragon I.	67
Universite Claude Bernard Lyon 1	364		Manna L.	67
Ludwig-Maximilians-Universität München	360		Henini M.	65
Technische Universitat Wien	357		Blau W.J.	65
Trinity College Dublin	354		Muller D.J.	64
Universität Duisburg-Essen	353		Fessi H.	64
Politechnika Warszawska	346		Ustinov V.M.	63
Universitatea Politehnica din Bucuresti	338		Dekany I.	63
University of Southampton	337		Mullen K.	63
Universite Joseph Fourier	333		Notzel R.	63

Table 3.2-1 General nanotechnologies in EU countries and associates

Affiliations	Records		Authors	Records
Universidade de Sao Paulo	784		Morais, P.C.	106
Universidad Nacional Autónoma de México	529		Terrones, M.	56
Universidade Estadual de Campinas	518		Mattoso, L.H.C.	55
Universidade Federal de Sao Carlos	305		Longo, E.	53
UNESP-Universidade Estadual Paulista	258		Duran, N.	39
Universidade Federal do Rio Grande do Sul	240		Knobel, M.	38
Universidade Federal do Rio de Janeiro	234		Pal, U.	38
Universidade Federal de Minas Gerais	225		Rivas, G.A.	38
Universidade de Brasilia	221		Mora-Ramos, M.E.	38
Centro de Investigacion y de Estudios Avanzados	217		Dupont, J.	38
Instituto Politécnico Nacional	205		Quivy, A.A.	38
Universidad de Buenos Aires	141		Araujo, E.M.	37
Universidad de Chile	140		Duque, C.A.	37
Universidade Federal de Santa Catarina	128		Jose-Yacaman, M.	36
Universidade Federal do Ceara	126		Guterres, S.S.	36
Universidade Federal de Pernambuco	122		Dantas, N.O.	35
University of Puerto Rico	121		Basiuk, V.A.	33
Universidade Federal do Parana	119		Torchynska, T.V.	33
Benemérita Universidad Autónoma de Puebla	119		Oliveira, O.N.	32
Instituto Mexicano Del Petroleo	114		Leite, E.R.	32
Centro de Investigacion en Materiales Avanzados	105		Jorio, A.	32

Consejo de Investigaciones Cientificas y Tecnicas	102		Dresselhaus, M.S.	31
Universidade Federal de Uberlandia	101		Angeles-Chavez, C.	31
Universidad Autónoma de San Luis Potosí	89		Azevedo, R.B.	31
Universidad de La Habana	85		Terrones, H.	31
Centro de Investigacion en Quimica Aplicada, Saltillo	81		Pohlmann, A.R.	31
Universidade Federal do ABC	79		Leite, J.R.	30
Instituto Potosino de Investigacion Cientifica y Tecnologica	78		Varela, J.A.	30
Universidad Nacional de La Plata	78		Alves, O.L.	30
Laboratorio Nacional de Luz Sincrotron	76		Cesar, C.L.	30
Universidad Autónoma de Nuevo León	75		Salas, P.	28
Universidade Federal de Goias	75		Qu, F.	28
Centro Atomico Bariloche	72		Zucolotto, V.	27
Universidad Autónoma del Estado de Morelos	72		Ascencio, J.A.	27
Universidad de Santiago de Chile	69		Basiuk, E.V.	27
Pontificia Universidade Catolica do Rio de Janeiro	69		Toma, H.E.	27
University of Concepcion - Chile	67		Tedesco, A.C.	27
Instituto Nacional de Pesquisas Espaciais	65		Zarbin, A.J.G.	26
Instituto Nacional de Astrofisica Optica y Electronica	62		Saito, R.	26
Universidad de Sonora	62		Freire, V.N.	26

Table 3.2-2 General nanotechnologies in Latin-American countries

Affiliations	Records		Authors	Records
Universidade de Sao Paulo	139		Terrones, M.	22
Universidade Estadual de Campinas	76		Mondragon, I.	19
Universidad Nacional Autónoma de México	76		Morais, P.C.	16
Universidad de Chile	58		Gusev, G.M.	15
Universidade Federal de Sao Carlos	54		Portal, J.C.	15
UNESP-Universidade Estadual Paulista	51		Brett, C.M.A.	15
Universidad de Buenos Aires	47		Goyanes, S.	14
Universidade de Brasilia	44		Terrones, H.	13
Universidade Federal do Rio Grande do Sul	42		Rivas, G.A.	12
Universidade Federal do Rio de Janeiro	38		Gonzalez, J.	12
CSIC - Instituto de Ciencia de Materiales de Madrid ICMM	37		Dufresne, A.	12
Universidad Autónoma de Madrid	37		Jovin, T.M.	11
Universidade Federal de Minas Gerais	33		Gonzalez, G.	11
Universite Pierre et Marie Curie	31		Oliveira, O.N.	10
Universidade Federal de Santa Catarina	31		Benavente, E.	10
Universidad de La Habana	31		Alonso-Vante, N.	9

Centro de Investigacion y de Estudios Avanzados	30		Jares-Erijman, E.A.	9
University of Concepcion - Chile	25		Knobel, M.	9
Centro Atomico Bariloche	25		Kibis, O.V.	9
Universidad de Santiago de Chile	25		Kogan, M.J.	9
CNRS Centre National de la Recherche Scientifique	24		Fiorani, D.	9
Universite Paris-Sud XI	23		Quivy, A.A.	9
Universidad Nacional de La Plata	22		Valenzuela, M.L.	9
Universitat de Barcelona	21		Portnoi, M.E.	9
Instituto Potosino de Investigacion Cientifica y Tecnologica	21		Lamas, T.E.	9
Universidad Autónoma de Barcelona	21		Santilli, C.V.	8
Universidad del Pais Vasco - Euskal Herriko Unibertsitatea	21		Souto, E.B.	8
Consiglio Nazionale delle Ricerche	20		Buske, N.	8
Consejo de Investigaciones Cientificas y Tecnicas	19		Goya, G.F.	8
Universidade Federal do Ceara	19		Perzynski, R.	8
Universite Joseph Fourier	19		Tourinho, F.A.	8
Benemérita Universidad Autónoma de Puebla	18		Nedev, N.	8
CSIC - Instituto de Ciencia y Tecnologia de Polimeros ICTP	18		Pestryakov, A.	8
Centro de Investigacion en Materiales Avanzados	17		Jose-Yacaman, M.	8
Universidade de Aveiro	17		Manolov, E.	8
Universidad Complutense de Madrid	17		Fierro, J.L.G.	8
Universidad de Oviedo	16		Duque, C.A.	8
Universitat d'Alicante	16		Vazquez, M.	8
Universidad de Valladolid	16		Pulcinelli, S.H.	8
Universidad Autónoma Metropolitana - Iztapalapa	16		Valdez, B.	8

Table 3.2-3 General nanotechnologies in EU-LA co-publications

Affiliations	Records		Authors	Records
Universite Paris-Sud XI	231		Bimberg, D.	178
CNRS Centre National de la Recherche	217		Cingolani, R.	159
Consiglio Nazionale delle Ricerche	173		Couvreur, P.	141
Freie Universität Berlin	171		Muller, R.H.	137
Eidgenossische Technische Hochschule Zurich	169		Kreuter, J.	125
University of Cambridge	140		Schmuki, P.	124
UCL	137		Forchel, A.	116
Johann Wolfgang Goethe Universität Frankfurt	133		Potschke, P.	102
Inserm	128		Hopkinson,	100
Universität Marburg	120		Irache, J.M.	86
Université de Genève	114		Pratsinis,	83
Westfälische Wilhelms-Universität Münster	112		Landfester,	82

Ecole Polytechnique Federale de Lausanne	112		Ledentsov,	81
Imperial College London	109		Prato, M.	80
Ludwig-Maximilians-Universität München	108		Fritzsche, W.	79
Universidade do Porto	106		Schmidt,	78
Katholieke Universiteit Leuven	106		Compton,	77
Københavns Universitet	100		Roth, S.	75
University of Nottingham	97		Chen, Y.	75
Universität des Saarlandes	97		Dubois, P.	75
Universidad de Navarra	95		Ritchie, D.A.	75
Universite Catholique de Louvain	93		Kenny, J.M.	75
Technische Universität München	93		Liz-Marzan,	74
Universitat de Barcelona	92		Konya, Z.	74
Università degli Studi di Torino	92		Karczewski,	73
Universidad de Santiago de Compostela	89		Chaudret, B.	72
Lunds Universitet	89		Sokmen, I.	72
University of Ljubljana	89		Kauppinen,	69
Technische Universität Dresden	88		Abstreiter,	68
Universite Claude Bernard Lyon 1	86		Milne, W.I.	68
Universiteit Gent	80		Mondragon,	67
Università degli Studi di Padova	78		Manna, L.	67
Danmarks Tekniske Universitet	78		Henini, M.	65
School of Pharmacy University of London	78		Blau, W.J.	65
University of Oxford	78		Muller, D.J.	64
Alma Mater Studiorum Università di Bologna	78		Fessi, H.	64
Hacettepe Üniversitesi	76		Ustinov,	63
Friedrich Schiller Universität Jena	76		Dekany, I.	63
Università di Pisa	74		Mullen, K.	63
Aarhus Universitet	73		Notzel, R.	63

Table 3.2-4 Nanotechnologies + HEALTH in EU and associates

Affiliations	Records		Authors	Records
Universidade de Sao Paulo	141		Maranhao, R.C.	23
Universidade Estadual de Campinas	73		Guterres, S.S.	19
Universidad Nacional Autónoma de México	61		Pohlmann, A.R.	16
UNESP-Universidade Estadual Paulista	54		Duran, N.	16
Universidade Federal do Rio Grande do Sul	47		Azevedo, R.B.	15
Universidade Federal do Rio de Janeiro	35		Terrones, M.	14
Universidade de Brasilia	32		Tedesco, A.C.	13
Universidade Federal de Minas Gerais	29		Quintanar-Guerrero, D.	12
Universidade Federal de Pernambuco	28		Silva, L.P.	12
Universidad de Buenos Aires	26		Mainardes, R.M.	12
Universidade Federal de Sao Carlos	26		Duque, C.A.	10

Universidade Federal do ABC	25		Mora-Ramos, M.E.	10
Universidad de Chile	21		Ruiz, F.	9
Universidade Federal de Sao Paulo	20		Zucolotto, V.	9
Instituto Potosino de Investigacion Cientifica y Tecnologica	19		Fontes, A.	9
Consejo de Investigaciones Cientificas y Tecnicas	19		Santos, B.S.	8
Centro de Investigacion y de Estudios Avanzados	18		Lapizco-Encinas, B.H.	8
University of Puerto Rico	17		Khalil, N.M.	8
Instituto Politécnico Nacional	16		Morais, P.C.	8
Universidade Federal do Ceara	15		Ferro-Flores, G.	8
Universidad Autónoma de San Luis Potosí	14		Lacava, Z.G.M.	7
Centro de Investigacion en Materiales Avanzados	13		Ferreira, L.A.M.	7
Universidade Federal de Santa Catarina	13		Marcato, P.D.	7
Universidad Nacional de La Plata	13		Valois, C.R.A.	7
Universidad Nacional de San Luis	12		Beck, R.C.R.	7
Universidad Autónoma de Madrid	12		Ganem-Quintanar, A.	7
Empresa Brasileira de Pesquisa Agropecuária - Embrapa	11		Terrones, H.	7
Universidad Autónoma del Estado de Morelos	11		Seabra, A.B.	7
Universidade Federal de Goias	11		Andrade, M.S.	6
Universidad de Antioquia	11		Martinez-Gutierrez, F.	6
Universidade Federal de Uberlandia	10		Endo, M.	6
Universidade Federal do Rio Grande do Norte	10		Rivas, G.A.	6
Universite Paris-Sud XI	10		Medina, H.	6
Fundacao Oswaldo Cruz	10		Toma, H.E.	6
Universidad de la Republica	10		Kogan, M.J.	6
Instituto Nacional de Investigaciones Nucleares	9		Kubota, L.T.	6
Benemérita Universidad Autónoma de Puebla	9		Santos-Magalhaes, N.S.	6
Universidad Autónoma de Nuevo León	9		Vilela, J.M.C.	6
Tecnológico de Monterrey	8		Oliveira, O.N.	5

Table 3.2-5 Nanotechnologies + HEALTH in Latin-American countries

Affiliations	Records		Authors	Records
Universidade de Sao Paulo	20		Kogan, M.J.	5
Universidad de Chile	14		Duque, C.A.	5
Universidad de Buenos Aires	12		Mora-Ramos, M.E.	5
Universidad Autónoma de Madrid	12		Ponchel, G.	5
UNESP-Universidade Estadual Paulista	10		Cedano, J.	5
Universidade Federal de Sao Carlos	10		Barbosa, D.B.	4

Universite Paris-Sud XI	10		Villaverde, A.	4
Universidad Autónoma de Barcelona	8		Vazquez, E.	4
Universidade Estadual de Campinas	8		Unzueta, U.	4
Universitat de Barcelona	7		Thalhammer, S.	4
Universidade Federal do Rio Grande do Sul	7		Terrones, M.	4
Universite Claude Bernard Lyon 1	7		Gorup, L.F.	4
Institucio Catalana de Recerca I Estudis Avancats	7		Domingo-Espin, J.	4
Universidade Federal do Rio de Janeiro	6		Maestro, L.M.	4
Instituto Potosino de Investigacion Cientifica y Tecnologica	6		Souto, E.B.	4
Universidad de Antioquia	6		Sokmen, I.	4
Consejo de Investigaciones Cientificas y Tecnicas	5		Jaque, D.	4
Universidade Federal de Santa Catarina	5		Jovin, T.M.	4
Universidad Autónoma del Estado de Morelos	5		Sari, H.	4
Universidad Nacional de La Plata	5		Kasapoglu, E.	4
Universidad Nacional Autónoma de México	5		Ferrer-Miralles, N.	4
Max Planck Institute for Biophysical Chemistry Karl Friedrich Bonhoeffer Institute	5		Giralt, E.	4
Universidad de la Republica	5		Negri, M.	4
CIBER Bioingenieria, Biomateriales y Nanomedicina	5		Monteiro, D.R.	4
Universität Erlangen-Nürnberg	4		Oliveira, O.N.	3
University of Concepcion - Chile	4		Rivas, G.A.	3
Universite Pierre et Marie Curie	4		Santana, M.H.A.	3
IRB Barcelona - Institute for Research in Biomedicine	4		Terrones, H.	3
CSIC - Instituto de Ciencia de Materiales de Madrid ICMM	4		Schaefer, U.F.	3
Cumhuriyet Üniversitesi	4		Severino, P.	3
Dokuz Eylül Üniversitesi	4		Silva, S.	3
Universidad de Zaragoza	4		Bermejo, E.	3
Centro de Investigacion y de Estudios Avanzados	4		Sole, J.G.	3
Universidade Fernando Pessoa	4		Tsapis, N.	3
Universidade do Minho	4		Kubota, L.T.	3
Helmholtz Center Munich German Research Center for Environmental Health	4		Jacinto, C.	3
Benemérita Universidad Autónoma de Puebla	4		Vetrone, F.	3
Universidade de Brasilia	4		Zapardiel, A.	3
Ludwig-Maximilians-Universität München	4		Guterres, S.S.	3

Table 3.2-6 Nanotechnologies + HEALTH in EU-LA co-publications

3.2.6.3 Development of the field

Scopus indexes nano-related publications between Latin-America and ERA countries since 1993, with almost constantly rising record counts:

Year	Records
2014	(8)[8]
2013	(201)[7]
2012	175
2011	182
2010	131
2009	122
2008	104
2007	94
2006	70
2005	58
2004	50
2003	34
2002	19
2001	19
2000	5
1999	14
1998	16
1997	12
1996	6
1995	1
1994	1
1993	1

Table 3.2-7 Joint publications in nanotechnology 1993-2014 of researchers in Latin-America and ERA

Screening the development over time of detailed research foci in nano-health research by analysing author-keywords assigned to these records results primarily in a remarkable differentiation between different research themes over time.

In the following figures, tag clouds[9] were created to gain a picture of the developments and rising variety of author keywords over the years. The first visualisation is from

[8] According to *Scopus* data maintenance for one year is not finalized before May in the consecutive year.
[9] Created with www.wordle.net with all author keywords mentioned at least once in the year screened.

2000, the next 2005, the third 2010 and the last one screens recent keywords assigned by the authors of our analysed records in 2013 only. The font-size of the keywords indicates the relative importance of each term or string over all the years tracked.

Health+nano: 4 289 in all years, range: 1-18 (references)

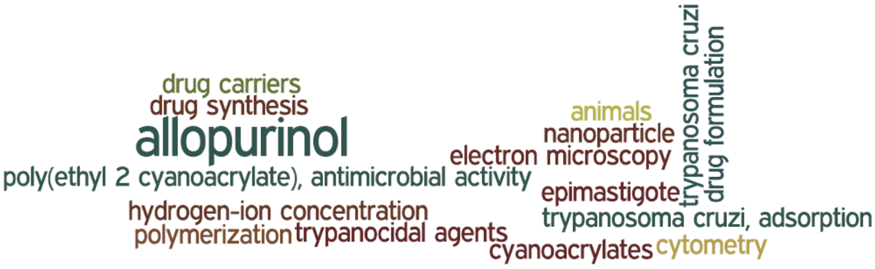


Figure 3.2-1 Tag Clouds 2000

n=16; range=1-2

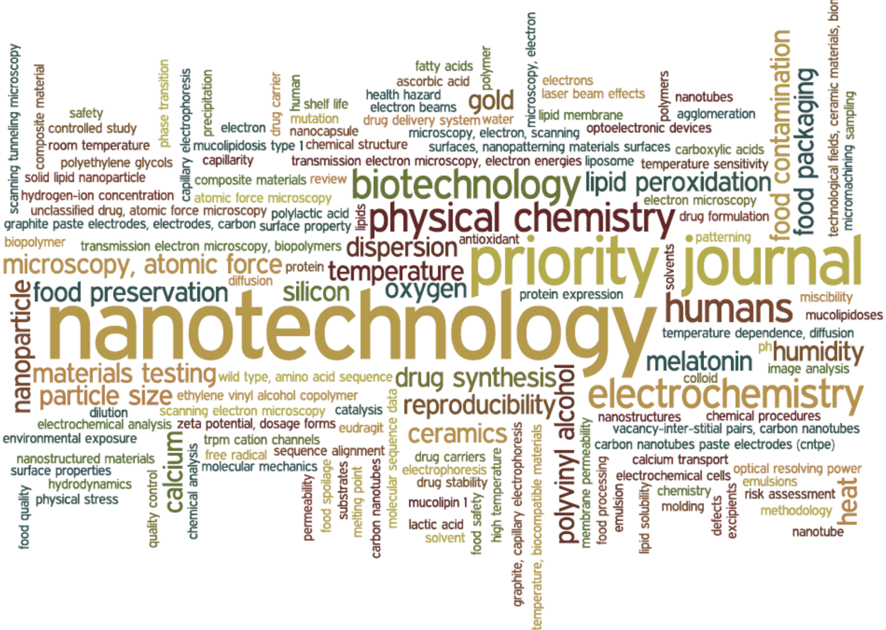


Figure 3.2-2 Tag Clouds 2005

n=161; range=1-7

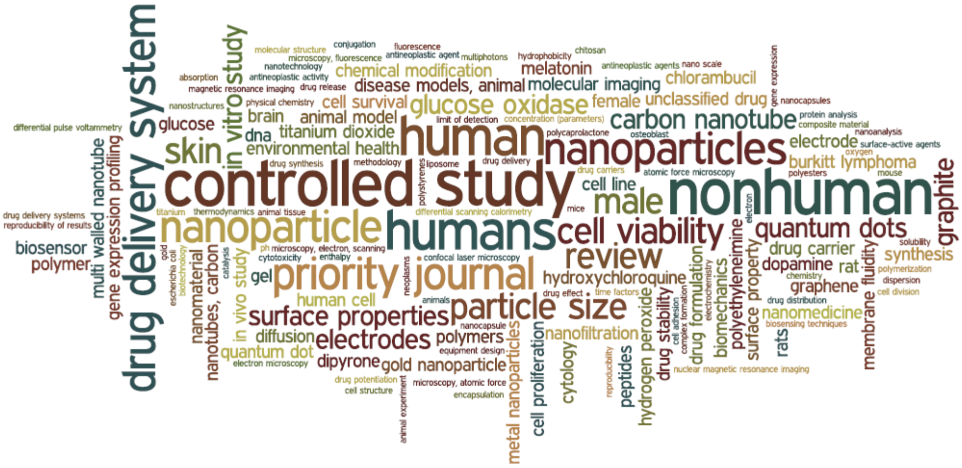


Figure 3.2-3 Tag Clouds 2010

n=508; range=1-7

Figure 3.2-4 Tag Clouds 2013

n=805; range=1-18

Little surprisingly, “nanoparticle(s)” and “nanotechnology” are the most frequented keywords indicating centrality within the field. It is observable, that over the years more keywords related to human medical trials are mentioned (human, nonhuman, drug, controlled study, in vitro study …). This could suggest a gradual extension of nano-research topic into the medical area. However, such interpretations as a more detailed analysis of the weight of the tags can only be achieved with the help of experts in the respective field.

As an additional analysis, we initially attempted to identify important funding institutions in the field of nano-science. *Scopus* tracks “sponsor” information, but unfortunately, as a test run showed, they are very rarely and inconsistently filled out. Since the interim version of this report, a drastic but un-systematic increase of funding information coverage in the Scopus data base was observed which seems to indicate that the indexing of funding information is currently still in progress. Analysing this data would lead to a blurred picture on sponsorship data at the time being and for the context of this study. Therefore it was decided to skip this section in the present analysis. ZSI may elaborate this issue within the following study elements by juxtaposing the results to funding information from Web of Science to ensure plausibility.

3.2.7 Comparison of Bibliometric Approaches and Outlook

While the study on Web of Science was restricted to key-word-based queries (or equations) that are designed to cover both, nanotechnology and health aspects of science publications, the second part chose a dual approach, including key-word sets to retrieve records on nano-technology combined with the journal subject area fields relevant for health as indexed by Elsevier Scopus.

Consequently, two different views on "nano medicine" derived which open up new perspectives to analysis and offer different scopes of results. Naturally, the total numbers differ due to the different sources (*Web of Science* and *Scopus*) and the different retrieval strategies. Put into relation similar patterns were nevertheless made visible:In both studies the most productive institutions in nano-medicine in Latin-America listed are very similar (asTable 3.1-3 and Table 3.2-2). Both tables are led by Brasilian institutions, first of all the Universidade de Sao Paulo amongst a couple of others, but also the Universidad Nacional Autónoma de México amongst the top 5. Very important partner countries in both studies are Spain and France as well as the USA as a third country partner in EU-LAC collaborations.

Interestingly, although Web of Science found the Universidad de La Habana as similarly important in nano-medicine as the Universidad Nacional de La Plata or the Instiuto Politécnico Nacional de México, but Universidad de La Habana was not found by the Scopus search. On the other hand, the Universidad de Puerto Rico is listed as similarly productive as the Instituto Politécnico Nacional de México in the Scopus study, which seems a remarkable difference.

Overall, the approach applied in the two parts also differed in that the first group focussed on Latin American publications while the second study is centered around Latin-American – European co-publications.Additional insights deriving from the application of the two approaches in parallel clearly emerge in the case of the most productive authors.

While the team using Web of Science focussed on certain sub-fields within nano-medicine, the Scopus team listed 40 very important authors for nano in general, and nano-health for the two regions each and the combination of the two. The results of the two approaches offer a bigger variety of specialists active in the field and therefore broaden the basis for finding relevant actors, which was one of the main objectives of the endeavour.

It is also worthwhile to have a look at the differences between the tables of major institutional actors in Latin-America (Table 3.1-3) and those in the table of European and Latin-American co-publications (Table 3.2-3). While the Universidade de Sao Paulo leads all tables, it is remarkable, that for example the Universidad Nacional Autónoma de México is less important in the bi-regional “ranking”. In the combined list for both regions, the trend of strong partnerships with Spain, France and Germany is confirmed, but also Turkey plays a certain role.

3.3 Analysis by country

A detailed analysis of the main six countries that appear as the most productive in the bibliometric study was undertaken.[10] These countries are: Brazil,followed by Mexico, Argentina, Chile, Colombia, and Uruguay. The countries will appear in this order.

3.4 Brazil

The Brazilian Science, Technology and Innovation Ministry (MCTI) and its agencies moved quickly to establish the basis for a national nanotechnology policy at the beginning of the 2000 decade. The first action taken was the funding of four multidisciplinary Cooperative Networks of Basic and Applied Research on Nanosciences and Nanotechnologies, with the purpose of creating and consolidating the national expertise in the field(Toma, 2005). In 2004, a Program for the Development of Nanoscience and Nanotechnology was incorporated into the MCTi’s Multi-year Plan for 2004-2007, which was expanded one year later and launched with the name of National Nanotechnology Program. The program funded R&D activities, paying particular attention to universities-companies partnerships, the construction and renovation of laboratories, projects for the incubation of nanotechnology companies, and human resources qualification. Ten new cooperative research networks were funded from 2005 to 2009 and another 17 were launched in 2010. By the end of 2008, 16 out of 109 National Institutes of Science and Technology were created with a focus on nanotechnology. There are currently 48 universities and research centers, 2 500 researchers and about 3 000 students involved in nanotechnology in the country (Plentz, 2013). In August 2013 the MCTI launched a new version of the

[10] Except for the case of Cuba, classified as the 5th by productivity, and not included because of the lack of information on the Web and our difficulty to access direct information.

nanotechnology plan, the Brazilian Nanotechnology Initiative. This plan has a new governance structure, composed of several ministries and government agencies, the Interministerial Nanotechnology Committee (MCTI, 2013a). One of the most important actions within the strategy is the implementation of a national system of laboratories, the SisNANO, aimed at developing high level research infrastructure. SisNANO is composed of eight strategic laboratories and 17 associated laboratories distributed in different regions of the national territory(MCTI, 2013b). The budget earmarked for nanotechnology by the MCT in 2013 was 150,7 million *reais* and the investment plan for 2014 is 300 million *reais*(Plentz, 2013).

Brazil has a universal public health system (SUS-Sistema Único de Saúde) created by the Federal Constitution of 1988 and promulgated in 1990, in the context of the redemocratization of the country. It is considered a responsibility of the State to guarantee the universal right to health. Although varying within the different regions, around three quarters of the population of the country depend on the SUS for medical attention. The system is supported by a number of public institutions including first care attention centers, hospitals, hemocenters, research laboratories and productive facilities, and contracts with some private institutions to provide specific services. SUS has its own research and technological development policy aimed at coping with the most relevant public health problems in the country (Paiva, 2012; Sistema Único Saúde, 2013). Given the importance of the SUS for the great majority of Brazilians that cannot afford a private health insurance, nanotechnology contributions to the SUS that may enhance the quality and effectiveness of the service or reduce its costs may be considered of broad social impact.

Since the establishment of the Worker´s Party´s government in 2002, successive industrial policy plans have considered the heath sector as one of the strategic areas. The current Great Brazil Plan 2011-2014 (*Plano Brasil Maior*) include goals such as the enhancement of the competitiveness of the pharmaceutical sector, the substitution of exports (reversing the commercial balance deficit), the development of new knowledge-intensive business, and the use of the State buying power to stimulate the development of the sector (MDIC, 2011). In line with this policy, the Brazilian Nanotechnology Initiative has emphasized the contributions that nanotechnology could make to achieve such goals, such as the development of systems for decentralized monitoring and diagnostics, prosthesis, new drugs and therapies and systems for controlled and targeted delivery of drugs.

The Ministry of Science, Technology and Innovation (MCTI) and its agencies CNPq (National Council for Scientific Research) and FINEP (Funding Agency for Studies and

Projects) have funded a number of projects in nanomedicine.Table 3.4-1highlights some of the most important calls for projects. The first six lines refer to FINEP´s nonrefundable funds directed to promote R&D in companies. The number of projects funded in the area of nanomedicine varies considerably depending on the priority areas defined in each call. In total, over the period 2006-2013, 22 projects focusing directly on nanomedine were funded among a total of 57 directed to the whole area of nanotechnology.

Name of the fund	Time period	Total of projects approved	Nanotechnology projects	Nano Medicine projects
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação – 2006[11]	2006-2009	148	12	2
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação 2007	2007-2010	153	19	11
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação –2008	2008-2011	206	4	2
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação – 2009	2009-2012	260	3	3
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação –2010	2010-2013	105	3	2
Chamada Pública MCT/FINEP/Subvenção Econômica à Inovação – 2013(especifica nanotecnologia)	2013-2016	na	16	2
Edital MCT/CNPq 01/2001 redes cooperativas de pesquisa em N&N	2001-2005	-	4	1
Edital MCT/CNPq 29/2005. Redes cooperativas de pesquisa em N&N	2006-2010	-	10	2
Edital 74/2010 Redes cooperativas de pesquisa em N&N	2010-2012	-	17	7
Chamada MCTI/CNPq N º 17/2011 - Nanotoxicologia	2011	-	6	1
Institutos Nacionais de Ciência e Tecnologia	2008-2013	109	16	3
Departamento de Ciência e Tecnologia do Ministério da Saúde – Vários editais em parceria com CNPq	2004-2010	-	-	28

Source: CNPq and FINEP webpages. Data in the last line cited from Faria(2013)

[11] Non-repayable funds to support R & D in innovative companies. Mechanism implemented in 2006 by FINEP, MCT agency. Selection through a public call

Note: Data is not exhaustive. Only main national funding initiatives were considered.

Table 3.4-1 Main lines of public funding of research and development in nanomedicine – Brazil

The last lines in Table 3.4-1 show research projects funded by CNPq. One of CNPq´s main funding lines to promote the field of nanotechnology has been the calls for cooperative research networks on nanoscience and nanotechnology that gather researchers from different institutions and regions of the country. These calls fund research projects in universities and research centers, but often require articulation with the productive sector. Up to now there have been three calls for research networks nanoscience and nanotechnology in 2001, 2005 and 2010 and one call for research networks in nanotoxicology in 2011, funding in total 37 networks. Among these, 14 have been addressing issues of nanomedicine as a central topic.

In 2008 the MCTI created a new institutional design to address critical issues through science and technology, the National Institutes of Science and Technology (NIST), funding 109 of them in several areas of knowledge. As seen inTable 3.4-1, three NISTs are specialized in nanomedicine, while others contribute with secondary lines of research in this area:

- ***National Institute of NanoBioPharmaceutics***, focused on pharmaceutical research, technologies for drug formulation with application in controlled drug delivery, and design of animal models for biomedical studies and experimentation. (http://www.inct-nanobiofar.com/ ?op=paginas&tipo =secao&secao=13&pagina=12)

- ***National Institute of Nanobiotechnology***, addresses the use of nanostructured complexes constructed by coupling drugs or biomolecules with magnetic and non-magnetic nanostructured materials for the application in human and veterinary health. (http://inctnanobiotecnologia.com.br/outros-incts/)

- ***National Institute of Nanobiostructures and Nanobiomolecular Simulation***, specialized in the biotechnological applications of crystals, amino acids films from DNA and RNA and proteins (including the engineering of crystals for drug development for neglected diseases); characterization and simulation of drugs and proteins and the development of biosensors and carbon and other nanomaterials for biotechnological applications. (http://www.nanobiosimes.ufc.br/index.php/apresentacao)

The last line ofTable 3.4-1 presents the projects on nanomedicine funded by the Department of Science and Technology of the Ministry of Health, in association with the CNPq, along with the priorities set in the research agenda of the former. From 2004 to 2010, 28 projects on nanomedicine were funded (Faria, 2013). Among these projects, the topic "controlled drug delivery systems", mainly directed to cancer and *leishmaniosis* treatment, is prominent, with 57,1% of the total of approved projects and 77,6% of the total budget over the period (Faria, 2013, p. 44).

The foundations of the Brazilian research system are the Research Groups, organized by CNPq. These units, focused on particular research lines, involving one or more institutions (universities and research centers), and composed of researchers, undergraduate and graduate students, technicians and, in some cases, companies, are the base for the constitution of larger research networks as the ones described above. CNPq maintain a public database of Research Groups that is updated periodically. We have conducted a search of the groups that carry out research on nanomedicine as its main activity or as a research line. The search started identifying all the registers on nanotechnology (searching the database with the word nanotechnology in the title or research lines of the groups), and then manually selecting the ones concerned with nanomedicine.[12] From a total of 281 registers we analyzed 77 groups focusing on nanomedicine (Table 3.4-2).

Nanomedicine as	Number of groups
Main or very relevant research focus	41
A research line	36
Total	77

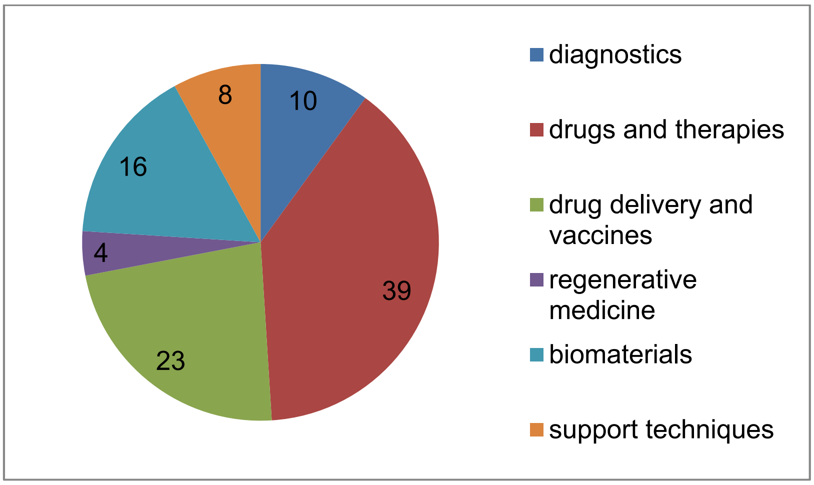
Source: CNPq. Diretório dos Grupos de Pesquisa no Brasil (CNPQ, 2013)

Table 3.4-2: CNPq Research Groups on nanotechnology

We classified the declared research lines of the 77 groups into six categories: diagnostics, drugs and therapies, drug delivery and vaccines, regenerative medicine, biomaterials and support techniques (including characterization, metrology, bioinformatics and other techniques applied to research in nanomedicie). It can be observed inFigure 3.4-1that the research and development of drugs and therapies, and the design of systems for controlled and targeted delivery of drugs and vaccines are the main focus of research in the country. Research on biomaterials follows, which is a transversal area with applications in diagnostics, drug delivery and regenerative medicine. Following this strategy the number of research groups is 77 while the

[12] Previous research by Alencar, Bochner and Dias (2013) on the same database, using 198 nanoterms related to different areas of research in nanomedine heavily enlarged the number of identified research groups to 878. However, the narrowing of the search to groups with relevant activity in nanomedicine reduced this number to 85 groups, a very similar result that the one obtained with our less sophisticated methodology.

research topics sum up 100, since some groups work on more than one research area. It should be noted that in the case of Brazil the research groups registered by CNPq are usually huge groups if compared with the rest of the countries analized.



Source: CNPq. Diretório dos Grupos de Pesquisa no Brasil
Note: One group may declare more than one area of research.

Figure 3.4-1Main nanomedicine areas of research of Brazilian Research Groups

A qualitative analysis allowed us to identify some groups of particular interest in relation to the focus of this research, that is, groups that research in areas of high potential social impact (Table 3.4-3). Although several group´s research can be considered within this category, we selected groups that are more directed to applied research and are in an advanced stage of research and development. Some of them have already established partnerships with companies or public productive facilities to start the production of the products obtained.

Research Group	Main research area	Institution(s)	Research Leader/contact	Associated companies
Biotecnologia & Nanotecnologia	**Drugs and therapies**- Nanostructured drugs **Regenerative medicine** Biomaterials for odontology and orthopedics	Instituto Federal do Ceará - Reitoria - IFCE	Marco Antonio Botelho Soares (85) 3307-3600	Evidence Soluções Farmaceuticas Ltda
Células-tronco e Nanotecnologia para a Engenharia de Tecidos	**Regenerative medicine** Nanotechnology associated to stem cell for tissue regeneration	Universidade Federal do Rio Grande do Sul - UFRGS	Patricia Helena Lucas Pranke (51) 3308-5275	
Desenvolvimento de sistemas nanoparticulados contendo fitoterápicos com atividade biológica	**Drugs and therapies** Drugs using phytotherapy for cancer and other diseases	Universidade Federal do Rio de Janeiro - UFRJ	Valeria Pereira de Souza (21) 2564-7380	
Engenharia Biomédica, Caracterização e Desenvolvimento de Biomateriais	**Biomaterials** Cement for ontological use	Universidade Fed de Pelotas	Evandro Piva, Neftalí Lenin Villarreal Carreño (53) 3222-6690	Angelus
Insumos Bio e Nanotecnológicos Antiparasitários e Imunomoduladores	**Drug delivery and vacines** Vaccine anti *leishmaniosis* Transdermical delivery of drugs	Universidade Federal do Rio de Janeiro - UFRJ	Bartira Rossi Bergmann (21) 2260-6963	Sanofi-Aventis Farmacêutica - Suzano - SANOFI-AVENTIS GlaxoSmithKline, Brasil
Grupo de Pesquisa em Nanoestruturas e Interfaces Biológicas	**Diagnostics** Biomarkers and biossenssors	Universidade Federal do Pernambuco, Recife	Patrícia Maria Albuquerque de Farias – (81) 2126-7818	Empresa Brasileira de Hemoderivados eBiotecnologia - HEMOBRAS
Laboratório de Micro e Nanopartículas Aplicadas na Terapêutica	**Drugs and therapies** encapsulation of nanostructured anti-inflammatory non-steroids drugs **Biomaterials** polymeric nanoparticles	Universidade Federal do Rio Grande do Sul - UFRGS	Adriana Raffin Pohlmann, Silvia S. Guterres (51) 3308-7237	Biolab Sanus

Medicamentos Oftálmicos e Terapêuticos	**Drugs and therapies** therapies for neglected ocular diseases	Universidade Federal de São Paulo - UNIFESP	Rubens Belfort Mattos Junior, Acacio Alves de S. Lima Filho (11) 5085-2082	Ophthalmos Indústria e Comércio de Produtos Farmacêuticos - OPHTHALMOS
Nano radiofarmacos e Novos Radiofármacos	**Drugs and therapies** Nano radiopharmaceuticals and its toxicological assessment	Universidade Federal do Rio de Janeiro - UFRJ, parcerias com Uruguay e Argentina	Ralph Santos-Oliveira, Marta de Souza Albernaz (21) 2562-2187	Biozeus Desenvolvimento de Produtos Biofarmaceuticos - BIOZEUS
Pesquisa e Desenvolvimento de Sistemas de Liberação de Fármacos Baseados em Nanotecnologia	**Drugs and therapies** Drugs using phytotherapics for câncer and other diseases	Universidade Estadual Paulista Júlio de Mesquita Filho - UNESP	Marlus Chorilli (16) 3301-6998	
Sistemas de liberação de fármacos para tratamento de doenças tropicais e emergentes	**Drug delivery and vaccines** Diverse systems for controlled delivery of drugs with a focus on tropical diseases	Universidade Estadual Paulista Júlio de Mesquita Filho - UNESP	Maria Palmira Daflon Gremião (16) 3301-6975	

Source: CNPq. Diretório dos Grupos de Pesquisa no Brasil

Table 3.4-3 Some research groups carrying out research of likely high social impact

The search of research networks, Institutes of Science and Technology and research groups allowed identifying a number of laboratories and hospitals that outstands in the country´s efforts to develop nanomedicine. We highlight: the NanoSUS Laboratory, the Institute of Technology in Pharmaceuticals(Farmanguinhos/Fiocruz), the Laboratory of Nanomedicine and Nanotoxicology, the Center of Nanotechnology and Engineering of Tissues, and the Polymers Facility of the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro.

NanoSUS is the *Laboratório de Nanobiotecnologia para Desenvolvimento, Prototipagem e Validação de Produtos para o Sistema Único de Saúde*. The laboratory, located in the city of Curitiba, is part of the Institute of Molecular Biology of Paraná, a partnership between the public institution Fundação Osvaldo Cruz (Fiocruz), with long tradition in excellence health research, and the Government of the State of Paraná. This laboratory was selected by the MCTI to compose the National Nanotechnology Laboratories System (SiSNANO), a nation-wide network of strategic laboratories for the advancement of nanotechnology, and it is the only lab in the SiSNANO specialized in the area of health. The main purpose of the NanoSUS is to develop, validate and produce prototypes of nanobiotechnological processes and products for the Sistema Único de Saúde. At this point the projects will be forwarded to the productive system (public and private). For more information see the chart below.

Laboratory	**NanoSUS** Parceria entre Fundação Oswaldo Cruz – (FIOCRUZ) e o Governo de Estado do Paraná O IBMP foi selecionado pelo MCTI para compor à rede Sistema Nacional de Laboratórios em Nanotecnologia (SisNANO), sendo o único laboratório da área da Saúde a compor este sistema. Para cumprir este papel, o IBMP, em parceria com a Fiocruz, irá organizar em Curitiba uma plataforma para receber projetos na área de nanobiotecnologia para o SUS. Esta plataforma, denominada NANOSUS, se destina ao desenvolvimento, validação e prototipagem de processos e produtos nanobiotecnológicos para o SUS. Objetivos Desenvolvimento e a incorporação tecnológica de alto nível; Formação de quadros tecnológicos; Ampliação do acesso da população a produtos com conteúdo tecnológico mais elevado; Redução do déficit da balança comercial; Agregação de valores à cadeia produtiva do complexo econômico e industrial da saúde (CEIS); Fortalecimento dos arranjos produtivos locais associados à nanobiotecnologia
Main Research áreas	O NanoSus pretende levar à escala de validação e estudos pré-clínicos projetos promissores (internos e externos à Fiocruz), que apresentem provas de conceito consistentes. Os projetos que ultrapassarem essa fase serem repassados para o setor produtivo, público ou privado.
Funding	Public funding
Director	Dir geral Samuel Goldenberg sgoldenb@fiocruz.br; sgoldenb@tecpar.br Dire do Lab : Rodrigo Stabeli

Contact	**Instituto de Biologia Molecular do Paraná** Tel. +55 (41) 2104-3260 Rua Algacyr Munhoz Mader, 3775 - Bloco C - CIC - CEP 81350-010 Curitiba - PR - Brasil - info@ibmp.org.br **http://ibmp.org.br**
Other info	Produção de produtos para o SUS Nacionalização de insumos para diminuição de dependência tecnológica estrangeira.

The **Institute of Technology in Pharmaceuticals (Farmanguinhos)** is public federal laboratory of the Fundação Osvaldo Cruz, with its main facility sited in Rio de Janeiro city. Farmanguinhos is the larger public laboratory of the Ministry of Health and produces more than one billion of medicines each year for the Sistema Único de Saúde, and for emergency demands in Brazil and abroad. This lab accomplishes a strategic role acting as a price regulator of the market of HIV drugs, and is instrumental for most Brazilians to have access to medicines.

Laboratory	**FARMANGUINHOS - Instituto de Tecnologia em Fármacos** (Farmanguinhos/Fiocruz) Public Federal Laboratory, Foudation Osvaldo Cruz
Main Research areas	-Nova formulação e sistema de entrega do Praziquantel (PZQ), medicamento indicado para o tratamento da esquistossomose, popularmente conhecida como barriga-d'água, uma das principais doenças negligenciadas que afeta cerca 200 milhões de pessoas em todo o mundo e 8 milhões no Brasil. Produção será realizada na planta de nanopolímeros da Coppe/UFRJ (ver destaque correspondente). - Uso de nanotecnologia para o desenvolvimento de um antirretroviral para tratamento da Aids. Ainda em fase embrionária de desenvolvimento, mas o estudo já tem apresentado resultados promissores.
Funding	Financiamento público (Laboratório federal)
Director	
Contact	(21) 3348-5050 www.far.fiocruz.br **Campus Sede:** Av. Brasil, 4365 - Manguinhos, Rio de Janeiro - CEP: 21040-360 - Tel: (0xx21) 2598-4242
Other info	O Instituto de Tecnologia em Fármacos (Farmanguinhos) é, atualmente, o maior laboratório farmacêutico oficial vinculado ao Ministério da Saúde. Farmanguinhos produz mais de um bilhão de medicamentos por ano para os programas estratégicos do Governo Federal, que são distribuídos à população pelo Sistema Único de Saúde (SUS), além de atender demandas emergenciais no Brasil e no exterior. Farmanguinhos exerce papel estratégico ao atuar como regulador de preços no mercado de antirretrovirais. Dessa forma, o Instituto se destaca na luta pela redução de custos, o que colabora para que mais brasileiros tenham acesso aos programas de saúde pública.

The ***Laboratory of Nanomedicine and Nanotoxicology*** **(LNN)** was recently created at the Physics Department of the University of the State of São Paulo at São Carlos city (UNESP-São Carlos). The laboratory is specialized in three main areas of research in the intersection of physics and medicine research: a) the development of functionalized nanoparticles for imaging, drug delivery and new drugs development; b) development of new materials for detection of biological substances and biosensors for diagnostics of several health conditions, including neglected diseases, and c) research on the toxic effects of nanoparticles and carbon nanotubes on healthy and cancer cells, among other toxicity studies.

Laboratory	**Laboratório de Nanomedicina e Nanotoxicologia** Grupo de Biofísica Molecular do Instituto de Física de São Carlos, Universidade de São Paulo.
Main Research areas	a) Nanomedicina Desenvolvimento de Nanopartículas Superparamagnéticas Funcionalizadas com Proteínas para Imageamento Molecular do Câncer (MRI). • Síntese e Funcionalização de Nanopartículas de Ouro com Proteínas, Peptídeos e DNA para entrega Controlada de Fármacos. • Desenvolvimento de Super-Antibióticos Nanoestruturados. • Nanoencapsulamento de Hormônios da Tireoide em Nanopartículas Poliméricas para Liberação e Reposição Hormonal Controladas. • Simulação Computacional da Interação entre Nanomateriais e Membranas Celulares. • Novos Sistemas Descartáveis para Diagnóstico Rápido e de Baixo Custo de Leishmaniose e Doença de Chagas Biosensores Objetivo: desenvolver novos materiais e novas arquiteturas de dispositivos para aplicação na detecção de substâncias biológicas e de interesse médico/ambiental. ♦ Síntese e Imobilização de Nanotubos de Carbono e Nanoparticulas de Ouro e Platina sobre Plataformas Transdutoras. ♦ Imobilização de Proteínas, Peptídeos e Anticorpos pelas Técnicas de Automontagem, LB e utilização de Self Assembled Monolayers (SAM)s. ♦ Novos Sistemas de Alta seletividade, Sensibilidade e Baixo Custo para Detecção de Glicose, Urea, Ácido Lático e Lactose. ♦Sistemas de Biossensoriamento e Diagnóstico de Leishmaniose e Chagas. ♦Novos Biossensores para Detecção de Hormônios (Tireóide e Estrógeno). Nanotoxicidade (um dos pioneiros na área no Brasil) ◊ Estudo dos Efeitos Tóxicos de Nanopartículas e Nanotubos em Células Saudáveis e Tumorais (*in vitro*). ◊ Investigação da Interação de Nanomateriais com Modelos de Membrana Celular, ou Membranas Celulares Reconstituídas. ◊ Estudos de Nanotoxicidade *in vivo* em modelos animais.
Funding	CNPq, FAPESP
Director	Prof. Dr. Valtencir Zucolotto
Contact	Zuco@ifsc.usp.br +55 16 3373 8656 http://www.nanomedicina.com.br/

The **Center for Nanotechnology and Tissue Engineering** is part of the University of São Paulo in the city of Riberão Preto. The laboratory produces nanostructured photo-activated drugs for skin cancer treatment. It also produces artificial skin in considerable scale, used in the treatment of burned patients or other scare-related conditions. The distribution of the artificial skin has not yet reached the Sistema Único de Saúde – agreements with the Ministry of Health are under study. The center works in collaboration with major public hospitals such as the Hospital of the Medicine School of the University of São Paulo at Riberão Preto; public universities such as the Universidade Federal de São Paulo (Unifesp) and Universidade de Brasília (UnB-HRAN); and other public institutions as the National Research Institute of the Amazon (Inpa) and the Excellence Center for the Treatment of Cancer in Belém do Pará.

Laboratory	**Centro de Nanotecnologia e Engenharia Tecidual** Universidade de São Paulo Riberão Preto.
Main Research areas	Produção de medicamentos nanoestruturados para o tratamento de câncer de pele com a aplicação com laser (fármacos fotoativados) Produção em escala da pele artificial, usada para recuperação de queimados e tratar problemas cicatriciais em geral.
Funding	Público
Director	Antonio Claudio Tedesco, do Departamento de Química, da Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP) da USP
Contact	+55-16-3602-3751 Contato por e mail em http://www.ffclrp.usp.br/docentes/quimica/antonioclaudiotedesco.php
Other info	Parceria com cinco centros ambulatoriais no País: Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto (HCFMRP) da USP, Universidade Federal de São Paulo (Unifesp), Universidade de Brasília (UnB-HRAN), Instituto Nacional de Pesquisas da Amazônia (Inpa) e Centro de Excelência do Tratamento de Câncer de Belém do Pará. A produção de pele artificial, que atualmente só é feita por indústrias, deve chegar a 100 cm²/mês no Centro de Nanotecnologia e Engenharia Tecidual da USP de Ribeirão Preto e ser utilizada não só para queimados, mas também em doenças cicatricias e como modelo cutâneo em muitos experimentos. A distribuição desse material não é realizada pelo Sistema Único de Saúde (SUS), e sim por meio de convênios de pesquisas entre a USP e os centros interessados, sendo custeado por agências de fomento à pesquisa. Mas a ideia é ter convênio com o Ministério da Saúde para subsidiar a produção e distribuição.

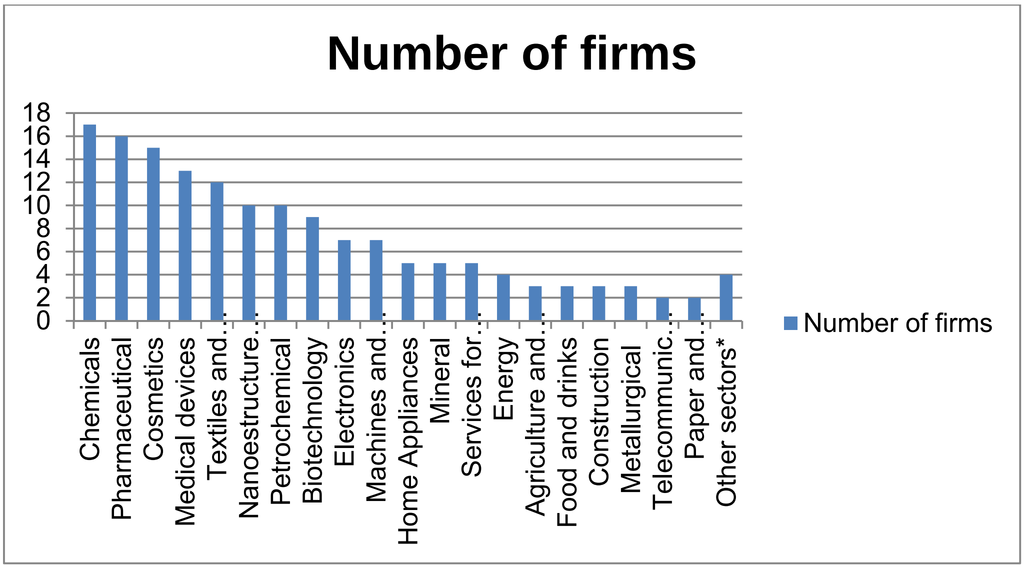
The **Polymers Facility** of the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro was recently inaugurated. It is the first pilot plant in the country with capabilities for scaling-up technologies for the production of polymeric micro and nanoparticles with applications in the medical, biotechnology and pharmaceutical areas. This plant will produce the medicine Praziquantel (PZQ) for the treatment of “barriga d´agua”, developed by Farmanguinhos.

Laboratory	**Planta de nanopolímeros** COPPE, Universidade Federal do Rio de Janeiro
Main Research areas	A Coppe/UFRJ inaugurou a primeira planta-piloto do país capaz de escalonar tecnologias para a produção de micros e nanopartículas poliméricas com aplicações nas áreas médica, biotecnológica e farmacêutica.
Funding	A fábrica-piloto é um projeto que conta com financiamento do BNDES e da Finep, no valor total de 11 milhões de reais
Director	Prof. José Carlos Pinto, coordenador do Laboratório de Engenharia de Polimerização da Coppe, onde está instalada a Planta Piloto de Polímero
Contact	
Other info	Inaugurada em outubro 2012 Resultado de um investimento de R$ 11 milhões, a

	Planta Piloto de Polímeros ocupa uma área de 740 m2 no Laboratório de Engenharia de Polimerização da Coppe. Abarca uma área construída de 740 m2, que inclui a planta industrial, um conjunto de seis laboratórios e os equipamentos mais modernos da área. A planta, concebida no Programa de Engenharia Química da Coppe com apoio do BNDES, Firjan e Fiocruz, foi considerada um marco na história da Universidade Federal do Rio de Janeiro e um modelo de transferência de conhecimento para a sociedade brasileira. A planta vai produzir o medicamento Praziquantel para tratamento de Barriga d´agua, desenvolvido por Farmanguinhos.

Brazilian enterprises with activities in nanomedicine

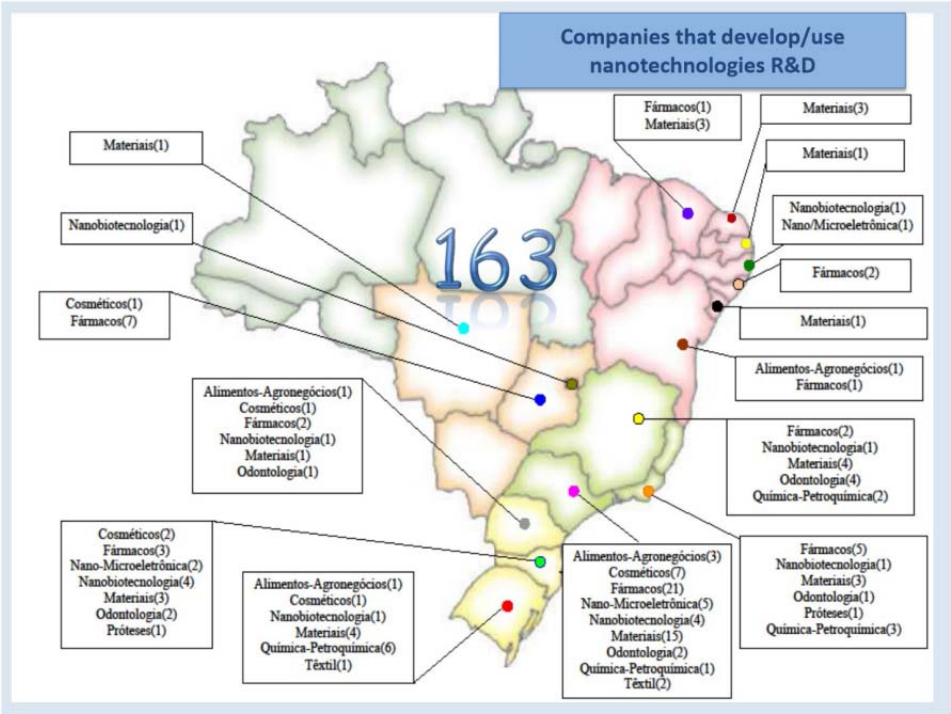
An inventory of firms developing or using nanotechnology in Brazil carried out by Invernizzi (2012)identified 155 companies by mid-2011, of which 29 were in the health sector: 16 of them in the pharmaceutical industry and another 13 in the production of diverse medical materials and devices (Figure 3.4-2).



Source: Invernizzi (2012)

Figure 3.4-2 Companies developing nanotechnology in Brazil by sector

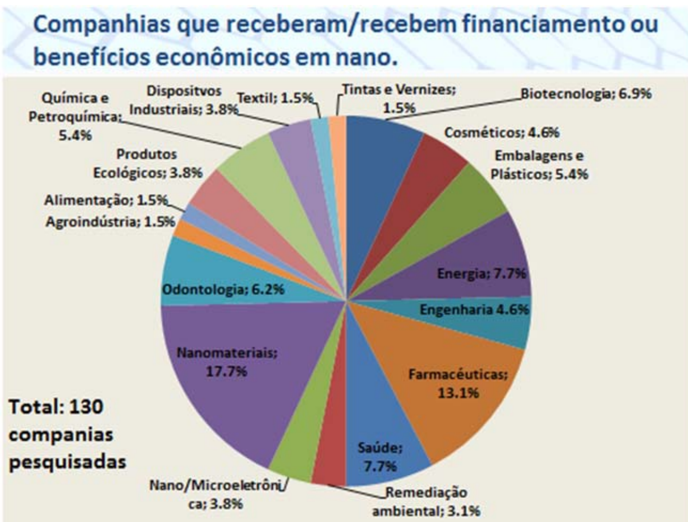
A more recent account of companies with activities in nanotechnology indicates that there are 163 firms, distributed in the national territory and covering different sectors (Fazzio, 2012) (Figure 3.4-3).



Source: Fazzio 2012

Figure 3.4-3 Companies that develop/use nanotechnology in Brazil

Figure 3.4-4 shows companies that received public funding for nanotechnology R&D. Of a total of 130 firms considered in this study, almost 8 % of the funding went to companies in the health sector and 13% to pharmaceutical companies.



Source: Plentz, F. (2013)

Figure 3.4-4 Brazilian companies supported by public funds for R&D in nanotechnology by sector

3.5 Mexico

The *Special Program of Science, Technology and Innovation 2008- 2012* established N&N as one of the nine priority areas for S&T development. By the end of 2010, the implementation of the N&N policy in Mexico took form in the creation of three significant developments: the creation of a national research network (RNyN); the construction of two national laboratories; and the development of technological parks.

The RNyN network was created with a budget of more than $700-thousand. It brings together more than 130 researchers from various universities and research centers throughout the country (CONACYT, n/d). The National Nanotechnology Laboratory (NaNoTeCH) at the Advanced Materials Research Center (CIMAV) in Chihuahua was constructed in 2006. The Potosí Institute of Scientific and Technological Research (IPICYT) built the National Laboratory for Nanoscience and Nanotechnology Research (LINAN). Both national laboratories received a budget of approximately US $2-million for their construction and equipment (CONACYT, 2006). These labs are leased to the interested parties. Several industrial parks were created in the first decade of the 21st Century. The Research and Technological Innovation Park (PIIT) located in the city of Monterrey represents a US $100-million investment for the physical plant with another US $150-million for equipment; moreover, it hosts two specialized incubators in emerging technologies: one for biotechnology and the other for nanotechnology. It is also the headquarters of the Nanotechnology Cluster of Nuevo León (CNNL), which is the signature project of the PIIT (Záyago Lau, 2011).

Mexico, second only to Brazil, is one of the most important countries in Latin America advancing nanotechnology (NT) research and development (R&D). The information related to NT R&D is scattered as no organization or institution tracks NT research in Mexico. This contrasts with Brazil and its CNPq in charge of collecting research information and making it available for any interested party. The following report of the state of health research in Mexico contains data that was gathered by exploring each cluster of research centers or universities, in a case-by-case basis. In general terms, the search entailed the use of a set of key terms. We are aware that some information might have been left out in this report; unintentionally of course, as many of the information might have not been up to date or even available on line.

We found out that most nanomedicine initiatives and research is distributed in eight institutions or organizations: Academic Clusters (AC) of the Ministry of Public Education, Research Centers of the National Council of Science and Technology (CONACYT), the National Polytechnic Institute (IPN), the National Autonomous University of Mexico (UNAM), the Center for Research and Advanced Studies (CINVESTAV) of the IPN, Hospitals and Research Centers of the Ministry of Health, Private Universities and some other universities.

Academic Clusters (AC)

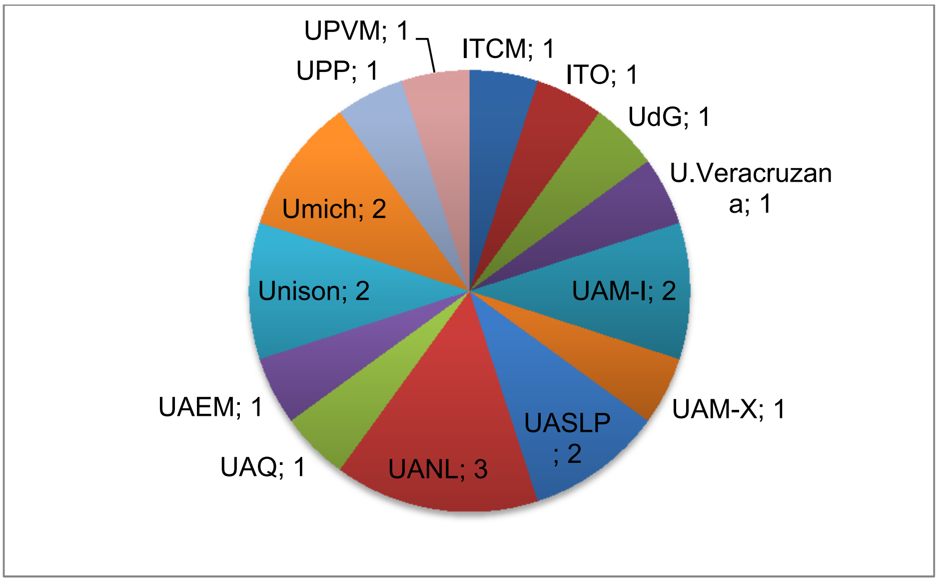
The AC program is an initiative of the Mexican Ministry of Public Education and is promoted simultaneously with the Professorship Development Program (PROMEP). The AC program was created to improve the research competence and scientific capabilities of the faculty attached to public universities, polytechnic universities and technological institutes(PROMEP, 2013). Each AC is brought together by a common research interest or topic with the main objective of generating new knowledge in the subject. Each AC is required to have 3 members and the program allocates resources to execute research plans, publish findings or encourage mobility amongst the members. As of January 2013 there were 4 087 AC formed (PROMEP, 2013).

Methodology: We conducted a search using the AC program´s search engine (http://promep.sep.gob.mx/ca1/) with the key word nano*. We obtained 99AC with research interests on NT. Afterwards, we explored each of the 99 AC to assess which ones were working with nanomedicine or any other related area. A quick search was performed using some key words such as: *nanomedicina, fármacos, diagnosis, salud* and, when this procedure was exhausted, we analyzed the description of the research area for each AC to uncover which ones were related to nanomedicine. There are 62 researchers integrating 20 AC that are working or doing research in nanomedicine.[13]

The 20 AC are distributed among 14 universities or institutions (Figure 3.5-1). The Universidad Autónoma de Nuevo León (UANL) leads the way with 3 AC. The Universidad Autónoma de San Luis Potosí (UASLP), the Universidad Autónoma Metropolitana-Iztapalapa (UAM-I), the Universidad de Sonora (Unison) and the

[13] Each CA must have at least 3 investigators. When search was performed there were CA where no data were found online for all its members; however, from each CA that works in nanomedicine at least one member was identified, and also CA with more than three members. each working with nanomedicine CA was identified at least one member and CA were also identified with more than 3 members. The National Autonomous University of Mexico (UNAM), the National Polytechnic Institute (IPN), the Research Center for Advanced Studies (CINVESTAV) Research Center and the National Council for Science and Technology (CONACYT) Research Centers do not participate in this program.

Universidad Michoacana de San Nicolas de Hidalgo (Umich) have 2 AC respectively. To complete the group, there are several universities with one AC: Instituto Tecnológico de Ciudad Madero (ITCM), Instituto Tecnológico de Oaxaca (ITO), Universidad de Guadalajara (UdG), Universidad Veracruzana (U. Veracruzana), Universidad Metropolitana-Xochimilco (UAM-X), Universidad Autónoma de Querétaro (UAQ), Universidad Autónoma del Estado de México (UAEM), Universidad Politécnica de Pachuca (UPP) and Universidad Politécnica del Valle de México (UPVM).



Source: Own research with PROMEP data(2013)

Figure 3.5-1 Number of AC per University or Institution

Most of the AC doing research in nanomedicine are in the sectdor of biomaterials and mechanic particles (10). All the details are located in(Table 3.13-1).

Research Centers of CONACYT

The CONACYT´s Research Centers system is clustered among 27 research institutions in four big areas of knowledge: exact and natural sciences, social sciences and humanities, technological innovation and development and graduate studies funding. To find all the research groups working in nanomedicine related areas, we explored all the CV´s of the personnel within the Research Centers of exact and natural sciences and technological innovation and development.

Methodology: the analysis began by entering key words such as “nanomedicina”, “nanotecnología” + “medicina”, “fámarco” + “nano” y “enfermedad” + “nano” in the search engines of each Reserch Center. At the same time, we reviewed the CV´s of the researchers attached to the subdivisions most likely to have some linkage with nanotechnology and medicine (i.e. material sciences, bioengineering, drug development).

The Centro de Investigación en Alimentación y Desarrollo (CIAD) hosts 5 researchers that have interest in pursuing research in nanomedicine related areas. The specific research focuses on developing nano-capsules with special drugs to treat specific pathogens (Table 3.13-2).

In the same token, the Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco (CIATEJ) has 3 scientists with research interest on nanomedicine. Dr. Rodolfo Hernandez Gutierrez is in the process of obtaining a patent for the design of a chip. The device, containing nanoparticles of gold, is expected to early detect some forms of cancer. Likewise Dr. Alejandro Arturo Canales Aguirre is developing nanomaterials to treat chronic diseases (such as diabetes) and Dr. Georgina Sandoval is creating drugs with nanomaterials. To check the other Research Centers or to find more information please see Table 3.13-2.

National Autonomous University of Mexico (UNAM)

The UNAM is the most important research institution in Mexico. Taking into account the number of students, faculty and funding, UNAM stands out as the largest university in Mexico and Latin America. In terms of nanoscience and nanotechnology publications, UNAM concentrates 25% of the total (Záyago Lau, Frederick, & Foladori, 2014).

Methodology: UNAM has several research centers or institutes with its own autonomy and resources, so that doing a general search was unproductive. This is why we decided to perform a research route that entailed the use of the search engines of each institute or center´s web site. In first place, we use the site that groups all the web addresses of all the research centers and institutes (http://www.cic-ctic.unam.mx/cic/subsistema/institutos_centros.cfm). Afterwards, we inserted the following key words: “nanomedicina”, “nanotecnología” + “medicina”, “fármaco” + “nano” y “enfermedad” + “nano”. Latter, we analyzed the research reports of the centers or institutes that were most likely to have infrastructure for nanomedicine research.

That was the case of the Center for Nanoscience and Nanotechnology Research (CNyN) of UNAM headquartered in Baja California. In this center Dr. Nina

Bogdanchikova plays an important role in developing silver nanoparticles to treat the diabetic foot. Dr. Rafael Vazquez Duhalt, on the other hand, is attached to the Institute of Biotechnology (IBT) and has a research protocol to create nanoparticles to be used in chemotherapy. At the Institute of Physics Sciences, Dr. Jorge A. Ascencio is working with nanoparticles for the medical industry (Table 3.13-3).

National Polytechnic Institute (IPN)

The IPN is the second most important research institution in Mexico. The IPN inaugurated, in 2009, the Center of Nanosciences and Micro and Nanotechnologies (CMN). The IPN, as part of the CMN, supports the Nanoscience and Micro-nanotechnology Network (NMN). This network has 146 members, all researchers of the IPN.

Methodology: We explored each one of the CV´s of the members of the NMN ((http://www.coordinacionredes.ipn.mx/redesip/rednano/Paginas/Miembros.aspx). Presumably, all the researchers of the IPN working in nanotechnology related areas are members of this network. Out of the 146 researchers, we found 13 that are doing research in nanomedicine (Table 3.13-4).

Center for Research and Advanced Studies (CINVESTAV) of the IPN

Initially CINESTAV was created, in 1961, as a Research Center part of the IPN system; however, in 1982, it acquired financial, administrative and legal autonomy. Today is one of the most important research centers regarding the advancement of scientific knowledge in the country. It has 10 sub-centers in different states. It has 4 research areas: exact and natural sciences, biological and health sciences, technology end engineering and social sciences and humanities.

Methodology: We explored the profiles of each researcher in the following departments: exact sciences, biological and health and technology and engineering. The analysis included the search for specific terms such as “nanomedicina”, “nanotecnología” + “medicina”, “fármaco” + “nano” “enfermedad” + “nano”. We managed to find 4 profiles of relevance for our purposes, nanomedicine research.

Dr . Luis Marat Álvarez Salas is looking at the area of nanomaterials to use them to treat cervical cancer and the Human papillomavirus (HPV). Dr. Rodrigo Balam Muñoz applies carbon nanotubes to treat diseases. Dr. Alicia Cortés is testing a nanopolymer to eliminate precancerous cells. Likewise, Dr. Andrea de Vizcaya is measuring the toxic levels of several nanoparticles used in nanomedical research (further details in Table 3.13-5).

Research Centers of the Mexican Government

There are several research institutions within the Mexican health care system. Their objective is to create new treatments, diagnosis protocols and drug delivery mechanism to alleviate the most common diseases among the Mexican population. The system is structured around 6 ministries at the federal level and 32 at the state level. Most of the research is performed in centers within those 6 main ministries of the federal government. Those are: Secretaría de salud, Instituto Mexicano del Seguro Social (IMSS), Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE), Instituto de Seguridad Social para las Fuerzas Armadas Mexicanas (ISSFAM), Servicios Médicos de Petróleos Mexicanos y el Sistema Nacional para el Desarrollo Integral de la Familia (DIF).

Methodology: We entered each one of the research centers of the Mexican public health care system and performed a search using the same key words used before. Later on, we executed a search in the research centers that had the infrastructure of interest in advancing emerging technologies for medical care.[14]

As a result of this search for data, we found 4 institutions that are working with nanomedicine. The Neuroscience and Neurosurgery National Institute (INNyN) is headquartering a nanotechnology laboratory directed by Dr. Tessy Lopez. This laboratory has the objective of designing new materials to deliver new drugs (INNyN, 2013). Dr. Rafael Morales works at the National Institute of Cancer Research (NICR) and is interested in diagnosing diseases with the help of nanotechnology. In the Mexican Institute of Social Security (IMSS) Dr. Mauricio Salcedo is developing new diagnosis methods for cancer and other diseases. More research is conducted at the Juarez Hospital.

The National Institute of Nuclear Research, sponsored by the Ministry of Energy, hosts a research group working in the diagnosis of diseases. Further information about this and the previous groups can be found at the Table 3.13-6.

[14] In newspapers, magazines, journals, conferences and other media.

Private Institutions

There is research that shows the limited presence of private institutions or research centers doing nanotechnology related research in Mexico (Zayago, Frederick and Foladori, 2014 in press). It was not different for the case of nanomedicine. For the purpose of this project, we examined the most important private universities and research centers to find what they were doing in the area of nanomedicine. We found only 2 groups: one at the University of Monterrey and another at the University of the Americas in Puebla (UDLAP). The one in Puebla is researching the array of applications of nanomaterials in biomedical procedures. The group is lead by Dr. Miguel Ángel Mendez Rojas, who is the coordinator of the Nanotechnology and Molecular Engineering Program at UDLAP. The group at the University of Monterrey is dedicated to the early diagnosis of dengue by developing new materials. This group is lead by Dr. Román Vidal Tamayo Ramirez.

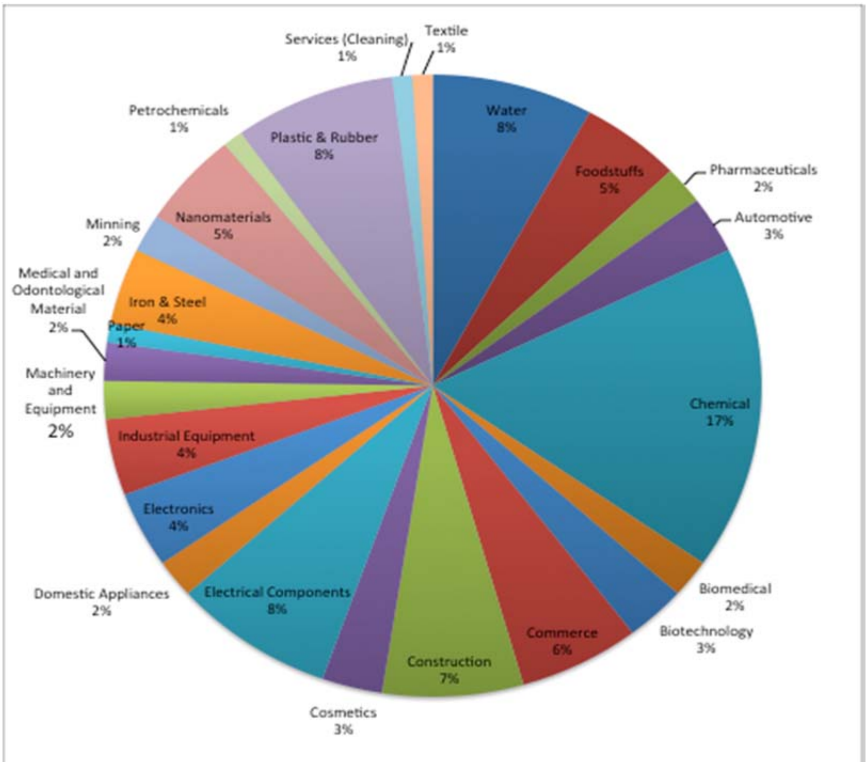
Other Researchers and groups

After completing the entire searches trough the specific routes, we decided to explore other universities and centers that might have something on nanomedicine. This was not arbitrary. We follow the lead of publications, web-based reports and some news in newspapers about scientists and their accomplishments in the area of nanomedicine. We managed to find 7 researchers. The details of their contact information, topic of interest and other information can be found in the Table 3.13-7

Additional Search Strategies

In order to expand the reach of the search strategies implemented in the latter sections, we dedicated some time to review the calls for funding in the area of nanotechnology. The most important source of these data was the calls made public by CONACYT. We were able to track all the grants allocated to foster nanomedicine research in Mexico within public universities and centers by consulting the CONACYT´s web site. It is worth mentioning, however, that the data only refers to the main researcher; thus not providing information if he or she was part of a larger research group. The Annex C: Mexico (Table 3.13-8) shows the results of several calls to fund nanotechnology research projects. There are several modalities with a different set of information, and some of them did not have data available on line at the time of the analysis. We ignore the amount of funding that each program granted as it was not available on line. 5% of the entire calls for projects were aimed to nanotechnology research; and from that percentage only 10% had the aim of fostering nanomedicine.

Another indirect way of illustrating the importance of nanomedicine development in Mexican academic spheres is to take into account the number of companies per area. In 2012 a group of researchers, members of the Latin American nanotechnology and Society Network (ReLANS), conducted a survey to find how many companies where using nanotechnology in their manufacturing process or were commercializing nanotechnology based products in Mexico (Záyago et al., 2012). The following Figure 3.5-2 shows the distribution per area of the 101 companies that were found. In this figure we observe that 2% of the companies are located in the Medical and Dentistry sector, another 2% in the biomedical sector and another 2% in pharmaceuticals. This could mean that 6% of the total is related to medical sectors (without taking cosmetics, which accounts for 3% of the total).



Source:(Záyago et al., 2012)

Figure 3.5-2 Percentage of companies working with NT per sector in Mexico

3.6 Argentina

Bibliometric indicators put Argentina in third place of production in Latin America, after Brazil and Mexico (Kay & Shapira, 2009; OICTeI, 2008; Robles-Belmont & Vinck, 2011). Governmental support for nanotechology in Argentina started in 2003, when the Secretary of Science and Technology establish nanosciences and nanotechnologies as one of the priority areas, along with biotechnology and information and communication technologies (Spivak L´Hoste et al., 2012). A year later, the National Agency for Scientific and Technological Promotion (ANPCyT) issued a call for project submission for several research areas, including nanotechnologies. The financed projects created, in fact, the four research networks in nanotechnology funded and publicly recognized (Andrini & Figueroa, 2007). In 2005 the State, through Decree Nº 380/2005, authorized the creation of the Argentine Nanotechnology Foundation (Andrini & Figueroa, 2007). In order to push forward the integration of the different research networks and individual researchers and also private enterprises, the Interdisciplinary Center for Nanoscience and Nanotechnology was created in 2007 (Spivak L´Hoste et al., 2012). In 2010 the government announced the launching of a specific fund for nanosciences and nanotechnologies (Fondo Sectorial de Nanotecnología -FSNano) (García et al., 2012; Spivak L´Hoste et al., 2012).

Four research networks were created in 2004, with public funding. One of them on issues related to the health area (Auto-organization of bio-structures for the transmission of molecular information in neurobiology and biological processes). It is worth mentioning that aside from these networks a laboratory on targeting of drugs was being created at the University of Quilmes, in the Province of Buenos Aires.

Argentina has 2 laboratories on nanomedicine. One, as said, at the University of Quilmes, specialized in targeting of drugs (2005), the other, the Laboratory of Engineeringof Tissues, Regenerative Medicine and Celular Terapies (Laboratorio de Ingeniería Tisular y Medicina Regenerativa -laboratoriomedreg@cucaiba.gba.gov.ar), a public institution sited in Cucaiba, Province of Buenos Aires (2007) (Foladori et al, 2012). Nanomedicine researchers in Argentina are organized through the Argentinean Association for Nanomedicine (Asociación Argentina de Nanomedicina www.nanomed-ar.org.ar), which organized four events over 2011 and 2012 (Table 3.6-1).

Date	Name of the Event	Local city
Oct. 2011	First Argentinean Symposium on Nanomedicine	La Plata
Oct. 2011	Second Latino-american School of Nanomedicine	La Plata
Nov 2012	Second Argentinean Symposium on Nanomedicine	San Luis
Sept. 2013	Third Latino-american School of Nanomedicine	Buenos Aires

Table 3.6-1 Events organized by NANOMEDar

The following Table 3.6-2 summarizes several of the members of this association as well as their institutions and research topics.

Institution	Topic	Contact person	email
Nanomedicine Programme. University of Quilmes. Pva. Buenos Aires	Drugs and therapies	Eder Romero (director)	elromero@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	María José Morilla	jmorilla@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Diana Ines Roncaglia	diana@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Ana Paula Perez	apperez@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Leticia Herminia Higa	lhiga@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Priscila Schilrreff	pschilrreff@unq.edu.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Maria Victoria Defain Tesoriero	mvdt@inti.gov.ar
Nanomedicine Programme. University of Quilmes	Drugs and therapies	Julia Altube	
Hospital Churruca-Visca, Ciudad Buenos Aires		Sandra Zapa	
Hospital Garrahan, Ciudad Buenos Aires		Guillermo Chantada	
Instituto de Investigación en Ciencia y Tecnología de Materiales (Intema), Univ. Nac de Mar del Plata	Biomaterials	Gustavo Abraham	gabraham@fi.mdp.edu.ar
Directora Area Cultivos celulares. Fundación Benaím	Regenerative medicine	Alicia Loreti	
Biomaterials and Nanotechnology for Improved Medicines (BIONIMED). Fac. de Farmacia y Bioquímica. Universidad de Buenos Aires	Drug delivery & vaccines	Alejandro Sosnik	alesosnik@gmail.com
Physics Department. Universidad de Buenos Aires	Polymeric materials & metallic particles	Fernando Stefani	fernando.stefani@df.uba.ar
Coord. Unidad Técnica Tecnología de nuevos procesos y productos. Instituto Nacional de tecnología Industrial (INTI)	Drug delivery & vaccines	Laura Hermida	lhermida@inti.gob.ar
Directora Centro de Química Aplicada (Cequimap). FAc. Ciencias Químicas. Universidad Nacional de Córdoba	Polymeric materials & metallic particles	Miriam Strumia	mcs@fcq.unc.edu.ar
Departamento de Química Orgánica. Facultad de Ciencias Químicas. Universidad Nacional de Córdoba	Polymeric materials & metallic particles	Marisa Martinelli	mmartinelli@fcq.unc.edu.ar
Instituto de Investigación Médica "Mercedes y Martín Ferreyra" (INIMEC)-Universidad		Dolores Carrer	dcarrer@gmail.com

Nacional de Córdoba			
Programa de Desarrollo de Materiales Avanzados Universidad Nacional de Río Cuarto	Polymeric materials & metallic particles	Cesar Alfredo Barbero	cbarbero@exa.unrc.edu.ar
Nanoproject. Universidad Nacional de Tucumán	Polymeric materials & metallic particles	David Comedi	dcomedi@herrera.unt.edu.ar
Centro Integral de Microscopia Electrónica. Universidad Nacional de Tucumán	Diagnosis & microscopy	Beatriz Winik	bwinik@fbqf.unt.edu.ar
Laboratorio de nanoscopias y fisioquímica de superficie. Instituto de Investigaciones Fisicoquimicas Teoricas y Aplicadas (UNIFTA). Universidad Nacional de La Plata	Diagnosis & microscopy	Maria Elena Vela	mevela@inifta.unlp.edu.ar
Centro Binacional (Arg.-Italia) de Investigaciones en Criobiología Clínica y Aplicada (CAIC), Universidad Nacinal de Rosario	Drug delivery & vaccines	Dra. Valeria Sigot	*vsigot@fbioyf.unr.edu.ar*

Source: own research based on events organized by the association

Table 3.6-2 Nanomedicine Researchers and Centers in Argentina (Argentinean Nanomedicine Association database)

Another source of nanomedicine groups comes from the Argentinean Nanotechnology Foundation register. Table 3.6-3 shows the information available. A distribution by topics show drug delivery and drugs & therapies as the main ones (Figure 3.6-1). The research groups were classified as follows:

Sector classification:

Diagnosis	D
Drugs, therapies & delivery, vaccines	T
Regenerative medicine	R
Biomaterials & metallic particles	B
Other & no specified	O

Group	Sector	Key wods	Institution
Nanoestructuras magnéticas	O	clinical applications	UBA-Fisica
Lab-Bio-Mems	T	glaucoma, microvalves, biomaterials	Instituto Nacional de Tecnologia (INTEC)
Area de Materiales Biomédicos	T	nanoencapsulation, nanocarriers	INTEMA
Nanomaterials, Toxicity and Cancer	T	cancer , procesos fotoinduzidos	Laboratório de Especies Altamente Reactivas (INIFTA)

Unidad de Biotecnologia	T	drug delivery, nanocarriers,biopoli mers	Subunidad de Biologia Molecualr y Biomateriales (CEPROCOR)
Laboratorio de Inmunologia Molecular y Estructural (LIME-IEIH)	T	proteinas recombinantes, ADN vacunas, imunología	FFYV-Universidad de Buenos Aires
Materiales compuestos de matriz polimérica	T	biocompositos	INTEMA
Nanopartículas Magnéticas /Laboratório de resonancias Magneticas	B	nanopartículas magnéticas	CAB-CNEA
Terapia fortoasistida contra el Cancer	T	erapia fotoasistida, fotosensibilizadores, biocompatibilidad	Facultad de Ciencias Exactas Universidad Nacional de Rio Cuarto
Grupo Nanotecnologia Farmacéutica	T		FFYB- Universidad de Buenos Aires
Biomaterials and nanotechnology for improved medicines	T	poverty-related diseases, HIV, tuberculose	UBA
Laboratorio de Biofísica Molecular y Biosuperficies	T	bioencapsulamiento y liberacion controlada	CIQUIBIC UNC
Laboratorio de Biomembranas	T		Univ. Nac. Quilmes
Química de materiales funcionales	T		UBA
Laboratorio de Nanobiomateriales	O		UNLP
Laboratorio de Terapia molecular y celular	T	inmunonanopartícula s, anticuerpos, medicina genómica	Instituto Leloir
Programa de nanomedicinas	T	antiinfecciosos, antioxidantes	UNLP
Nanomateriales	D		INTI
Laboratorio de sistemas de liberación controlada	T		INTI
Biomateriales G-Bio	r		INTI

Table 3.6-3 Nanomedicine Researchers and Centers in Argentina (FAN database)

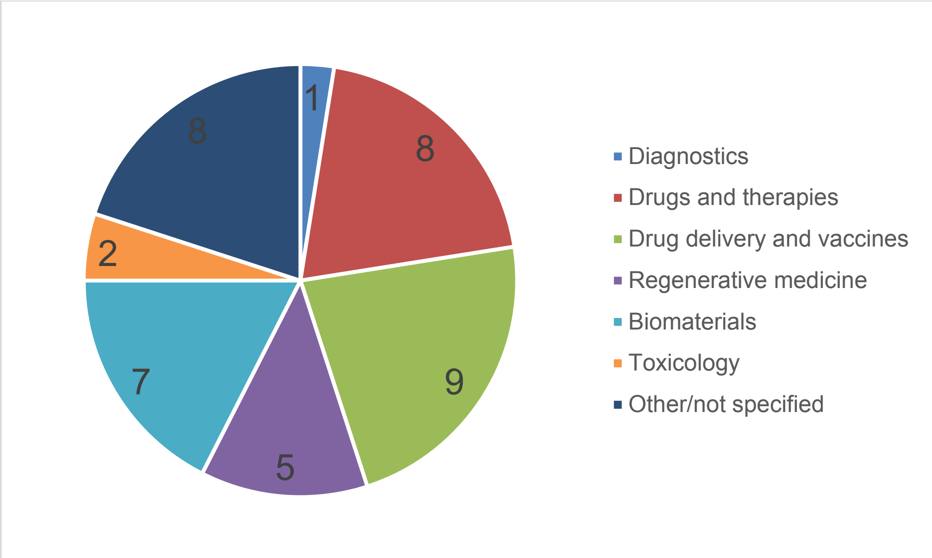


Figure 3.6-1 Nanomedicine Groups by Topic in Argentina. FAN database 2011

3.7 Chile

Federal funds in Chile started promoting nanotechnology R&D since the ninetieth of last century. In 1997, the *Comisión Nacional de Ciencia y Tecnología* (CONICYT) (National Commission of Science and Technology) opened its Centers of Excellence via the *Programa Fondo de Investigación Avanzada en Áreas Prioritarias* (FONDAP) (Program of Advanced Research in Strategic Areas). One of this priority areas was nanotechnology, and FONDAP funded, in 1999, the *Centro para la Investigación Interdisciplinaria Avanzada en Ciencia de Materiales* (Center of Advanced Interdisciplinary Research in Science of Materials) in the Universidad de Chile. Another funding for nanotechnology came from the World Bank. The Scientific Millennium Initiative, encouraged by the World Bank, was implemented in Chile as the prototype to be further developed in other countries. In 1999, the Chilean Government created the National Commission of Millennium Initiatives. In consequence, the World Bank granted a loan of US $5 million for the first stage of two-and-a-half years on top of the US $10 million provided by the national government (ICM, s/f.a).In the first stage of the MSI three institutes and five nuclei were created. One of them was created to perform nanotechnology research (Physics of Condensed Materials) headquartered in the Universidad Técnica Federico Santa María (ICM, s/f.a). During the second stage, five research nuclei were created, but none of them oriented towards nanotechnology research. For the third stage, inaugurated in 2002 and implemented in 2003, a new project related to nanotechnology research was approved. It was headquartered at the Universidad Andrés Bello (Material science and nanotechnology, organic physiochemical and theory of densities) and the program of Physics of Condensed Materials was extended for another three years (ICM s/f.b) (Foladori & Fuentes, 2008).

Nowadays, bibliometric studies position Chile in fourth place in scientific articles on nanotechnology in Latin America (Brazil 53.3%, México 23.8%, Argentina 16%, Chile 6.9%), although there is yet no national policy for the promotion of nanotechnology (Cortés-Lobos, 2012), al. Nanomedicine is not a strong topic within the nanotechnologies research areas in Chile.

Lacking a central body for the registration of nanotechnology R&D activities, the path to identify topics by institutions and centers is not simple, and might involuntary miss research groups. The following table was done by searching those nanotechnology projects approved for federal funds whose information is on line –which is not the case of all projects approved. Besides a manual search on the main institutions that research on nanotechnology was done and added to Table 3.7-1.

Institution	Nanomedicine	Contact person	Sector[15]
Universidad de Chile. Centro para la Investigación Interdisciplinaria Avanzada en Ciencia de los Materiales (CIMAT).	Magnet Nanoparticles to treat cancer and Alzheimer's	José Luis Arias **jarias@uchile.cl**	T
Universidad de Chile Centro de Estudios Avanzados de Enfermedades Crónicas (ACCDiS)	Treatment and prevention of chronic diseases	*Sergio Alejandro Lavandero* González slavander@uchile.cl	T
Universidad de Chile	Polymeric materials and metallic particles	Marcelo Kogan	B
Universidad de Santiago de Chile. Centro para el Desarrollo de la Nanociencia y la Nanotecnología (Cedenna)	Transport and characterization of fluids in arteries and brain aneurysms	cedenna@usach.cl	T

[15] Sector classification:

Diagnosis	D
Drugs, therapies & delivery, vaccines	T
Regenerative medicine	R
Biomaterials & metallic particles	B
Other & no specified	O

Universidad de Santiago de chile. Facultad de Química y Biología	plásticos como transportadores de fármacos con liberación programada	Franco Rabagliati franco.rabagliati@usach.cl Hugo Cárdenas,	T
Pontificia Universidad Católica de Chile. División de Obstetricia y Ginecología de la Escuela de Medicina	hipertensión arterial	Paola Casanello pcasane@med.puc.cl	T
Universidad Andrés Bello. Departamento de Ciencias Químicas	Nanopartículas antibacteriales	Daniela Geraldo, daniela.geraldo@unab.cl	T
Universidad Andrés Bello. Departamento de Ciencias Químicas	detección temprana del cáncer por nanopartículas renio as bactericide	Ramiro Arratia Secretary of Department: luisa.gonzalez@unab.cl	D
Universidade de Talca, Centro de Bioinformática y Simulación Molecular. & Instituto Fraunhofer Gesellschaft, Alemanha,	Tratamiento para el Cancer	Danilo González Nilo dgonzalez@utalca.cl	T

Source: **http://www.conicyt.cl/;** (Foladori & Fuentes, 2008)**,** institutional sites

Table 3.7-1 Main institutions and topics related to nanomedicine in Chile

3.8 Colombia

Nanosciences and nanotechnologies are boost by the Administrative Department on Science, Technology and Innovation (Departamento Administrativo de Ciencia, Tecnología e Innovación -Colciencias), which is the institution in charge of fostering Colombian S&T policy. In 2005 the Institute of Electric and Electronic Engineers (IEEE) launched the National Council on Nanosciences and Nanotechnologies within their institution. In 2006 the National Development Plan on Science, Technology and Innovation included nanosciences and nanotechnologies as a strategic sector (Duarte Urueña, n/d).

The main instrument to promote S&T in Colombia is the Excellence Research Centers, a program launched by Colciencias in 2004(Pérez Marteló & Vinck, 2012).Between 2004 and 2009 8 Excellence Research Centers were created, with one explicitly oriented towards nanotechnologies. The CENM (Centro de Excelencia en Nuevos Materiales) is organized by 19 research groups on four research topics: Materials and coatings, Nanocompound materials, Nanomagnetism and solid state devices, sensors and Mesoscopic systems (Pérez Marteló & Vinck, 2012)

Without a formal institutional structure, another center, nanoCiTec (de Ciencia y Tecnología Nanoescalar) was created in 2006 by the ex-president of the National Council on Nanosciences and Nanotechnologies of the IEEE, as a not for profit association, which grouped interdisciplinary professionals interested in nanotechnology research. Built up as a network, it uses the infrastructure of the different universities where their members work (e.g. Universidad Javeriana). The central research nanomedicine topic is “Cancer and nanotechnology” (Vinck & Pérez Marteló, 2008).

The platform of Colciencias (ScienTI) offers a research machine for scientific research groups registered in Colombia (http://201.234.78.173:8083/ciencia-war/). A search in that platform (November, 2013) by the prefix “nano” reported 10 research groups, but only one with research on nanomedicine, taken place at the Universidad Javeriana.

Name of group	Starting year	Institution, Web page & coordinator	Topics
Grupo de nanociencia y nanotecnología	2006	Universidad Javeriana http://gnano.javeriana.edu.co Edgar Emir Gonzalez Jimenez egonzale@javeriana.edu.co	• Salud • Energía • Remediación • Nanomateriales

Table 3.8-1 Research group in nanomedicine in Colombia

The research group “nanoscience and nanotechnology” from the Universidad Javeriana, started in 2006, and within their research topics is health entitled “Transporte e internalización en células tumorales

de nanopartículas metálicas y sus efectos citotóxicos”. The group is coordinated by Edgar González Jiménez (egonzale@javeriana.edu.co) (Table 3.8-1).

A private institution, The Clinic Shaio has a research team working on Mems/Nems for pacemakers, with the research name “Nanopuente Aurículo- Ventricular” (Colmédica, 2013).

3.9 Uruguay

Research in nanotechnology started at the University of the Republic (Universidad de la República –UDELAR), and at the Instituto de Investigaciones Biológicas Clemente Estable (IIBCE). In 2009 the UDELAR established the Center in Nanotechnology and Chemists and Physics of Materials (Chiancone, 2012).

The following Table 3.9-1 summarizes the main research groups in nanomedicine in the country. The information was obtained from the individual curriculum vitaes on line from the Nationa Agency of Researchers (ANII) of the researchers of the centers where nanotechnology is being undertaken. A detailed diagnosis of the R&D on nanotechnology in Uruguay is actually in press (VVAA, 2013).

Institution	Lab./ Department	Sector [16]	Number of researchers	Contact peson
Universidad de La República				
Facultad de Ciencias	Laboratorio de Radiofarmacia - Centro de Investigaciones Nucleares (CIN)	D	3	Pablo Cabral pcabral@cin.edu.uy
Facultad de Ciencias	Laboratorio de Biomateriales / Instituto de Química Biológica.	B	4	Eduardo Méndez emendez@fcien.edu.uy
Facultad de Química & Centro Nanomat	Cátedra de Física/Laboratorio de Cristalografía/Centro NanoMat - DETEMA	R	16	Alvaro Mombrú amombru@fq.edu.uy
Facultad de Odontología	Cátedra de Fisiología ¨	B	7	Dr. Marcelo Kreiner mkreiner@netgate.com.uy
Instituto de Investigaciones Biológicas Clemente Estable	Laboratorio de Señalización Celular y Nanobiología / División Neurociencias.	D	10	Dr. Juan C. Benech benech@iibce.edu.uy
Instituto Pasteur de Montevideo	Laboratorio de Neurodegeneración	T	4	Hugo Peluffo hugo.peluffo@pasteur.edu.uy
Universidad ORT	Facultad de Ingeniería. Laboratorio de Biotecnología	D		

Source: Individual researchers Curriculum Vitae and institutional pages.

Table 3.9-1 Main research groups in nanomedicine in Uruguay

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[16] Sector classification:

Diagnosis	D
Drugs, therapies & delivery, vaccines	T
Regenerative medicine	R
Biomaterials & metallic particles	B
Other & no specified	O

4.7 Latin America – European Union research projects

A search on the Cordis database only gave one project on nanomedicine with a Latin American collaboration. Data is below:

Programme Acronym	Name	Date	Coordinator	Latin American Countries	Contact person & Institution
FP7-Health	**Berenice** (Benznidazol and Triazol Research group for Nanomedicine and Innovation on Chagas disease)	2012-2017	Institut Catalá de la Salut	Brazil	Rodrigo Correa Oliveira. Fiocruz
				Argentina	Luis Ferrero. Lab. Elea. Buenos Aires.
				Argentina	Ezequiel Cravero. Adm. Nacional de Laboratorios e Institutos de Salud

Source: Cordis, November 2013. Query terms searched: "nanomedicine" in subject: Medicine & Health (http://cordis.europa.eu/newsearch/index.cfm?page=advSearch&js=1&language=en#

Table 3.9-2 EU-Latin American Nanomedicine Projects

3.10 Conclusions

Two approaches were used to identify nano-health R&D activities in Latin America: a quantitative publication analysis based on bibliometric studies using the two major international citation databases available, and a qualitative approach oriented to identify the main research groups, researchers and funding devoted to nanomedicine in six countries: Brazil, Mexico, Argentina, Chile, Colombia and Uruguay. Information available in these countries was very unequal and, therefore,difficult to compare.

The main findings obtained through our quantitative analysis are:

- Research on nano-health has increased steadily since the middle of the last decade. However, the growth is not the same between different areas of nanomedicine, and some areas are still in an early stage of development. The most developed area, according to the number of publications, is drug delivery.

- The data obtained after executing both methodologies showed a strong concentration of publications in Brazil and Mexico.The Universidade de São Paulo and Universidad Nacional Autónoma de Mexico are the two top research institutions.

- Co-authoringis another important trend. Authors from the EU region represent, approximately, one quarter of the publications according to date taken from the Scopus database; butis less representative according to the WOS database. In both studies, Spain, France and Germany stand out as the most common partners in EU-LAC collaborations

The qualitative study indicated that all countries have oriented public funding to nanomedicine, but only data for Brazil and Mexico illustrate a comprehensive picture of these matters. In the case of Brazil more than one third of thenanotechnology projects granted to companies, with nonrefundable funds, were directed to promote nanomedicine. Furthermore, we found out that around one third of the funding directed towards research networks was secured by nanomedicine related projects. In this context it is worth to pint out that the Brazilian Ministry of Health allocated funds directly to this area. In Mexico a study of several calls for research showed that around 5% of the budget was aimed to nanotechnology research; and out of that only 10% had the aim of fostering nanomedicine.

All the countries have research groups working in nanomedicine, with some specialization on different specific areas:

- Brazil has funded 37 nanotechnology research networks since 2001, out of which 14 have been addressing issues of nanomedicine, mainly in the areas of drugs and therapies and drug delivery.

- Mexico has several groups working on nanomedicine distributed in public universities, national research centers, and hospitals and research centers of the Ministry of Health. The main research themes are materials for diverse applications in nanomedicine, drugs and therapies, and drug delivery.

- Argentina has funded four nanotechnology research networks since 2004; one of them is dedicatedto health. The main research topics are drug delivery and tissue engineering

- Chile has some research groups headquartered at the main universities of the country, mostly addressing drugs and therapies research
- Colombia´s research groups have a strong focus on nanotechnology applied to cancer research.
- Uruguay has several small groupsworking with nanomedicine, scattered among different areas.

Additionally, nanotechnology is researched and developed by some companies. Brazil has the largest number, with 30of them in the area of pharmacy and health; that have received public funding to enhance R&D activities. In Mexico, only 2 % out of the 101 companies with activities on nanotechnology are looking at medical applications, 2% are located in the Medical and Dentistry sector, another 2% in the biomedical sector and another 2% in pharmaceuticals. No information was available for the other countries.

Two remarks are worth mentioning after finishing this mapping:

First, although differences in resources and capabilities are notorious among countries, there is a considerable amount of research on nanomedicine in Latin America. Drugs and therapies, drug delivery and materials for different applications are the most developed areas of research. Research groups in most countries have some degree of cooperation with international research networks, within and outside the region. Enhancing cooperation between the European Union and Latin American countries will require further discussion on priority areas for cooperation.

Second, it is not an easy task distinguishing what research in the area of nanomedine could be of social relevance for the Latin American region. On the one hand, most of the research is very basic in nature, so the potential applications and benefits are very difficult to envisage. On the other hand, several Latin American countries have crossed the "epidemiological transition" and present a very similar pattern of diseases and causes of deaths than most developed countries. Although some typical diseases such as tropical diseases are still of importance, most research seems to be directed to a more global landscape of medical issues. Further theoretical discussion will be needed on this topic.

3.11 Annex A

Area	Equation	Results

Drug delivery	TS=((nano* and ((liposome*) or ("polymeric drug*") or ("drug polymer conjugate") or ("protein polymer conjugate") or ("pegylated protein*"))) or ((drug) and ((nanoparticle*) or (nanocapsule*) or (nanosuspension*) or (nanocrystal*) or ("gold nanoparticle*") or ("colloidal gold") or ("silicate nanoparticle*") or ("calcium nanoparticle*") or (biosilic*) or ("titanium dioxide nanoparticle*")) or ("solid lipid nanoparticle*"))) AND CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	616
Drugs and therapy	TS=((fullerene drug*) or (dendrimer drug*) or (nanoshell* and (phototherap* and "hypothermal therap*")) or (magnetic nanoparticle* and hyperthermal therap*)) AND CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	26
In vivo imaging	TS=((superparamagnetic iron oxide) or (“ultrasmall superparamagnetic iron oxide”) or (“monocristalline iron oxide nanoparticle*”) or (cross-linked iron oxide nanoparticle*) or (liposome and ultrasound) or (nanoparticle* and nuclear imaging) or (nanoparticle* and optical imaging) or (nanoshell* and optical imaging) or (quantum dot* and optical imaging)) and CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	203
medical biosensors	TS=((“medical biosensor*”) or (“surface plasmon resonance” and biosensor*) or (cantilever biochip*) or (“DNA chip*” and “electrical detection”) or (nanoarray* and diagnostic*) or (“quantum dot*” and diagnostic*) or (“gold nanoparticle*” and diagnostic*) or (“magnetic nanoparticle*” and diagnostic*) or (“lab on a chip”)) and CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	78
Biomaterials	TS=((“bone cement*” and nanostructure*) or (“dental implant*” and nanocomposite*) or (“orthopedic implant*” and nanostructure*) or (“cardiovascular implant*” and nanostructure*) or (“tissue	41

	engineering” and nanostructure*) or (“silver nanoparticle*” and (implant* or “wound dressing*”)) or (biomarker* and nano*)) and CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	
Intelligent implants / neural prothesis	TS=((“electronic drug delivery system*” and nanotechnolog*) or (“neural prothesis” and nanotechnolog*)) and CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	0
Nanomedicine	TS=(nanomedicine*) and CU=(mexico or brazil or venezuela or argentina or chile or colombia or peru or paraguay or panama or nicaragua or jamaica or honduras or haiti or belize or belice or guyana or guatemala or french guiana or granada or grenada or ecuador or dominican rep or cuba or costa rica or bolivia or barbados or bahamas or uruguay or "trinid tobago" or surinam or puerto rico or salvador or martinique or st lucia or st vincent or antigua barbu or trin tobago or trinid tabago or guadeloupe)	34
Total	#8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1	950

Table 3.11-1 Search e equations and results in the identification of bibliometric references in the field of nanomedicine in Latin America and the Caribbean

Antigua y Barbuda	Chile	Granada	Nicaragua	Saint Lucia
Argentina	Colombia	Guatemala	Panama	Surinam
Bahamas	Costa Rica	Guyana	Paraguay	Trinidad and Tobago
Barbados	Cuba	Haiti	Peru	Uruguay
Belize	Dominica	Honduras	Dominican Republic	Venezuela
Bolivia	Ecuador	Jamaica	San Cristobal and Nieves	
Brazil	El Salvador	Mexico	Saint Vicente and The Grenadines	

Table 3.11-2 List of member countries of the Latin American and Caribbean Community

3.12 Annex B

3.12.1 Definitions

Affiliation: By affiliation we refer to a unique author-institution combination related toone record. The same author can be affiliated with several institutions within onesingle record. If this is the case, we consequently count several affiliations. Therefore, publications with one author, but two affiliations, one in Mexico and one in France, are included in the analysis and considered a co-publication. The number of affiliations in the EU-LA co-publications therefore shall not be confused with the number of authors.

Categories and main categories: The two scientific literature databases used in this study assign the recorded books or periodicals to one or more thematic key words based on a classification system. In Elsevier's *Scopus* we have around 340 of these thematic keywords (3.12.2). Only a small percentage of the scientific works is classified independently of the general classification of the periodical.

Co-publication: In the context of this study we refer to international scientific publications, indexed in literature databases, with the participation of at least two institutions/organisations in at least two different countries. For this study the term co-publication therefore is only used for international co-publications, unless explicitly stated otherwise.

Document types:*Scopus* assigns a certain document type to the tracked publications to better describe them. These types reach from articles over abstracts and conference papers to editorials, errata and even music, movie or software reviews.

Institute/Organisation: Because the scientific literature database *Scopus* used in this study relates authors to different organisational entities (i.e.: in one case the university as a whole is named, in another case we have detailed description of the institute or even the research group, etc.), we agreed on the usage of the label "institute" for the more detailed, subordinate level often called "organisational unit" (university institute, department, laboratory, sub entity of a company or international organisation) and the term "organisation" as the bigger entity, for example university, academy or intergovernmental organisation, etc.

3.12.2 Set of Keywords

scanning probe microscopy, nanoscience, nanoparticle, nanomaterials, nanomanipulation, nanoindentation, nanoimprint lithography, nanofiltration, nanofibers, nanocrystals, nanobiotechnology, molecular electronics microfluidics, microfabrication, mems, gold nanoparticles, electrospinning, electron beam lithography, chitosan; technology, carbon nanotubes, atomic force microscopy, nanotribology, nanorobotics, nanomachining, nanofluidics, nano-integration, nanosensors, nanochips, nanodevices, nanomagnetism, nano-optics, nanoelectronics, nanophysics, nanoscale fullerenes, nanoscale thin films, quantum wells, quantum wires, quantum dots, nanoclusters, nanocrystalline materials, nanocomposites, nanoprobes, nanofabrication, nanolithography, nems, nanoelectromechanical systems, nanotextiles, nanotoxicology, nanostructure, nanomedicine, nanomaterials, nanobiophysics, nanorods, nanoparticles, nanowires, nanotubes, nanotechnology

3.12.3 Scopus Query (including country list):

LAC+EUACCC+nano keywords; topic 1 HEALTH; retrieved on Thursday; Oct 18, 2013; results: 99

(AFFILCOUNTRY(austria) OR AFFILCOUNTRY(belgium) OR AFFILCOUNTRY(bulgaria) OR AFFILCOUNTRY(czech republic) OR AFFILCOUNTRY(cyprus) OR AFFILCOUNTRY(denmark) OR AFFILCOUNTRY(estonia) OR AFFILCOUNTRY(finland) OR AFFILCOUNTRY(france) OR AFFILCOUNTRY(germany) OR AFFILCOUNTRY(greece) OR AFFILCOUNTRY(hungary) OR AFFILCOUNTRY(ireland) OR AFFILCOUNTRY(italy) OR AFFILCOUNTRY(latvia) OR AFFILCOUNTRY(lithuania) OR AFFILCOUNTRY(luxembourg) OR AFFILCOUNTRY(malta) OR AFFILCOUNTRY(netherlands) OR AFFILCOUNTRY(portugal) OR AFFILCOUNTRY(poland) OR AFFILCOUNTRY(romania) OR AFFILCOUNTRY(slovakia) OR AFFILCOUNTRY(slovenia) OR AFFILCOUNTRY(spain) OR AFFILCOUNTRY(sweden) OR AFFILCOUNTRY(united kingdom) OR AFFILCOUNTRY(switzerland) OR AFFILCOUNTRY(norway) OR AFFILCOUNTRY(turkey) OR AFFILCOUNTRY(serbia) OR AFFILCOUNTRY(croatia)) AND (AFFILCOUNTRY(costa rica) OR AFFILCOUNTRY(el salvador) OR AFFILCOUNTRY(guatemala) OR AFFILCOUNTRY(mexico) OR AFFILCOUNTRY(honduras) OR AFFILCOUNTRY(nicaragua) OR AFFILCOUNTRY(panama) OR AFFILCOUNTRY(cuba) OR AFFILCOUNTRY(puerto rico) OR AFFILCOUNTRY(haiti) OR AFFILCOUNTRY(argentina) OR AFFILCOUNTRY(bolivia) OR AFFILCOUNTRY(brazil) OR AFFILCOUNTRY(chile) OR AFFILCOUNTRY(ecuador) OR AFFILCOUNTRY(columbia) OR AFFILCOUNTRY(paraguay) OR AFFILCOUNTRY(peru) OR AFFILCOUNTRY(uruguay) OR AFFILCOUNTRY(venezuela) OR AFFILCOUNTRY(dominican republic) OR AFFILCOUNTRY(barbados) OR AFFILCOUNTRY(belize) OR AFFILCOUNTRY(bahamas) OR AFFILCOUNTRY(antigua AND barbuda) OR AFFILCOUNTRY(dominica) OR AFFILCOUNTRY(grenada) OR AFFILCOUNTRY(guyana) OR AFFILCOUNTRY(jamaica) OR AFFILCOUNTRY(saint kitts AND nevis) OR AFFILCOUNTRY(saint lucia saint vincent AND the grenadines) OR AFFILCOUNTRY(suriname) OR AFFILCOUNTRY(trinidad AND tobago)) AND (AUTHKEY(scanning probe microscopy) OR AUTHKEY(nanoscience) OR AUTHKEY(nanoparticle) OR AUTHKEY(nanomaterials) OR AUTHKEY(nanomanipulation) OR AUTHKEY(nanoindentation) OR AUTHKEY(nanoimprint lithography) OR AUTHKEY(nanofiltration) OR AUTHKEY(nanofibers) OR AUTHKEY(nanocrystals) OR AUTHKEY(nanobiotechnology) OR AUTHKEY(molecular electronics) OR AUTHKEY(microfluidics) OR AUTHKEY(microfabrication) OR AUTHKEY(mems) OR

AUTHKEY(gold nanoparticles) OR AUTHKEY(electrospinning) OR AUTHKEY(electron beam lithography) OR AUTHKEY(chitosan,technology) OR AUTHKEY(carbon nanotubes) OR AUTHKEY(atomic force microscopy) OR AUTHKEY(nanotribology) OR AUTHKEY(nanorobotics) OR AUTHKEY(nanomachining) OR AUTHKEY(nanofluidics) OR AUTHKEY(nano-integration) OR AUTHKEY(nanosensors) OR AUTHKEY(nanochips) OR AUTHKEY(nanodevices) OR AUTHKEY(nanomagnetism) OR AUTHKEY(nano-optics) OR AUTHKEY(nanoelectronics) OR AUTHKEY(nanophysics) OR AUTHKEY(nanoscale fullerenes) OR AUTHKEY(nanoscale thin films) OR AUTHKEY(quantum wells) OR AUTHKEY(quantum wires) OR AUTHKEY(quantum dots) OR AUTHKEY(nanoclusters) OR AUTHKEY(nanocrystalline materials) OR AUTHKEY(nanocomposites) OR AUTHKEY(nanoprobes) OR AUTHKEY(nanofabrication) OR AUTHKEY(nanolithography) OR AUTHKEY(nems) OR AUTHKEY(nanoelectromechanical systems) OR AUTHKEY(nanotextiles) OR AUTHKEY(nanotoxicology) OR AUTHKEY(nanostructure) OR AUTHKEY(nanomedicine) OR AUTHKEY(nanomaterials) OR AUTHKEY(nanobiophysics) OR AUTHKEY(nanorods) OR AUTHKEY(nanoparticles) OR AUTHKEY(nanowires) OR AUTHKEY(nanotubes) OR AUTHKEY(nanotechnology)) AND (LIMIT-TO(SUBJAREA, "BIOC") OR LIMIT-TO(SUBJAREA, "PHAR") OR LIMIT-TO(SUBJAREA, "MEDI") OR LIMIT-TO(SUBJAREA, "IMMU") OR LIMIT-TO(SUBJAREA, "HEAL") OR LIMIT-TO(SUBJAREA, "NURS"))

3.12.4 List of countries

ERA	LAC
Austria	Antigua Barbuda
Belgium	Argentina
Bulgaria	Bahamas
Croatia	Barbados
Cyprus	Belize
Czech Republic	Bolivia
Denmark	Brazil
Estonia	Chile
Finland	Columbia
France	Costa Rica
Germany	Cuba
Greece	Dominica
Hungary	Dominican Republic
Ireland	Ecuador
Italy	El Salvador
Latvia	Grenada
Lithuania	Guatemala
Luxembourg	Guyana
Malta	Haiti
Netherlands	Honduras
Norway	Jamaica
Poland	Mexico
Portugal	Nicaragua
Romania	Panama
Serbia	Paraguay
Slovakia	Peru
Slovenia	Puerto Rico
Spain	Saint Kitts and Nevis

Sweden Switzerland Turkey United Kingdom	Saint Lucia Saint Vincent and the Grenadines Suriname Trinidad and Tobago Uruguay Venezuela

3.13 Annex C

Sector classification:

Diagnosis	D
Drugs, therapies & delivery, vaccines	T
Regenerative medicine	R
Biomaterials & metallic particles	B
Other & no specified	O

3.13.1 Annex C: Mexico

Name of University	Name and AC ID	Sector [17]	Key researcher	Description
UAM-I	CA 106 Fisicoquímica de sistemas nano--estructurados	B	Dr. Nikola Batina bani@xanum.uam.mx	Síntesis y caraterización de sistemas nano-estructurados para su aplicación en ciencias de materiales y ciencias médico-biológicas
UAM-I	CA 95 Materiales Orgánicos e inorgánicos	B	Dr. Juan Padilla Noriega jpn@xanum.uam.mx	La Línea de Investigación "Magnetoquímica" fue aprobada el 30 de septiembre de 1999 por el Consejo Divisional de C.B.I. Consiste de dos proyectos. El primero es un tema de frontera en ciencia básica y consiste en el diseño, síntesis y caracterización de nuevos materiales de dimensiones nanométricas con propiedades magnéticas específicas, que potencialmente sirvan para desarrollar nuevas tecnologías. En particular, se sintetizan nuevos radicales orgánicos nitronil nitróxido, se funcionalizan y se hacen reaccionar con ácidos de Lewis fuertes de iones metálicos de transición y transición interna, y forman especies polinucleares de diversa dimensionalidad estructural y magnética. El segundo versa sobre la "Investigación sobre compuestos macromoleculares formados por receptores calixarenos con elementos de las tierras raras y con sustratos orgánicos de interés médico y ambiental"
Universidad Politécnica del Valle de México	CA 2 Ingeniería de Materiales y Procesos	B	M. Sc. Saúl Rangel Lara (Director of the industrial engineering program)	Sintetisis de materiales y nanomateriales; así como su el análisis de superficies, estructura, micro y nano estructura, así como sus propiedades físicas y propiedades químicas asociadas, mediante SEM, TEM, AFM, OM, Raman, FTIR y UV-VIS, entre otras técnicas de caracterización. Asimismo, analiza las posibles aplicaciones industriales o médicas.

[17]

Drugs, therapies & delivery, vaccines	T
Regenerative medicine	R
Biomaterials & metallic particles	B
Other & no specified	O

			spolitecnicas@yahoo.com.mx	
Universidad Politécnica de Pachuca	CA 13 Nanotecnología y sistemas inteligentes	B	Dra. Maricela Villanueva Ibañez villanueva@upp.edu.mx	Se genera investigación fundamental y desarrollo tecnológico en la elaboración de materiales nanométricos y nanoestructurados simples, compuestos e híbridos con aplicación en áreas médica e industrial.
Universidad Michoacana de San Nicolas de Hidalgo	CA 228 Síntesis y caracterización de compuestos orgánicos y materiales	B	Dra. Rosa Elva N. del Río Torres ndelrio@umich.mx	Esta línea de generación del conocimiento consiste en la construcción planificada de moléculas orgánicas que presenten estructuras muy sencillas o complejas, lo cual se lleva a cabo mediante síntesis total o síntesis parcial, además incluye la caracterización fisicoquímica de diversos materiales con una gran variedad de aplicaciones. Particularmente, la síntesis de bionanocompuestos con aplicaciones biomédicas, síntesis de moléculas orgánicas con aplicación en materiales, así como la síntesis y prueba de compuestos orgánicos como catalizadores en reacciones modelo.
Universidad Michoacana de San Nicolas de Hidalgo	CA 190 Bioingeniería	R	Dra. Zaira del Rocío López López gcginacarbajal@gmail.com	Desarrollo, optimización y aplicación de diversos grupos de materiales cuyas características físicas y químicas les permitan interactuar con sistemas biológicos, para reemplazar y/o inducir a la regeneración del algún tejido u órgano dañado. así como aplicar conocimientos y técnicas matemáticas, computacionales y fisicoquímicas al estudio de sistemas biológicos complejos
Universidad de Sonora	CA 163 Estudios de materiales biofotónicos	R	Dr. Alejandro Apolinar Iribe apolinar@fisica.unison.mx	Se estudian propiedades físicas y mecánicas de músculos utilizando métodos ópticos, así como la funcionalización de nanomateriales para detección de moléculas cancerígenas utilizando fotones.
Universidad de Sonora	CA 86 Ciencias de materiales	T	Dra. Teresa Castro del Castillo terecat@polimeros.uson.mx	Esta línea de investigación incluye proyectos basados en la preparación de nuevos materiales utilizando polímeros naturales. Se trabaja en la obtención y caracterización de membranas de nanofibras de biopolímeros utilizando de electrohilado, así como el estudio de su uso potencial en la liberación controlada de fármacos e ingeniería de tejidos. Se llevan a cabo también trabajos enfocados en la síntesis y caracterización de hidrogeles basados en polímeros naturales y su posible aplicación en la liberación controlada de fármacos u otras sustancias químicas de importancia biológica
Universidad Autonoma del Estado de México	CA 11 Física estadística	D	Dr. Miguel Mayorga Rojas mmr@uaemex.mx	Estudiar teorica y experimentalmente la conformacion, estructura propiedades dinamicas, termodinamicas, reologicas y las funciones de las diversas biomoleculas- particularmente proteinas, bajo diferentes ambientes ionisados con el proposito de comprender los mecanismos de informacion y/o desarrollo o de multiples enfermedades humanas y desarrollar tecnologias

				de diagnosticos, son la termoforesis y la nanotermometria para aplicaciones biotecnologicas y medicas.
Universidad Autónoma de Querétaro	CA 111 Nanotecnología	B	Dra. Janet Ledesma García janet.ledesma@uaq.mx	Desarrollo de materiales nanoestructurados con aplicaciones en las áreas de energía, ambiente y salud.
Universidad Autonoma de Nuevo León	CA 162 Síntesis y caracterización de materiales	B	Dr. Carlos Alberto Guerrero Salazar cguerrer@ccr.dsi.uanl.mx	Desarrollo y caracterización de nanomateriales como nanofibras, nanotubos y fullerenos funcionalizados. se trabaja en la obtención y caracterización de materiales nanoestructurados o auto-nanoestructurados como nanocapas, nanotúneles y nanoporos, así como el desarrollo de sus posibles aplicaciones en áreas como la electrónica, la biología y la medicina.
Universidad Autonoma de Nuevo León	CA 180 Química biológica	B	Dr. Sergio Arturo Galindo Rodríguez segalind@fcb.uanl.mx	Nanotecnología Aplicada a las Ciencias Biológicas y de la Salud. La línea de investigación está enfocada al diseño, desarrollo y evaluación biológica in vitro e in vivo de formulaciones de nanopartículas cargadas con agentes que presentan una actividad biológica específica (i.e. fármacos, nutrientes, extractos vegetales, aceites esenciales, insecticidas, antioxidantes).
Universidad Autonoma de Nuevo León	CA 304 Nanobiotecnología	B	Dr. José Luis Comparan Elizondo comparan_e@yahoo.com	Diseño, creación, síntesis, manipulación y aplicación de materiales, aparatos y sistemas funcionales a través del control de la materia a nano escala, y la explotación de fenómenos biológicos, microorganismos, enfermedades y propiedades de la materia y los seres vivos a nanoescala
UASLP	CA 213 Bioprocesos	T	Dra. Luz María Teresita Paz Maldonadopteresita.paz@uaslp.mx	Se encamina al diseño, producción y caracterización de biomoléculas con actividad terapéutica. En lo particular, son de intéres el estudio de modelos de inmunización contra enfermedades infecciosas o crónicas, tales como el SIDAo la hipertensión, así como el efecto antioxidante de metabolitos secundarios
UASLP	CA 9 Materiales	B	Dr. Martinez Mendoza, José Refugio lash@fciencias.uaslp.mx	Aplicación de las diversas técnica espectroscópicas para su aplicación en ingeniería de materiales y medicina.
UAM-X	CA 85 Materiales nanoestructurados y biocompatibilidad para la liberación	D	Dra. Tessy López Goerne tessy3@prodigy.net.mx	1) Después de llegar a los materiales nanoestructurados se hará un estudio de distribución de tamaño de poro ya que dependiendo del tamaño de la molécula del fármaco, los poros deberán diseñarse para que la liberación sea gradual y por un tiempo mayor a 6 meses.2)Cuando el fármaco se ocluye dentro del material no deben existir enlaces reales tales

	de fármacos			como un enlace iónico o covalente porque el fármaco nunca saldrá. Es por ello que se harán estudios detallados y apegados a los resultados experimentales para tener únicamente interacciones débiles entre la matriz y la droga. este tipo de interacciones pueden ser dipolo-dipolo puentes de hidrógeno o Van del Walls.3)Ya ocluido el fármaco en la matriz nanoestructurada se harán pruebas de liberación por diferentes métodos y se elaborarán las ecuaciones sinéticas que describan el proceso. La liberación se medira por diferentes métodos y en diferentes medios y sera seguida por las señales espectroscópicas así como por sistemas ópticos. La difusión es también muy importante para ver el enlace local que tiene el fármaco ya que se pretende colocar el dispositivo directamente en el lobulo temporal. Para ello se determinará la difusión por termoluminiscencia, EDS y técnicas láser. 4)viabilidad celular de los Materiales Nanoestructurados. 5)Desarrollaremos un Sistema Educativo, de acuerdo con los programas pedagógicos "Jugar y Vivir los Valores (JVLV)" y "Jugar y Vivir la Ciencia (JVLC)", que viene desarrollando el Dr. Antonio Paoli desde hace 10 años en el estado de Chiapas, como un proyecto de la UAM con apoyo de la Secretaría de Educación del Gobierno de Chiapas, el CONACyT, el COCYTECH y la Universidad de Ciencias y Artes de Chiapas (UNICACH). En el nuevo programa que elaboraremos habrá principios didácticos, así como cuentos, en los que se aplicarán, de manera práctica y elemental, las nociones señaladas. El programa JVLV y JVLC ya cuentan con decenas de cuentos para la educación básica y cerca de 300 canciones publicadas por la Secretaría de Educación del Gobierno de Chiapas, la UAM y la UNICACH.
U. Veracruzana	CA 314 Nanobiotecnología y nanomedicina	T	Dra. Claudia Mendoza Barrera omendoza@uv.mx	Fabricar, caracterizar, funcionar y aplicar biomateriales y biosensores de alta especificidad a enfermedades y problemas de alta incidencia social e industrial. Los estudios en ciencia básica y aplicada abarcan fabricaciones y caracterizaciones por rutas secas y húmedas, físicas y química, moleculares, superficiales, celulares e in vivo.
U de G	CA 682 Biología celular	T	Dra. Zaira del Rocío López López zlopez@cuci.udg.mx	Determinar la citotoxicidad de productos bioactivos y nanomateriales con utilidad potencial en la industria farmacéutica, cosmética o alimenticia

Instituto Tecnológico de Oaxaca	CA 4 Ciencia de materiales y química ambiental	D	Dra. Pérez Santiago, Alma Dolores http://www.itox.mx/posgrado/index.php/maestria-en-ciencias-en-desarrollo-regional-y-tecnologico/mcdryt-productividad	La línea de Nanobioquímica surge del interés en desarrollar proyectos de investigación que interconecten la nanotecnología y la bioquímica en la identificación de agentes causantes de enfermedades, los determinantes antigénicos que las causan, y los glicoconjugados que participan, ya que con frecuencia no pueden ser determinados con precisión por la falta de pruebas de diagnóstico específicas y sensibles. Con lo anterior, se requiere el desarrollo de materiales nanoestructurados y agentes conjugados con ligandos muy específicos que permita la elaboración de pruebas de detección sensibles y que puedan eliminar el uso de reactivos costosos. En este contexto, se proponen la utilización de nuevos materiales como nanotubos de carbono, dendrímeros o nanopartículas metálicas con propiedades superficiales y electrónicas únicas), y la miniaturización o aplicación de nanotecnología.
Instituto Tecnológico de Ciudad Madero	CA 2 Nanocompositos sinteticos y semisinteticos	D	Dra. Patricia nancy Zavala Diaz npatdiaz@hotmail.com	Sus aplicaciones de los nanogeles van desde la fabricación de sensores hasta lentes de contacto y productos farmacéuticos. Principalmente sus aplicaciones pueden ser en materiales médicos, agroindustria, pañales desechables, lentes de contacto suaves, etc.. Los geles en tamaño nanometrica ofrece un potencial en cuanto el mejoramiento de sus propiedades fisicas, quimicas y biologicos en futuras aplicaciones.

Source: Own research with Promep data (2013)

Table 3.13-1 Academic Clusters working with nanomedicine in Mexico (2013)

Name of the Research Center	Sector	Key Researcher	Description of Research Area
CIAD (Centro de Investigación en Alimentación y Desarrollo)	T	Dra. Luz Vázquez Moreno Email: lvazquez@ciad.mx	Actividad biológica de estructuras oligosacáridas. Síntesis de neoglicanos para la prevención de infecciones. Nanotecnología aplicada a la producción de cápsulas bio-dirigidas contra patógenos de humano, cerdo y camarón.
CIATEJ (Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C.)	D	Dr. Rodolfo Hernández Gutierrez	Chip de proteínas para la detección oportuna del cáncer. Prototipo de un Chip basado en proteínas y nanopartículas de oro. Solicitud de patente para el Chip de Diagnóstico.
CIATEJ (Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C.)	T	Dr. Alejandro Arturo Canales Aguirre Email: acanales@ciatej.net.mx	Obtención de Moléculas Bioactivas para el tratamiento y/o prevención de enfermedades crónicodegenerativas. Utilización de líneas celulares en el desarrollo de medicamentos en la fase preclínica y en toxicología.
CIATEJ (Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C.)	T	Dra. Georgina Coral Sandoval Fabián Email: gsandoval@ciatej.net.mx	biocatalizadores para la síntesis de lípidos de alto valor agregado, fármacos enantiopuros y nanomateriales
CIQA (Centro de Investigación en Química Aplicada)	T	Dra.. Rebeca Betancourt Galindo Email: rgalindo@ciqa.mx	Tratamiento pata acelerar la cicatrización del pie diabético

Source: Own research, 2013

Table 3.13-2 CONACYT Research Centers working with nanomedicine in Mexico (2013)

Name of the Research Center	Sector	Key Researcher	Description of Research Area	Further info.

CNyN (Centro de Nanociencia y Nanotecnolog ia)	T	Dra. Nina Bogdanch ikova	Aplicación de nanoplata en medicina y en veterinaria	CNyN informe 2012
Instituto de Biotecnología (IBt)	T	Dr. Rafael Vazquez Duhalt	Material nanoestructura do con fines terapéuticos. Se trata de hacer eficiente la acción de los compuestos que se utilizan como fármacos anticancerígen os. La idea es que estas nanopartículas virales lleven actividad enzimática para que la quimioterapia sea mucho menos agresiva y más eficiente	http://noticias.universia.net.mx/en-portada/noticia/2012/01/03/902637/disena-unam-nanoesferas-aumentan-efectividad-quimioterapia.html
Instituto de Ciencias Físicas	O	Dr. Jorge A. Ascencio	Nanomateriale s aplicados a la medicina	Email: ascencio@fis.unam.mx

Source: Own Research 2013

Table 3.13-3 Researchers working with nanomedicine at UNAM (2013)

Name of the Research Center	Sector	Key Researcher	Description of Research Area
CIC	D	DC Martínez Rivas Adrián nanobiomex@hotmail.com	Elaboración de nanoarreglos para el diagnóstico de diabetes en la población mexicana
CICATA LEG	D	DC Rivera Montalvo Teodoro riveramt@hotmail.com	Dosimetría física y clínica en campos micro. Dosimetría de fantoma en radioterapia.
CICATA LEG	T	DC San Martín Martínez Eduardo esanmartin@ipn.mx	Nanotecnologia aplicada a fitofármacos y nano nutrientes CONACYT Registro = 000000000162997. Vigencia: Noviembre 2011 – Noviembre 2012. Monto: $

			5,532,314.00 M.N
CICATA LEG	B	DC Valverde Aguilar María Guadalupe valverdeag@gmail.com	Materiales nanoestructurados para catálisis y aplicaciones en medicina
ENCB	T	DC Burgueño Tapia Eleuterio eleuterio@woodward.encb.ipn.mx	Síntesis nano-orgánica y diseño de fármacos
ENCB	T	DC Delgado Reyes José Francisco fdelgado@woodward.encb.ipn.mx	Síntesis y diseño de fármacos
ENCB	D	DC García Pérez Blanca Estela abrilestela@hotmail.com	Nanopartículas y biosensores para aplicaciones en el diagnóstico y tratamiento de enfermedades infecciosas
ENCB	D	DC Ramón Gallegos Eva eramon68@hotmail.com	nanopartículas de oro para aumentar la eficiencia de la terapia fotodinámica y nuestra principal aportación es haber encontrado que las nanoparticulas aumentan la fluorescencia de la porfirina y podría utilizarse como método de diagnóstico del cáncer
ENCB	T	DC Reyes Arellano Alicia Romualda areyesarellano@yahoo.com.mx	Síntesis y diseño de fármacos Efficiency of thephotodynamic therapy using gold nanoparticles (np-Au) and PpIX induced andnot induced. Medical Physics
ESM	D	DC González Díaz César Antonio gonzalezantoni@hotmail.com	Es autor de cinco patentes internacionales y nacionales relacionadas con el desarrollo de tecnología innovadora para el monitoreo no invasivo del paciente en estado crítico y tratamiento de cáncer asistida con nanotecnología
ESM	T	DC Villanueva López Guadalupe Cleva villanuevacleva3@gmail.com	Farmacología clínica nanotecnología
UPIBI	T	DC Brito Arias Marco Augusto mbrito@ipn.mx	Síntesis y caracterización

			estructural de glicósidos y heterociclos de interés farmacológico
UPIITA	B	DC Douda Janna jannaduda@hotmail.com	nanomateriales para la industria farmacéutica

Source: Own Research 2013

Table 3.13-4 Researchers working with nanomedicine at the IPN (2013)

Researchers´name	Sector	Description of Research Area
Dr. Luis Marat Alvarez Salas lalvarez@cinvestav.mx	T	Aptámeros y aptazimas Nanotecnología. Cáncer cervical y papilomavirus (VPH).
Dr. Rodrigo Balam Muñoz Soto	T	Nanotubos de Carbonosobre el Endotelio Vascular
Dra. Alicia Cortés Hernández	T	Nanopolímero para eliminar células cancerígenas óseas en menos de 15 minutos con una efectividad de 90 por ciento en la destrucción de tumores
Dra. Andrea De Vizcaya Ruiz	D	Llevamos a cabo estudios de toxicidad de nanoparticulas de metales (con potencial uso en la industria de ahorro de energía, electrónica y medica) a través de estrategias que consideran como sus características fisicoquímicas tienen repercusión en la inducción de muerte celular, estrés oxidante, daño al ADN y señalización intracelular en modelos in vitro de órganos blanco, así como la exploración de la ADME y toxicidad en modelos experimentales in vivo, proporcionando un valor agregado para el uso seguro de estos materiales en la industria.

Source: Own Research, 2013

Table 3.13-5 Researchers at CINVESTAV working with nanomedicine (2013)

Ministry of Health (Secretaría de Salud)			
Institute/department	**Area/ Lab**	**Sector**	**Contact person**
Instituto Nacional de Neurología y Neurocirugía “Manuel Velasco Suárez”	Laboratorio de nanotecnología	T	Tessy López Tel: 5606 3822 ext. 5034 tessy3@prodigy.net.mx
Instituto Nacional de Cancerología	Departamento de Medicina Nuclear e Imagen Molecular	D	Rafael Morales Enrique Estrada eel_mex@yahoo.com Edgar Gómez
Instituto Mexicano del Seguro Social.	Laboratorio de Oncología Genómica. Unidad de Investigación Médica en Enfermedades Oncológicas	O	Mauricio Salcedo maosal89@yahoo.com

	Hospital de Oncología.		
Hospital Juárez de México	Área de Genómica. Unidad de Investigación Geomédica	O	
Ministry of Energy (Secretaría de Energía)			
Instituto Nacional de Investigaciones nucleares	Materiales radioactivos Química	O	Guillermina Ferro Flores guillermina.ferro@inin.gob.mx Blanca Elí Ocampo García, Enrique Morales Ávila, Clara Leticia Santos Cuevas, Andrei N. Mendoza Sánchez Flor de María Ramírez de la Cruz
		B	Guillermo Cruz

Source: own research based on Web page of the institute and manual research on the investigators. http://portal.salud.gob.mx/contenidos/institutos/institutos.html; http://www.inin.gob.mx/

Table 3.13-6 Researchers at Governmental Ministries working with nanomedicine

Name of the researcher	Institution	Sector	Description of research area	Source
Dra. Bertha Jimenez Delgadillo	Universidad Autónoma de Yucatán	O		http://www.conacyt.gob.mx/FondosyApoyos/Sectoriales/InvestigacionBasicaAplicada/SSA/Documents/FOSISS_RESULTADOS_PERTINENCIA_2013.pdf
Dr.Jaime Ruíz García	UASLP	T	Terapias en nanomedicina usando cepas virales	http://www.conacyt.gob.mx/FondosyApoyos/Sectoriales/InvestigacionBasicaAplicada/SSA/Documents/FOSISS_RESULTADOS_PERTINENCIA_2013.pdf Email:jaime@ifisica.uaslp.mx
Dr. Francisco Rodriguez Felix	UNISON	T	Liberación prolongada de fármacos a partir de nanoesferasde almidón entrecruzadopara tratar diabetes tipo II	http://www.conacyt.gob.mx/FondosyApoyos/Sectoriales/InvestigacionBasicaAplicada/SSA/Documents/FOSISS_RESULTADOS_PERTINENCIA_2013.pdf
Dr. José de jesus Olivares Trejo	Universidad Autónoma de la Ciudad de México	T	Uso de nanoparticulas para el tratamiento de infecciones causadas por Streptococcus Pneumoniae	http://www.conacyt.gob.mx/FondosyApoyos/Sectoriales/InvestigacionBasicaAplicada/SSA/201201/Resultados_Definitivos_2012.pdf
Dra. Maria Elisa Barbosa	Universidad de Sonora	T	Nanomaterials of interest for the pharmaceutical industry (cancer treatment)	Google: CV Maria Elisa Barbosa

Dr. Domingo Ixcóatl García Gutiérrez (Lider CA) Dr. René Fabian Cienfuegos Pelaez	Universidad Autonoma de Nuevo León	O	Nanostructures for the electronic, medical and biological sector PhD in Material Science at Texas-A (2006) Thesis Research focused on Nanomaterials	domingo.garciagt@uanl.edu.mx https://www.google.com.mx/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDMQFjAB&url=http%3A%2F%2Fwww.ciidit.uanl.mx%2Fcurriculum_investigadores%2Fdomingo_garcia_gutierrez.pdf&ei=z759UpeQBIWlyAHj8oCABQ&usg=AFQjCNEfN3LFHylqPOa-mYakB6M6xdCQKw&sig2=axGtWjbkEJPWmsMHvHqJMw

Source: Own Research 2013

Table 3.13-7 Researchers working with nanomedicine in Mexico (2013)

Name of the fund	Time period	Total approved	Nanotechnology projects	Nano medicine
FORDECyT	2009-2012	71	1	0
CIAM*	2004-2012	39	19	2
FIC Equipment support	2009-2012	218	16	2
FIC –Infrastructure for GMOs	2011	10	0	0
FIC. Equip. for Research Groups	-------	0	0	0
Basic Research SEP-Conacyt	2004-2012	5381	340	33
Complementary support for SNI I	2006-2011	1617	61	2
CIBIOGEM	2005-2013	40	0	0
IDEA	Discontinuated	0	0	0
FOMIX	2004-2010	356	45	1
SECTORIAL FUNDS				
ASA-CONACYT	2005-2012	37	0	0
CONAGUA-CONACYT**	2006-2012	41	2	0
INIFED-CONACYT	2012	1	0	0
CONAFOR-CONACYT***	2005-2012	69	2	0
CONAVI-CONACYT	2007-2011	43	1	0
INMUJERES-CONACYT	2008-2012	38	1	0
SAGARPA-CONACYT	2005-2012	80	0	0
SSA/IMSS/ISSSTE-CONACYT	2005-2012	1113	8	8
SE-CONACYT	2007-2012	586	11	0
SEGOB-CONACYT	-------	0	0	0
SEMAR-CONACYT	2005-2013	11	0	0
SEMARNAT-CONACYT	2006-2008	106	0	0
SENER-CONACYT	----	0	0	0
SENER-HIDROCARBUROS-CONACYT****	2009-2012	118	1	0
RELACIONES EXTERIORES-CONACYT	2006-2012	38	3	2
SECTUR-CONACYT	2010-2012	13	0	0

INEGI-CONACYT	2011-2012	10	0	0
TOTAL		10 036	511	50

*one in nanomedicine by manual revision (viral)
** two in water by manual revision (membranes)
***one in water by manual revision (new bio-absorbent material)
**** one in nanotechnology by manual revision (anti-corrosion)
Note: Only 1 fund made calls explicitly for nanotechnology: FOMIX (Chihuahua 1; Morelos 1; Querétaro 1; Tamaulipas 3; Nuevo León 6)
Search terms in titles: nano+ medicine, vaccine, solar, water.
Only 1 fund made calls explicitly for nanotechnology: FOMIX (Chihuahua 1; Morelos 1; Querétaro 1; Tamaulipas 3; Nuevo León 6)

Abbreviations/Acronyms

FORDECyT	Fondo Institucional de Fomento Regional para el Desarrollo Científico, Tecnológico y de Innovación.
CIAM	Fondo Institucional Ciencia. Convocatorias Convenios de Cooperación Proyecto Colaboración Interamericana en Materiales.
FIC-Equipo	Fondo Institucional Ciencia. Apoyo complementario para actualización de equipo científico.
FIC-OGM	Fondo Institucional Ciencia. Apoyos para infraestructura para confinamiento de organismos genéticamente modificados
FIC-CA y GI	Fondo Institucional Ciencia. Apoyos para cuerpos académicos y grupos de investigación.
SEP-Conacyt	Convocatoria de investigación básica SEP-Conacyt
FIC-SNI1	Fondo Institucional Ciencia. Complementario a Investigadores en proceso de consolidación SN1
CIBIOGEM	Fondo para el fomento y apoyo de la investigación científica y tecnológica en bioseguridad y en biotecnología.
IDEA	Incorporación de científicos y tecnólogos mexicanos en el sector social y productivo del país. (Descontinuado)
FOMIX	Fondos Mixtos Conacyt-Gobiernos de Estado
ASA-Conacyt	Investigación para el desarrollo aeroportuario y la navegación Aérea
CONAGUA-Conacyt	Investigación y desarrollo sobre el agua
INIFED-Conacyt	Infraestructura Educativa
CONAFOR-CONACYT	Investigación, desarrollo e innovación tecnológica forestal
CONAVI-CONACYT	Desarrollo Científico y Tecnológico para el Fomento de la Producción y Financiamiento de la Vivienda y el Crecimiento del Sector Habitacional.
INMUJERES-CONACYT	Investigación y Desarrollo
SAGARPA-CONACYT	Investigacion en materias agrícola, pecuaria, acuacultura, agrobiotecnología y recursos fitogenéticos
SSA/IMSS/ISSSTE-Conacyt	Investigación en Salud y Seguridad Social
SE-CONACYT	Innovación tecnológica. Secretaría de Economía-Conacyt
SEGOB-CONACYT	Investigación y Desarrollo. Secretaría de Gobernación-Conacyt
SEMAR-CONACYT	Investigación y Desarrollo en Ciencias Navales
SEMARNAT-CONACYT	Investigación ambiental
SENER-CONACYT SENER-	Sustentabilidad Energética. Secretaría de Energía. Hidrocarburos. Secretaría de Energía

HIDROCARBUROS-CONACYT	
SER-CONACYT	Secretaría de Relaciones Exteriores-Conacyt
SECTUR-CONACYT	Secretaría de Turismo. Conacyt.
INEGI-CONACYT	Instituto Nacional de Geografía y Estadística-Conacyt

Table 3.13-8 Main Federal Call for Project sources and approved projects in nanotechnology by sector. México 2004-2012

4 Energy sector

Nano-energy is understood as the study and application of nanotechnology in the energy sector. This is a new and very broad field, as much from the theoretical point of view as the practical. Theoretically, because so many disciplines address the topic: among them chemistry, electronics, mechanics, technology, etc. This wide dispersion makes it difficult to systematize information regarding research, because it appears across very diverse faculties or research centers. Practically, because the value chain of energy has many branches, and also, there are applications that are not directly linked but are nonetheless significant that affect energy supplies, such as types of glass that maintain interior temperatures, or catalyzers that have a variety of distinctive applications.

Within the field of nanotechnologies, nano-energy is one of the fastest-growing. In a bibliometric study, Menéndez-Majón and collaborators showed that while scientific articles on nanotechnology tended to stabilize in the latter years of the first decade in this century, those relating to nano-energy continued to grow (Menéndez-Majón, et al, 2011). Perhaps one of the reasons for nano-energy's great growth is due to the global concern that natural energy resources may be running out and the search for clean and renewable alternatives. And, although it is debatable if new energy sources could displace existing ones in the medium term, the desire to find better storage alternatives is key for the concentration of energy and its distributions to various destinations. It is the latter reason that lends urgency to research in nano-energy in the early stages of the value chain.

A basic sketch of the value chain of nano-energies shows the following stages (Mendéndez-Majón, et al., 2011): **Harvesting** (fuels, solar, wind, nuclear) =>**Conversion** (photovoltaic, fuel cells, combustion turbines. =>**Storage** (batteries, supercondensors) =>**Distribution** (high temperature superconductors, optimal high voltage alternating current transmission) =>**Usage** (thermal isolation, efficient illumination….). Each of these steps is related, in terms of scientific research, to different materials and/or processes, and may be situated within institutions with varied science and technology emphases.

Regarding our research on nano-energy in Latin America, bibliometric research and a manual effort were carried out simultaneously by country and research center / institute. Information is provided for Latin America as a whole, as well as for the following individual countries: Argentina, Brazil, Colombia, Chile, Mexico, and Uruguay.

A thorough study on publications in energy related nanotechnology research has been conducted. Two approaches to cover the research output of interest and the most important actors involved were applied: While ReLANS consulted the Thomson Reuters' Web of Science database, ZSI retrieved its underlying data set from both major available sources (Elsevier's Scopus and Web of Science) and unified the data. Whereas ZSI was focusing on European-Latin American co-publications, the approach used by ReLANS enables to analyse Latin American publications and their networks in some more detail. As recommended, bibliometric quantitative data was enriched by qualitative desktop research.

The manual research effort examined the websites of each of the key universities and/or research centers in the selected countries. Where there existed a more reliable database it was reviewed, as in the case of Brazil, which permitted a search of the research groups via the webpage of the CNPq, or in Colombia with Colciencias, or partial databases such as Mexico's PROMEP. Furthermore, the study incorporates secondary information from various bibliographic sources that were identified from a reading of articles from various countries, and from the authors' personal knowledge of research networks in each country and in the region as a whole. The methodology is explained in each case.

In the manual research efforts, once articles or research groups in nanotechnology were identified, the second stage consisted of identifying those that worked in the area of nano-energy. To that end, a list of categories was created, drawn from readings of key texts in nano-energy. The following table summarizes those categories:

English	Español
Solar	Solar
Wind power	Eólica
Fossil Fuel	Combustible fósil
Biofuel	Biocombustible
Hydrogen	Hidrógeno
Electric: Lighting	Eléctrica: iluminación
Batteries	Baterías

4.0 1 Nano-energy search categories (English and Spanish)

4.1 Bibliometric Analysis: Web of Science

As has proven to be beneficial in the course of the previous study on health-releated research in the field of nanotechnology, again a dual approach of measuring bibliometric output and identifying important research clusters in the area of nanotechnology dealing with energy-related issues within the last ten years (2003-2012) was done.

The first approach focused on publications authored by at least one researcher affiliated in a Latin American or Caribbean country. Based on data from Thomson Reuters' *Web of Science*, the data was analysed for the development of different topical strands, inner-regional and international strands in scientific collaboration networks, highly productive authors and the importance of different research fields along the Web of Science Categories.

The second approach reduced itself to international co-publications that were co-authored by at least one author from Latin America or the Caribbean and another author from a European country, associated to the Seventh Framework Programme of the European Union. Yet the data sources were enriched by records from Elsevier's *Scopus* database and unfied with the records of the *Web of Science* database. This procedure allows to even out errors from that databases' side and typically broadens the data set for a plus of around 20% of the records, due to the different covering strategies of the sources. The consolidated set was analysed for the publication strength of the regions and countries on each side of the Atlantic, the development of the collaboration over time, the importance of the different *Science Metrix* Sub-Fields, the importance of author key-words and the most productive institutions and individual authors, also recognizing their geographical mobility over time.At the end a summary is provided, comparing the two approaches.

In this part of the report, we provide the results of an analysis of scientific articles published in the field of nanotechnology and the energy sector that were produced by researchers who are members of academic and research bodies located in Latin America and the Caribbean and were tracked in the Web of Science reference database. We focus on bibliometric and scientometric indicators that give us a broad view of the development of these technologies in Latin American and Caribbean countries. Before we address the results of the study, it is necessary to outline some methodological points regarding the tools employed in this research effort.

4.1.1 Methodology

The results shown in this report have been obtained from a review of the Web of Science (WoS) databases, particularly: the Science Citation Index, the Social Science Citation Index, and the Arts & Humanities Science Citation Index. The search for bibliometric data in the nanotechnology field (energy sector) employed a search strategy containing five search equations composed of keywords representative of various areas in the energy sector, such as photovoltaic energy, wind energy, fossil fuels, hydrogen applications, and energy transport and storage. The following table shows the words utilized in each of the queries:

Topic	Keywords
Energy storage	((nano* and (energ* or power)) and ("battery" or "batteries" or "fuel cell" or "energy storage"))
Energy transport	((nano* and (energ* or power)) and ("condenser*" or capacitor or "wire*" or "lighting"))
Fossil fuels	((nano* and (energ* or power)) and (fuel* or petroleum or "gas" or (catalys* and petroleum) or (catalys* and natural gas) or (catalys* and "shale gas") or (catalys* and oil) and (catalys* and "shale oil")))
Wind energy	((nano* and ("wind power" or "energ* eolic")) or (nano* and (("wind" or "eolic") and ("light material*"))))
Photovoltaic energy	(nano* and ("solar cell*" or "photovoltaic" or "solar energ*" or "solar power"))

Table 4.1-1 Topicsand keywords used in the database search on nanotechnology in the energy sector

To identify the scientific publications produced in the countries of Latin America and the Caribbean, the search of the data utilized a list of CELAC countries (Table 3.11-2) in the country field of the WoS search engine. This study covers a period up to the year 2012, with the WoS consultation revealing a total of 816 scientific articles.

The bibliometric data was accessed with the help of the informatics tool *Acces*. The tables and graphics were created with *Excel* and the maps and network diagrams were made in *MapPoint, Pajek* and *VOSviewer*.

4.1.2 The emergence and development of nanotechnology in the energy sector in Latin America and the Caribbean

The five areas that we identify in this study within the field of nanotechnology and the energy sector and the articles discovered in the databases are shown in

Table 4.1-2. In the results we see that the area of photovoltaic energy has seen the most development in Latin America and the Caribbean, with a total of 306 published articles identified, the equivalent of 26.33% of the total articles in the field of nanotechnology in the energy sector. The next two areas of greatest development are in fossil fuels with 268 articles and energy storage with 140. The forth area is energy transportation with 139 scientific articles. In the area of wind energy, which we had thought to be one of the more widely promoted renewable energy sources, particularly in Mexico, there have been no articles published in the region.

Areas	Published Articles	% of 816
Photovoltaic energy	306	26.33
Fossil fuels	268	23.06
Energy storage	140	12.05
Energy transportation	139	11.96
Wind energy	0	00.00

Table 4.1-2 Frequency of published articles on nanotechnology in the different energy sectors in Latin America and the Caribbean

The evolution of the production of new knowledge in the five areas we have highlighted in nanotechnology and the energy sector were reviewing with the goal of evaluating its development over time. The first articles identified in this study were published in 1994, within the area that we identify as Energy Transportation.

Figure 4.1-1 shows the evolution of the articles published across four areas of nanotechnology in the energy sector for the period 2000-2012. These results show that the development of this emerging field presents significant variations among the different areas that we have identified in this study. Of the four areas, that of photovoltaic energy has presented the most consistent growth over the past four years. In fact, as we see in the graphic, until 2007 this area experienced small decreases before registering a strong increase.

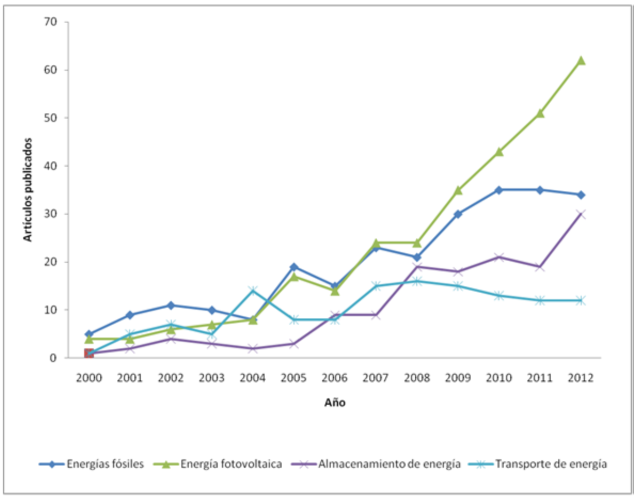

Figure 4.1-1 Evolution of publications in a variety of areas within the nanotechnology field and the energy sector in Latin America and the Caribbean for the period 2000-2012

The four areas in the field of nanotechnology applications for energy show increases that reflect their emergency. Although the four cases show several decrease and increase periods over the years; Transportation of energy has shown a sustained decrese in scientific production in the Latin America and the Caribbean region since 2008.

In reviewing the production of articles by country, we see that a total of 13 countries in the region of Latin America and the Caribbean have produced at least one article.Table 4.1-3shows the list of countries and the frequency of articles published via co-authoring with some other country in Latin America and the Caribbean. The results show a strong concentration of production of new knowledge inBrazil, with a total of 635 articles, or 77.82% of the total.[18] Mexico is second, with a total of 430 articles (52.70% of the total). Third is Argentina, where a total of 170 articles were produced (20.83% of the total). The remaining countries of Latin America and the Caribbean present on the list are: Chile (11.27%), Colombia (7.48%), and the rest of the countries in the region have produced less than 5%. Complementing the analysis,Figure 4.1-2shows a map of the Latin American and Caribbean region in which the geographic distribution of the production of scientific articles identified in this study can be seen.

With regard to the countries that have collaborated with Latin America and the Caribbean, the same table shows that the key scientific collaborator with the region in the field of nanotechnology and the energy sector is the United States, with which some 20.83% of the total articles were published. Next in line are collaborations with European countries such as Spain (12.87%), Germany (6.99%), France (5.27%) and Italy (4.90%).

[18] As many articles are coauthored with more than one country registered, the relative total does not sums 100.

País	Artículos	% de 816
Brazil	**635**	**77.82%**
Mexico	**430**	**52.70%**
USA	170	20.83%
Argentina	**170**	**20.83%**
Spain	105	12.87%
Chile	**92**	**11.27%**
Colombia	**61**	**7.48%**
Germany	57	6.99%
France	43	5.27%
Italy	40	4.90%
England	36	4.41%
Cuba	**34**	**4.17%**
Uruguay	**27**	**3.31%**
Venezuela	**22**	**2.70%**
Japan	19	2.33%
Portugal	17	2.08%
Canada	15	1.84%
Sweden	12	1.47%
Ireland	9	1.10%
Belgium	7	0.86%
Netherlands	7	0.86%
China	6	0.74%
India	6	0.74%
Switzerland	6	0.74%
Peru	**5**	**0.61%**
South Africa	5	0.61%
Taiwan	5	0.61%

País	Artículos	% de 816
South Korea	4	0.49%
Costa Rica	**4**	**0.49%**
Ukraine	3	0.37%
Austria	3	0.37%
Barbados	**3**	**0.37%**
Yugoslavia	2	0.25%
North Ireland	2	0.25%
Algeria	2	0.25%
Bulgaria	2	0.25%
Scotland	2	0.25%
Byelarus	1	0.12%
Turkey	1	0.12%
Australia	1	0.12%
Bolivia	**1**	**0.12%**
Trinid & Tobago	**1**	**0.12%**
Croatia	1	0.12%
Syria	1	0.12%
Malaysia	1	0.12%
Denmark	1	0.12%
Slovakia	1	0.12%
Finland	1	0.12%
Sri Lanka	1	0.12%
Monaco	1	0.12%
Poland	1	0.12%
Russia	1	0.12%
Czech Republic	1	0.12%

Table 4.1-3. Countries and the frequency of published articles in the field of nanotechnology and the energy sector in Latin America and the Caribbean to 2012

Figure 4.1-2: Geographic distribution of scientific activities in the field of nano-technology and the energy sector in Latin America and the Caribbean to 2012

The frequency of collaborations at the institutional level is shown inTable 4.1-4. The list in this table shows institutions where more than 20 articles have been produced. This corresponds to a concentration of scientific activity in the field of nanotechnology and the energy sector in few universities in Latin America and the Caribbean. Effectively, the Universidad de Sao Paulo and the Universidad National Autónoma de Mexico are those that top the list with 16.79% and 12.13% of the total, respectively. The universities and research institutions from Brazil and Mexico top this list, distantly followed by those of Argentina. Also notable is University of Habana, Cuba.

Institución	País	Artículos	% de 816
Univ Sao Paulo	Brazil	137	16.79%
Univ Nacl Autonoma Mexico	Mexico	99	12.13%
Univ Estadual Campinas	Brazil	81	9.93%
Ctr Invest & Estud Avanzados	Mexico	64	7.84%
Univ Estadual Paulista	Brazil	31	3.80%
Comissao Nacl Energia Nucl	Brazil	31	3.80%
Univ Fed Sao Carlos	Brazil	29	3.55%
Inst Politecn Nacl	Mexico	29	3.55%
Univ Fed Rio Grande do Sul	Brazil	28	3.43%
Univ Autonoma Nuevo Leon	Mexico	27	3.31%
Univ Fed ABC	Brazil	27	3.31%
Univ Habana	Cuba	26	3.19%
Comis Nacl Energia Atom	Argentina	22	2.70%
Univ Fed Parana	Brazil	21	2.57%
Ctr Invest Mat Avanzados SC	Mexico	21	2.57%
Univ Nacl Cordoba	Argentina	20	2.45%
Univ Fed Minas Gerais	Brazil	20	2.45%
Univ Autonoma San Luis Potosi	Mexico	20	2.45%

Table 4.1-4 Institutions with more than 20 articles published in the field of nanotechnology and the energy sector in Latin America and the Caribbean to 2012

4.1.3 Scientific collaboration networks in nanotechnology and the energy sector in Latin America and the Caribbean

Scientific collaborations are interesting subjects for this kind of study. In the following three Figures, scientific collaborations are shown between the co-authors of articles identified within the field of nanotechnology and the energy sector in Latin America and the Caribbean. The nodes represent various countries, the lines are the scientific collaboration relationships and the thickness of the lines indicates the frequency of co-authorships. The first collaboration network covers the co-authors among countries in the Latin American and Caribbean region (Figure 4.1-3), where the strongest collaborations are between Brazil and Argentina, Chile and Mexico and will less presence between Mexico and Argentina. These relationships that are highlighted call attention to the correlation of geographic distance and scientific collaborations. As well, one can see in this network map that five countries of the region have not developed new knowledge in this field under study in collaboration with any other country in the region.

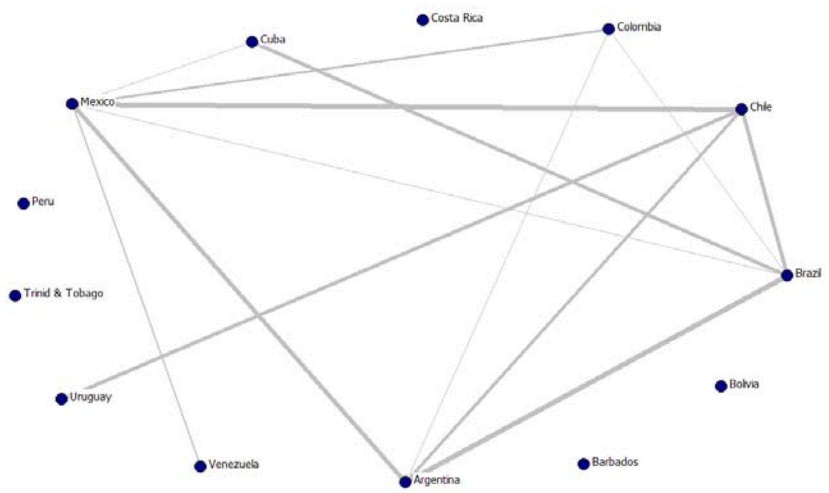

Figure 4.1-3: Networks of scientific collaboration in the field of nanotechnology and the energy sector in Latin America and the Caribbean to 2012

With regard to the collaboration network with European Community countries, Figure 4.1-4 shows the networks developed from an analysis of co-authored articles. The network configuration of these collaborations shows that Spain, Germany, England and France are the European countries that have maintained significant collaborations with Latin America and the Caribbean in the field of nanotechnology and the energy sector. The standout scientific collaboration networks exist between Spain and Mexico and Cuba, and to a lesser extent wit Argentina, Brazil, Chile and Colombia, as well as collaborations between France and Germany with Brazil. England has maintained strong relationships with Brazil, as Figure 4.1-4 shows. The two countries within the Latin America and the Caribbean region that have not collaborated with Europe in this emerging field are Trinidad and Tobago, and Barbados.

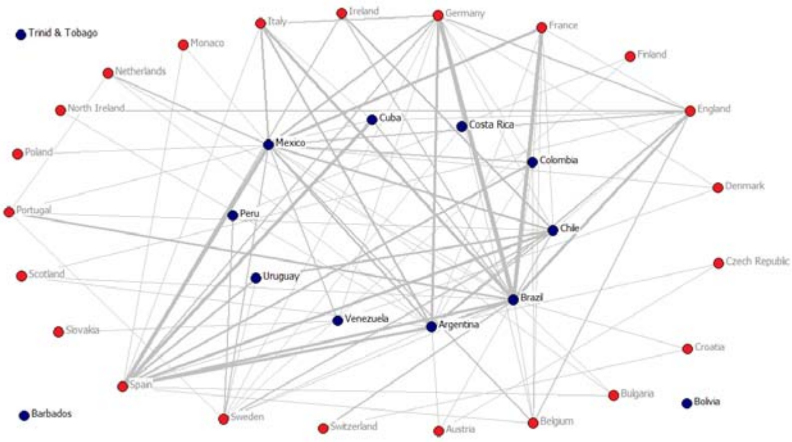

Figure 4.1-4: Scientific collaboration networks in the field of nanotechnology and the energy sector in the Latin America and Caribbean region with Europe to 2012

The final scientific collaboration network that we have mapped in this study at the country level are those that countries of the Latin America and Caribbean region have maintained with countries outside of the European Community. These networks are shown in Figure 4.1-5. The results confirm the position occupied by the United States within scientific collaborations in this field of nanotechnologies, as evidenced by the scientific relationships it has maintained through the co-authorship of articles with the key countries in Latin America and the Caribbean: Mexico, Brazil and Argentina. In this image we also highlight the scientific relationships between Canada and Brazil and Argentina, as well as the relationships between Japan and Brazil. Three countries in the region that we have studied and that have only collaborated with European countries are Peru and Costa Rica. Barbados, for its part, has undertaken no collaborations with any country – that is to say, its articles have been produced without collaboration.

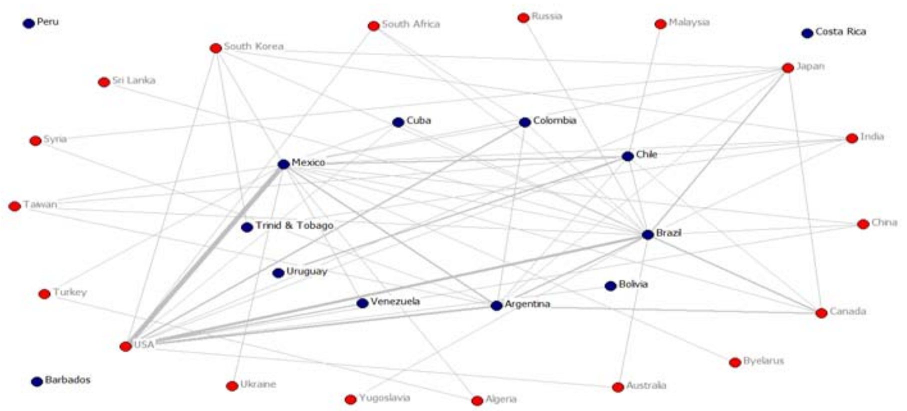

Figure 4.1-5 Scientific collaboration networks in the field of nanotechnology and the energy sector in the Latin America and Caribbean region minus Europe to 2012

4.1.4 Key scientists in the development of the nanotechnology field and the energy sector in Latin America and the Caribbean

In this section we concentrate on identifying the key scientific authors of articles in each of the four areas of the nanotechnology field and the energy sector in Latin America and the Caribbean. The goal in this section is to identify the most productive authors in each of the areas, given the premise that the scientists with greater production are leaders in their collaboration groups. In the following tables we present the lists of researchers with greatest production of articles in each of the areas under study. It is worth noting for the reader that the authorship of the articles have not been standardized, since to undertake this task represents considerable work and time does not permit the pursuit of an exhaustive effort in this study.

Autores	Artículos	Institución	País
Fazzio, A	9	Univ Sao Paulo	Brazil
da Silva, AJR	8	Univ Sao Paulo	Brazil
Miwa, RH	7	Univ Fed Uberlandia	Brazil
Riccardo, JL	7	Univ Nacl San Luis	Argentina
Ramirez-Pastor, AJ	6	Univ Nacl San Luis	Argentina
Terrones, H	6	Oak Ridge Natl Lab / IPICYT	USA / Mexico
Terrones, M	6	Penn State Univ / IPICYT	USA / Mexico
Guirado-Lopez, RA	5	Univ Autonoma San Luis Potosi	Mexico
Mejia-Rosales, S	5	Univ Autonoma Nuevo Leon	Mexico
Moller, T	5	Tech Univ Berlin	Alemania
Perez-Tijerina, E	5	Univ Autonoma Nuevo Leon	Mexico

Table 4.1-5 Researchers who have published at least 10 articles in the area of fossil fuels in Latin America and the Caribbean to 2012

Autores	Artículos	Institución	País
Nogueira, AF	34	Univ Estadual Campinas	Brazil
Iha, NYM	20	Univ Sao Paulo	Brazil
De Paoli, MA	14	Univ Estadual Campinas	Brazil
Dalchiele, EA	14	Univ de la Republica	Uruguay
Oskam, G	13	Ctr Invest & Estudios Avanzados	Mexico
Marotti, RE	11	Univ de la Republica	Uruguay
Otero, L	10	Univ Nacl Rio Cuarto	Argentina

Table 4.1-6 Researchers who have published at least 10 articles in the area of photovoltaic energy in Latin America and the Caribbean to 2012

Authors	Articles	Institution	Country
Linardi, M	21	Comissao Nacl Energia Nucl	Brazil
Spinace, EV	17	Comissao Nacl Energia Nucl	Brazil
Neto, AO	16	Comissao Nacl Energia Nucl	Brazil
Solorza-Feria, O	13	Ctr Invest & Estudios Avanzados	Mexico
Arriaga, LG	11	Ctr Invest & Desarrollo Tecnol Electroquim SC	Mexico
Kokoh, KB	9	Univ Poitiers	France
Carmo, M	7	Inst Pesquisas Tecnol Estado Sao Paulo SA / Yale Univ	Brazil / USA
De Andrade, AR	7	Univ Sao Paulo	Brazil
Gonzalez, ER	7	Univ Sao Paulo	Brazil
Santos, MC	7	Univ Fed ABC	Brazil
Godinez, LA	6	Ctr Invest & Desarrollo Tecnol Electroquim SC	Mexico

Table 4.1-7 Researchers who have published at least 10 articles in the area of energy storage energy in Latin America and the Caribbean to 2012

Authors	Articles	Institution	Country
Fazzio, A	14	Univ Sao Paulo	Brazil
Farias, GA	9	Univ Fed Ceara	Brazil
Cotta, MA	7	Univ Estadual Campinas	Brazil
da Silva, AJR	7	Univ Sao Paulo	Brazil
Mikhailov, ID	6	Univ Ind Santander	Colombia

Table 4.1-8 Researchers who have published at least 10 articles in the area of energy transport in Latin America and the Caribbean to 2012

4.1.5 Research profile of the nanotechnology field and the energy sector in Latin America and the Caribbean

The scientific profile in the area is another point of interest, which provides an idea of how nanotechnology science is structured in the energy sector, as well as showing the collaboration between scientific networks. One of the ways to analyze science development is by looking at the disciplines that converge in the emerging fields of science and technology. On this point, we performed a category analysis in which the articles identified through the Web of Science were indexed. This involved a total of 279 categories of specialized disciplines in scientific publications (scientific journals) where the articles and other scientific documents have been published. In the Web of Science databases, the journals can be indexed by at least one category and the articles published in the journals are then classified in one or more categories. The analysis that we performed applies the method of identifying similarities with the support of the *Pajek* and *VOSviewe*r programs (Waltman & Van Ech, 2012), which is based on an analysis of social networks and the integration of similarities applied to the categories. The result of this analysis is a visualization of the structure of scientific knowledge in disciplinary terms. These analyses can be interpreted as a reflection of the profile of scientific knowledge.

The articles identified within the field of nanotechnology and the energy sector in Latin America and the Caribbean have been indexed in 51 categorical disciplines in the Web of Science.Figure 4.1-6 shows the result of this analysis, which gives us a total of 15 combinations. In the resulting figure we see that the key disciplines according to the size of the node that is determined from the frequency of the disciplines are Materials Sciences, Physicochemical, Applied Physics and Nanosciences and Nanotechnology.

Other disciplines stand out to a lesser degree, such as Multidisciplinary Chemistry, Electrochemistry, Energy and Fuels, among others.

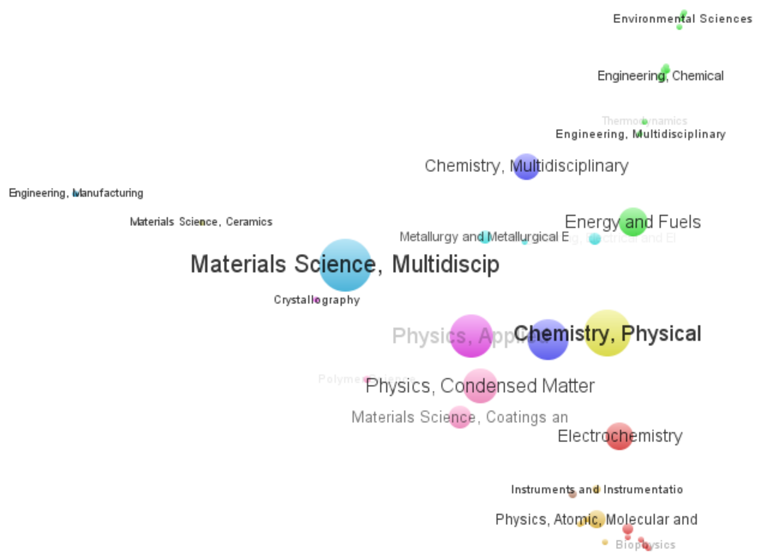

Figure 4.1-6 Profile of the nanotechnology field in the energy sector in the Latin America and Caribbean region in terms of disciplines of knowledge (WoS Categories) to 2012

4.2 Co-publication Analysis between Europe and Latin America + Caribbean: Scopus & Web of Science

The following is a co-publication analysis that has been conducted by ZSI and whichcovers co-publication activity between Latin American and Caribbean countries[19] and the countries within the European Research Area[20]in the thematic fields of nanotechnologies and energy. It identifies the quantity of publications in and co-publications between these regions. It also provides key institutions and individual researchers that are involved in EU-LA nano-research topics with focus on energy. Our methodology combines the two most common scientific citation databases: Elsevier's Scopus and Thomson Reuteurs' Web of Science. Data was retrieved in October 2013 and covers co-publications from 2003 to 2012.

The data gathered was analysed according to the following dimensions:

- total numbers of co-publication output in nano-technology
- total numbers for the specific area in focus(energy) and their comparison with overall co-publication output per country
- the development of co-publications in the two thematic focus areas over time

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[19] For the list of countries included to this study please see 4.12.3. The list of CELAC countries was decided in accordance with the task leader. The list of ERA countries includes all EU members, associate and candidate countries.
[20] As associated to the 7^{th} Framework Programme of the European Union

- important thematic fields according to the Science-Metrix Ontology of Science
- analysis of author keywords
- cities that are important in terms of their co-publication output in the analysed research areas
- relevant institutions (operationalised as the top 40 "affiliations" =Institution-author relations according to Scopus)
- *relevant authors*and the most important links of *authors and affiliation cities*, where data was available

This report is structured as follows: At first we commit ourselves to a brief description of the methodological framework used for the present study in terms of data retrieval and analysis. The subsequent and core chapter shows the analysis results regarding the different dimensions. This is followed by data visualisation to understand developments in keyword usage. Finally, we offer an outlook and attach further details on definitions, queries and keyword-lists in 4.12.2.

4.2.1 Methodology

4.2.1.1 Data sources

This bibliometric analysis covers co-publications of the region Latin America with the region Europe (countries in and associated with ERA) as well as publications in each geographic region in the area of nanotechnologies (keyword based). The data analysed in this study has been sourced from the two best known and most comprehensive multi-disciplinary academic citation data bases:

- Elsevier's Scopus and
- Thomson Reuter's Web of Science (WoS).

Data has been retrieved in autumn 2013 for the time period 2003 to 2012. Data of all document types were retrieved, but restricted for the impact analysis to citable material published in scientific journals or conference proceedings (no letters, articles in press,…). As a result of the data retrieval we obtained a series of database extracts (in different batch sizes) in BibTeX format with partly different field names and different quality (depending on the data source). A bundle of software tools and algorithms was especially developed to assure (1) that the formats of the data allow unification and (2) the increase of quality of metadata of publications tracked in both sources. The steps involved are described in detail in the next section. The results of these processes at first are database-specific tables, into which parsed BibTeX data are inserted. The four resulting tables containing records and affiliations for Scopus and WoS separately are then unified into one record table and one affiliation table.

4.2.1.2 Data cleaning and consolidation of data sources

On the basis of raw data tables retrieved from Scopus and WoS in BibTeX format, a unified data set was created using a series of processing steps in our SQL database and with a specifically developed web interface for a multi-stage data cleaning process (e.g. duplicate detection, raw data correction, journal classification - if they are not already classified by Science Metrix,…) including both, automatic and manual steps.

Import of raw data

After importing the data-chunks in our data base, they are imported in a SQL-database (PostgreSQL) with specifically adjusted Parsers. At first the BibTEX-data are imported in a raw data table as key-value-pairs, where every record has an Import-ID, a specific Import-Date (which is important e.g. for analysing Impact and citation counts), information of data source (Scopus or WoS), an identifier, the key-value-pairs and a marker, if data is manually corrected or not. Simultaneously the key characteristics (normed fields as DOI, author, title, journal, year, volume, number, pages, document type) are written in a separate table for the search of duplicates.

Duplicate Detection

The identification of records from both sources describing the same publication is led through by searching for conformities in the following variables: DOI, title, year, begin page, ISBN and begin page, journal ID or ISSN and begin page, year and author. With a specific algorithm, adapted to the sometimes poor data quality, those duplicates can be identified and unified automatically. In the Web Interface those automatically identified records, which may be duplicates but are still doubtful, are manually revised.

Raw data correction

After the automatically check of raw data - conducted with regular expressions (e.g. invalid values for DOI, space between characters and in fields) -, possible raw data errors have to be corrected manually as well. Because this study does not analyse affiliation of authors, these raw data errors could be ignored. All other fields as year, volume, DOI, ISSN, etc. were corrected entirely and every manual correction was registered in our database.

Classification

The record table contains a column with Journal_ID, which refers to another table with journals. In this journal table all journal names contained in WoS records are imported from Science-Metrix -ontology, that classification, which we use for disjunct attribution of one journal to one category. As a next step all Journal-names, which are only covered by Scopus, are added and if necessary, classified manually. Additionally there are always some Journals not classified in Science Metrix which also have to be assigned to a Science-Metrix sub-field. After the manual classification of all unclassified journals every journal has a distinct classification. For this study, we had to classify more than 4 000 unclassified Journals.

Data Unification

The corrected data sets are distributed across different tables: authors, affiliations, normed and full data sets. On the basis of the normed data sets and with a complex matching-algorithm data sets from Scopus are identified with those from Web of Science and therefore unified. Following steps are necessary for data unification of both data sources:

- In a first step journal names are unified. Many records appear in Scopus and WoS, but with different spelling, institution or author notation, etc. After normalising syntax and spelling of journal names detected as identical (e.g. with differing capitalization) in a second step all records are unified using a matching-algorithm between normalized author names.
- To identify identical records we use Document Object Identifiers (DOI) of all records in our database. Those DOIs are unique (disregarding typos in the original databases, whose rate of occurrence lies at roughly 1%) for any registered publication worldwide (but unfortunately often are missing).
- If DOIs are missing or wrong they are unified with combination of better available data (e.g. address from Web of Science, author list from Scopus) using different complex algorithms to search for counterparts through ISBN, author names, title, year, pages, etc.
- Ambiguous cases are reworked manually.

For the data unification the corrected data sets are distributed across different tables: authors, affiliations, normed and full data sets. Merging the two data sources in our experience typically leads to an enlargement of data stock by around 20%.

After these data cleaning steps it can be shown which benefits the consultation of both data sources can offer for the present analysis: Scopus listed 133 214 records for co-publication involving at least one author affiliated in CELAC and one affiliated in ERA in the period of 2003 to 2012, WoS 104 759. After the unification process 140 932 co-publications could be identified as unique. 19 948 co-publications were listed in WoS only and 48 403 in Scopus only. These figures show the remarkable gain in data coverage through consulting both databases as data retrieval sources.

4.2.1.3 Thematic Areas

Each cleaned record not only contains keywords given by the author(s) but has also been assigned with the journal subject categories of the respective source database(s). Unfortunately the two thematic classification systems in Web of Science and in Scopus not only distinguish themselves in the way of assignment, but also in the set of the used categories. Each database classifies each listed journal with one or more journal subject categories (249 in Web of Science) or with the help of All Science Journal Classification numbers (ASJC; 334 categories in Scopus). Because of the benefits of the Science-Metrix Ontology – more complex but more reasonable classification, respected in the bibliometrics-community and is classified per journal and disjunct – we use this classification. More than 15 000 journals are assigned to distinct sub-fields from Science-Metrix, and therefore it could easily be adopted for most of the Journals appearing in this study. But some Journals were not classified by Science-Metrix and therefore in sum around 4 000 had to be integrated manually in this Ontology.

For extracting those co-publications, relevant for the fields of nanotechnology and the thematic specialsiations of energy- and water-related research, the following methodology was applied:

Just as in the previous study for health, "nano" was defined by an expert-vetted set of keywords developed by a study lead by Peter Haddawy (UNU) in 2011 (list of author keywords attached).

This set was crossed with a keyword set for water (*drinking ~, brackish ~, desalination, drink, filtration, fresh~, fresh~ pollution, ground~, natural ~s, pesticide remediation, reverse osmosis, salt~, sea~, ~ pollution, ~ purification, ~ treatment;* study on water forthcoming;) and energy (*energy; power*) each.

4.2.1.4 Restrictions and error estimates

There are a few things to be kept in mind when interpreting the results and data presented:

- Data and results presented unfold their full potential by triangulating them with additional qualitative data and complementary analyses, such as expert consultations or other activities outlined in task 2.1.

- We have put a lot of effort in data cleaning and processing. Depending on the type of analysis (overall figures, subject areas, impact data, etc.), a rough analysis of possible errors points to an error probability of 1-5%. This may become especially important for those results, which are based on only a small number of publications.

- Caution is necessary with impact measures (average times cited counts) in subject areas with a small number of co-publications. The outliers are more likely to have a significant impact in these cases.

- Impact data is a snapshot at a given point in time. While the number of publications in the two databases is stable approximately half a year after the end of the year of publication, times cited counts are naturally constantly changing.

- We measure publications, not the work behind those publications. In case a specific piece of research is published via multiple channels in similar ways, there is no way at the meta level to identify this and control for this kind of duplicates. Despite considerable data processing and cleaning efforts, there will always be a certain margin of error in the data. More specifically, errors can stem from one of the following circumstances (or combinations of those):

    - Some of the ERA-CELAC co-publications might not be retrieved when looking for publications by ERA or CELAC-based authors in Scopus and Web of Science in case the country is not or not correctly assigned. This error, however, can be estimated as not higher than 2-3 % based on previous comparable studies.

    - Duplicates might be wrongly corrected or not identified. This error can be estimated at around 0,1-0,2 %.

    - Errors in the raw data: Out of the around 100 000 raw data records that we retrieved (Scopus and Web of Science), between 1 000 and 2 000 have raw data errors of different kinds (missing document object identifiers, wrong author-institution-links, etc.). The most relevant of these errors have been corrected.

    - Unification: When unifying data from Scopus and Web of Science, two errors can occur: Records that should be unified are not; records that should not be unified are unified. The combined error amounts to below 1 % according to previous experience and studies.

    - Limitations are being faced when it comes to benchmarks to other countries or total publications counts of whole countries or regions, since the huge amount of records cannot be cleaned, unified and standardised to the same extend like the data set within this study. The set for analysis in the present study therefore is hardly comparable with total sums published in other studies, since they usually only use one data source. If benchmarks have to be made, figures by Scopus/SCImago are being used, but direct comparison has to be read with caution.

- Another comparability problem is at stake when it comes to research fields. The different citation databases use different classification systems based on different logics for categorisation (e.g.: multiple assignment, single classification …). For as the Science-Metrix Ontology of Science was used for analysis here, comparison with All Science Journal Classification fields used in Scopus or Web of Science categories remains blurred and normalized field citation scores published by Thomson Reuters are difficult to drawn upon and used as a benchmark in this context.

4.2.2 Co-publication ties: an overview

The following data are included for a better overview on the data situation and are taken from a similar study for the ALCUE NETproject. The full report is available on the project website.[21]

4.2.2.1 Total publication counts for the EU-CELAC collaboration and important players

For this time period, authors from CELAC and ERA are involved in 140 932 jointly published scientific publications between 2003 and 2012. Brazil has the most co-publications involving at least one author from ERA compared to all other CELAC countries, followed by Mexico, Argentina, Chile, Colombia and Venezuela (see

Table 4.2-1). From the ERA countries' perspective, Spain is involved the most in co-publications with authors from CELAC, followed by France, Great Britain, Germany, Italy and the Netherlands (see

Table 4.2-2). Whereas Brazil is involved in nearly 40% of all CELAC and ERA co-publications and all the other CELAC countries do have a percentage of the overall CELAC and ERA co-publications below 20%, the percentages of the most active ERA countries involved in CELAC and ERA co-publications do not differ that much: Spain is involved in 28 % of all ERA and CELAC co-publications, France in 21%, Great Britain

[21] http://alcuenet.eu

in 19% and Germany in 18 %. Portugal ranks on place 8 with around 5% of the co-publication share.

CELAC country	Numbers of co-publications with ERA 2003-2012	Overall publication output according to SCImago (2003-2012)	Share of co-publications with ERA regarding overall publication output
Brazil	56,005	373,360	15.00%
Mexico	27,909	126,404	22.08%
Argentina	21,647	84,121	25.73%
Chile	18,102	51,538	35.12%
Colombia	9,286	30,957	30.00%
Venezuela	4,695	18,800	24.97%
Cuba	4,188	16,809	24.92%
Peru	2,703	7,512	35.98%
Uruguay	2,434	7,261	33.52%
Ecuador	1,840	3,645	50.48%
Costa Rica	1,499	4,727	31.71%
Bolivia	1,363	1,939	70.29%
Panama	1,131	2,436	46.43%
Puerto Rico	780	8,064	9.67%
Trinidad and Tobago	525	2,891	18.16%

Table 4.2-1 CELAC countries - co-publications with ERA and overall output, 2003-2012 (Sources: WoS+Scopus; SCImago)

ERA country	Numbers of co-publications with CELAC 2003-2012	Overall publication output according to SCImago (2003-2012)	Share of co-publications with CELAC regarding overall publication output
Spain	39,476	568,836	6.94%
France	30,139	878,307	3.43%
Great Britain	26,834	1,308,900	2.05%
Germany	26,473	1,223,419	2.16%
Italy	17,212	684,238	2.52%
Netherlands	8,615	388,568	2.22%
Switzerland	7,951	282,454	2.81%
Portugal	7,676	113,400	6.77%
Belgium	7,353	214,924	3.42%

Sweden	5,890	253,839	2.32%
Poland	3,774	256,110	1.47%
Austria	3,592	155,941	2.30%
Denmark	3,483	146,630	2.38%
Israel	2,984	150,499	1.98%
Czech Republic	2,915	124,111	2.35%

Table 4.2-2 ERA countries - co-publications with CELAC and overall output, 2003-2012 (Sources: WoS+Scopus; SCImago)

For the 15 most active ERA countries in co-authorship with CELAC countries, the share of co-publications with CELAC countries in their overall publication output is below 10%. In more than 6% of all publications involving Spanish or Portuguese author(s) an author affiliated in a CELAC country is involved. More than 3.4 % of France' and Belgium's publications involve at least one CELAC country, for Switzerland and Italy this applies for more than 2.5% of their publication output. For all other countries the share of co-publications with CELAC in their overall publication output is below 2.5% (see

Table 4.2-2).

Looking at the 15 CELAC countries most active in co-publications with ERA countries, only Puerto Rico has less than 10% of their overall publications with ERA affiliated authors involved. All other countries have a share of co-publications with ERA countriesover 15% (in some cases considerably more). For the five countries with the highest overall publication output in CELAC more than 15% of their overall publications involve at least one author from an ERA country: Brazil (15%), Mexico (22%) and Argentina (25%), Colombia (30%) and Chile (35%). Venezuela (25%) and Cuba (25%) do have a quite similar share of co-publications with ERA (compared to their overall publication output). Some research communities with a lower overall output show even shares of co-publications with ERA far beyond the 15% benchmark: more than 46% of Panama's publications involve an author from an ERA country, Ecuador reaches more than 50%, in Bolivia even 70% of all indexed publications involve at least one author from ERA (see

Table 4.2-1).

It has to be kept in mind that the numbers of the overall publication outputs of ERA and CELAC countries are drawn from SCImago (based on Scopus database) and are not unified data from Scopus and Web of Science. Thus it has to be considered that the numbers for the overall publication outputs of the different countries are lower than if they had been unified and retrieved from both databases.

4.2.2.2 Total publication counts in nanotechnologies

According to the nano-related keyword query, there are 63 578 publications in this area in the European Research Area (ERA) and 6 549 publications in the CELAC-region in all years tracked by Scopus. Thus, ERA's output in nano-science has been so far almost 10 times higher than the output in Latin American countries.

With a sum of more than 115 000 co-publications between ERA and LAC, the share of nano-research in this collaboration is almost 1,2 %. Looking at the total output in these regions and comparing it to each region's output in nano-research, these shares differ between the two regions: ERA (> 14 Mio publications) and CELAC (> ½ Mio publications) have a share of nano-related research of approximately 0,4% and 1,1% respectively.

4.2.3 Nanotechnology and energy research

For research on nanotechnology on energy-related topics, there were 870 records found in the unified dataset of all entries from Scopus and Web of Science, published in about 300 journals between 2003 and 2012 containing at least one author from ERA and one from a CELAC country. An average article of this set was cited 13.86 times, which is a remarkable rate as compared to the average citation rate that was found in the parallel study for the ALCUE NET project, where an article published jointly between ERA and CELAC in the field of energy was cited slightly more than 7 times on average in the same time period. An article co-published in this set, has 6.4 authors from 2.6 countries involved, on average.

4.2.3.1 Publication strengths per country

As shown in the tables below (Table 4.2-3), the strongest partner in absolute figures for European nano-research on energy issues is Brazil, followed by Mexico and Argentina. The highest average impact can be found in co-publications with Peru. From the Latin-American perspective, the strongest European partners are Spain, Germany and France, while co-publications with Sweden and Turkeytend to have citation rates clearly above average (over 28 and 21 respectively).

CELAC-Country	Co-publications with ERA	Mean citation rate / record
Brazil	391	13.84
Mexico	218	14.26
Argentina	135	10.8
Chile	76	18.2
Colombia	52	11.39
Cuba	28	12.77
Venezuela	26	11.86
Puerto Rico	8	12.19
Uruguay	7	7.13
Peru	4	9.71
Costa Rica	2	78.8
Ecuador	2	3.5
Jamaica	1	15
Trinidad and Tobago	1	7

Table 4.2-3 Co-publications on nanotechnology with focus on energy with ERA per CELAC-country and their average citations, 2003-2012 (Sources: WoS+Scopus)

ERA-Country	Co-publications with CELAC	Mean citation rate / record
Spain	253	14.73
Germany	194	18.04
France	171	10.84
Great Britain	77	12.4
Italy	73	11.11
Portugal	46	9.33
Belgium	34	27.14
Sweden	32	18.41
Switzerland	24	14.98
Finland	19	8.96
Netherlands	14	21.76
Turkey	14	6.21
Ireland	13	11.62
Czech Republic	11	18.27

Table 4.2-4 Co-publications on nanotechnology with focus on energy with CELAC per ERA-country and their average citations, 2003-2012 (Sources: WoS+Scopus)

These absolute figures do not yet tell a lot about research strength in the field for each country, as compared to their total publication output. As shown in Figure 4.2-1, Braziland Mexico have a comparably higher percentage of nanotechnology+energy publications measured by the total collaborative output with ERA. On the European side, Germany in these relations leads the rank.

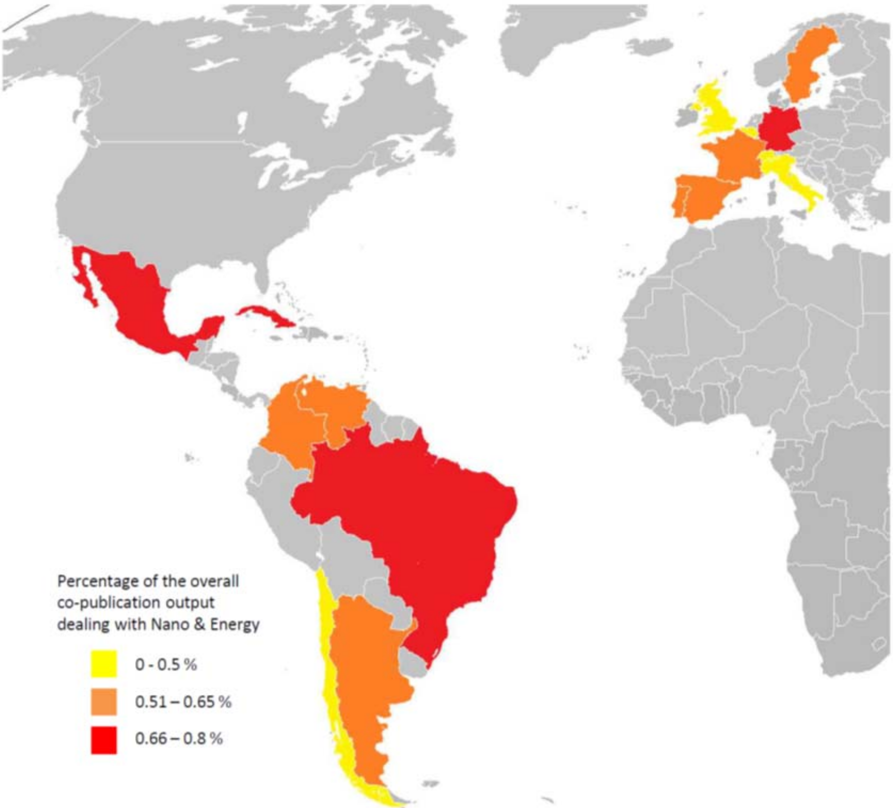


Figure 4.2-1 Percentage of the overall co-publication output between ERA and CELAC countries dealing with nanotechnology and energy,2003-2012 (Sources: WoS+Scopus)

4.2.3.2 Development over time

As outlined in the table below, there has been an increase of joint publications within the last decade, with a short stagnation in the early 2000s followed by a steady growth until 2012.

Year	Co-publications	mean citation rates / record	Mean author count
2012	134	3.17	6.4
2011	130	6.85	5.6
2010	102	11.32	5.48
2009	109	9.64	5.82

2008	90	13.91	12.07
2007	86	17.26	5.64
2006	62	16.81	5.05
2005	54	19.71	6.22
2004	51	47.5	5.73
2003	52	23.44	5.55

Table 4.2-5 Development over time: ERA and CELAC co-publications on nanotechnology with focus on energy and their average numbers on citations and involved authors, 2003-2012 (Sources: WoS+Scopus)

4.2.3.3 Science-Metrix sub fields

According to the Science-Metrix Ontology of Science, the strongest journals used for publishing collaborative articles on energy related nano-research between authors affiliated in ERA and CELAC countries are classified in the Science Metrix areas of *Natural* or *Applied Sciences*, with main fields involved being *Physics*, *Chemistry* and *Enabling & Strategic Technologies*.

Of the 870 records in sum, 185 were published in *Applied Physics* journals, 113 are classified in *Fluids & Plasmas* and 94 in *Nanoscience & Nanotechnology*, where energy-related articles have quite high citation rates. Yet, the highest citation rates are being reached by nano-energy publications in journals classified as dealing with either *General Chemistry* (cited almost 14 times on average) or *Organic Chemistry*, where articles reach an average citation count of over 54.

Science-Metrix Sub-Field	Publications	Mean citation count
Applied Physics	185	11.32
Fluids & Plasmas	113	13.52
Nanoscience & Nanotechnology	94	15.11
Chemical Physics	70	12.86
General Physics	61	13.99
Materials	59	9.76
Physical Chemistry	58	14.83
Energy	57	12.22
Polymers	18	14.67
Optoelectronics & Photonics	17	3.47
General Chemistry	14	33.57
Analytical Chemistry	13	11.23
Electrical & Electronic Engineering	10	1
Nuclear & Particles Physics	10	2.2

Organic Chemistry	7	54.14

Table 4.2-6 Science Metrix sub-fields of ERA-CELAC co-publications on nanotechnology with focus on energy, 2003-2012 (Sources: WoS+Scopus)

4.2.3.4 Nanotechnology and energy keywords

Figure 4.2-2 shows the keywords assigned to ERA-CELAC nanotechnology and energy co-publications by their authors in the time period 2003 to 2012. The size of the letters indicates the frequency of the keyword. In this case “nanoparticles” is the most frequent used keyword with 26 entries. The keywords with the least entries displayed in Figure 4.2-2 are mentioned twice. It has to be kept in mind, thatFigure 4.2-2 does not quote all the author-keywords assigned to the ERA-CELAC nanotechnology-energy co-publications and that there are many more author keywords than those displayed below (more than 1 600 whereof more than 1 370 are only mentioned once).

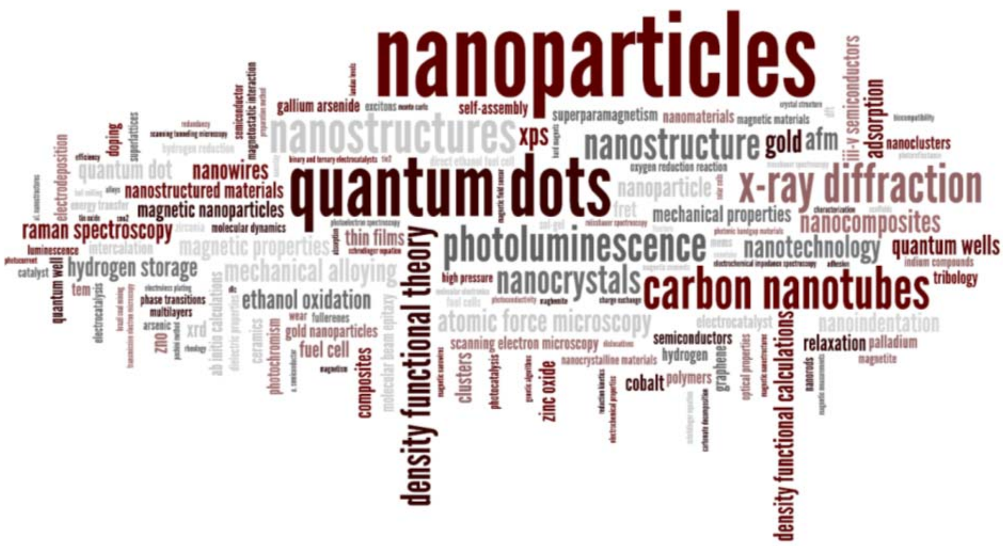


Figure 4.2-2 Author-Keywords in ERA-CELAC nanotechnology and energy co-publications, 2003-2012 (Sources: WoS+Scopus; n=233(1607); threshold=2; max=26)

4.2.3.5 Most active institutions and authors in EU-LA co-publications

Since data cleaning on institutional level is not possible with the given resources, we offer three attempts for approximating a valid overview on the most important actors involved in the field:

1. A list of the most frequent cities as indexed in affiliation data

2. Top 40 Institutions in the field as listed by Elsevier Scopus
3. The most active authors and traces of their mobility according to their affiliation cities

The figures presented do not offer definite amounts of publications, but rather weigh their relative importance to the other entities, since different data sources have been used and institutional information could not be exhaustively cleaned and standardised.

4.2.3.6 Important cities in EU-CELAC collaboration in nanotechnology and energy

Table 4.2-7 shows the most frequent cities in both areas with the number of co-publications they are listed in. For orientation American cities are marked green and those on the European side in blue colour. Researchers in Mexico City, São Paulo and São Carlos co-publish most actively with European partners in the field of nanotechnology and energy, followed by Spanish cities as their transatlantic counterparts (Madrid and Barcelona).

City	Participations in co-publications
Mexico City	215
São Paulo	134
SãoCarlos	74
Madrid	73
Barcelona	63
Campinas	55
Santiago de Chile	54
Buenos Aires	54
Río de Janeiro	52
San Luis	41
Belo Horizonte	40
Valparaíso	39
Paris	36
Grenoble	32
San Luis Potosi	29
Medellín	28
Toulouse	27
Ceará	27
Brasília	26
Berlin	25

Table 4.2-7 Most frequently publishing cities in ERA-CELAC co-publications in nanotechnology + energy 2003-2012 (Source: WoS+Scopus). Green lines mark American cities, blue lines are European cities

Please note, that in cases where several institutions from the same city are mentioned within one record, the city is only counted once in the above calculations.

4.2.3.7 Most frequent institutions in ERA-CELAC collaboration on nanotechnology and energy

As listed by Elsevier Scopus (only), amongst the top 40 players in nanotechnology and energy on the American side are Brazilian, Mexican and Argentinian institutions, represented by the biggest universities of each. More information can be retrieved from Table 4.2-8.

Institution	Country
Universidade de Sao Paulo	BR
Universidad Nacional Autonoma de Mexico	MX
Universidade Federal de Sao Carlos	BR
Universidad de Buenos Aires	AR
Centro de Investigacion y de Estudios Avanzados	MX
Universidade Estadual de Campinas	BR
Universidad de Antioquia	CO
Universidad de Chile	CL
Universidade Federal de Minas Gerais	BR
Instituto Potosino de Investigacion Cientifica y Tecnologica	MX
Universidade Federal do Rio Grande do Sul	BR
Universidad De Los Andes Facultad de Ciencias	CO
Universidad Autonoma del Estado de Morelos	MX
Universidade Federal de Uberlandia	BR
Universidad de La Habana	CU
University of Concepcion - Chile	CL
UNESP-Universidade Estadual Paulista	BR
Universidade Federal do Ceara	BR
Universidade Federal do Rio de Janeiro	BR

Table 4.2-8 Most relevant institutional players in nanotechnology+energy amongst the top 40 on the American side (Source: Scopus)

Amongst the top 40 players in nanotechnology and energy on the European side we identified Spain with CSIC and the Universitat de Barcelona, followed by the Turkish Cumhuriyet Üniversitesi as the most productive institutions in the partnership (Table 4.2-9).

Institution	Country[22]
CSIC - Instituto de Ciencia de Materiales de Madrid ICMM	ES
Universitat de Barcelona	ES
Cumhuriyet Üniversitesi	TR
Universite Paul Sabatier Toulouse III	FR
Dokuz Eylül Üniversitesi	TK
Universidad de Zaragoza	ES
INSA Toulouse	FR
Universidad Autonoma de Madrid	ES
Universidad Complutense de Madrid	ES
Institut Universitaire de France	FR
Universite de Poitiers	FR
Max Planck Institute for Biophysical Chemistry Karl Friedrich Bonhoeffer Institute	DE
CSIC - Instituto de Microelectronica de Barcelona IMB-CNM	ES
University of Sheffield	GB
The Royal Institute of Technology KTH	SE
Universitat de Valencia	ES
Universidade do Porto	PT
Imperial College London	GB
Universidad de Cantabria	ES
Donostia International Physics Center	ES
CSIC - Instituto de Ciencia de Materiales de Barcelona ICMAB	ES

Table 4.2-9 Most relevant institutional players in nanotechnology+energy amongst the top 40 on the European side (Source: Scopus)

4.2.3.8 Most active authors and their affiliation country, acknowledging mobility

As typical for co-publication analysis on author-level, certain error has to be incalculated since there might be cases where two authors by coincidence have exactly the same surnames and initals. The exact numbers and ranking has to be cautiously interpreted, since unique author-identification is very tricky, due to orthographic problems (e.g.: special characters), spelling mistakes, marriages with name changes, number and space for (middle) initials, or simply identical names and name combinations.

Table 4.2-10 lists the top 50 authors found in the set of co-publications as ranked by their publication numbers. Of the more than 4 000 author names found in the dataset, the researcher listed most often was M. Terrones, with 19 entries in sum. There were

[22] Country codes abbreviated according to ISO 3166-1 alpha-2. A list of countries and codes is available for example at http://en.wikipedia.org/wiki/ISO_3166-1#Current_codes

86 authors with 5 publications found, so the position of J. Andrés as the last one in the top 50 ranking is coincidal due to alphabetical order.

Authors	Records	Authors	Records
Terrones, M.	19	Arriaga, L.G.	6
Terrones, H.	14	Baglio, V.	6
Duque, C.A.	10	Bakarov, A.K.	6
Jares-Erijman, E.A.	10	Beltrán, A.	6
Jovin, T.M.	10	Brasil, M.J.S.P.	6
Peeters, F.M.	10	Caicedo, J.C.	6
Aguilera-Granja, F.	9	Carlos, L.D.	6
Jorio, A.	9	De Andrade, A.R.	6
Rodríguez, J.A.	9	Dias, I.F.L.	6
Dresselhaus, M.S.	8	Domínguez, C.	6
Goya, G.F.	8	Domínguez-Adame, F.	6
Gusev, G.M.	8	Duarte, J.L.	6
Iikawa, F.	8	Egues, J.C.	6
Kasapoglu, E.	8	González, G.	6
Kokoh, K.B.	8	Harmand, J.C.	6
Portal, J.C.	8	Illas, F.	6
Quivy, A.A.	8	Leite, E.R.	6
Sökmen, I.	8	Longo, E.	6
Vega, A.	8	López-López, M.	6
Charlier, J.-C.	7	Loss, D.	6
González, J.	7	Malachias, A.	6
Grobert, N.	7	O'Dwyer, C.	6
Reyes-Reyes, M.	7	Saito, R.	6
Sari, H.	7	Silva, L.F.O.	6
Vargas, P.	7	Andrés, J.	5

Table 4.2-10 First 50 authors in ERA-CELAC co-publications on nanotechnology+energy 2003-2012 ranked by their number of records (approximations; Source: WoS+Scopus)

Table 4.2-11 below lists those authors that have more than four publications linked to an affiliation city in the field of energy-relevant nanotechnology research in 2003-2012 in co-publications between authors affiliated in ERA and CELAC. To be precise, we list authors that are involved in at least four affiliation-record links, not necessarily *publications*. What Table 4.2-11 rather tries to depict is how authors move and therefore covers better the overall productivity in the described certain field. Because of this individual mobility it is possible that one author has more than one affiliation within the same record and therefore is over-represented in his publication strength. Yet the higher number signals certain strength in international connectedness and supposedly experience in international collaboration, which is how Table 4.2-11 and the figures given have to be read. It has to be noted, that due to data cleaning issues not all author entries had information on the affiliation country. Therefore the sum of entries found does not correspond to the overall publication numbers, since there are not country information availablefor all records.

Author Name	**Country I[23] + records**		**Country II + records**		**Country III + records**		**Country IV + records**		**Country V + records**		**Country VI + records**		**sum**
Aguilera-Granja, F.	MX	4	ES	2	CL	1							7
Altbir, D.	ES	2	DE	1	CL	1							4
Bakarov, A.K.	RU	1	BR	1	DE	1	FR	1	UA	1			5
Caicedo, J.C.	CO	4	MX	1	ES	1							6
Capaz, R.B.	DE	2	FR	1	BR	1							4
Chiappe, G.	ES	3	AR	1									4
Diaz, C.	ES	1	CL	3									4
Domínguez-Adame, F.	ES	4	RU	1									5
Dorantes-Dávila, J.	FR	3	MX	1									4
Duque, C.A.	TR	9	CO	1									10
Evans, J.	VE	3	ES	1									4
Gómez, H.	CL	3	FR	1									4
Goya, G.F.	BR	2	ES	2	RS	1							5
Grobert, N.	DE	1	FR	1	GB	1	MX	1					4
Gusev, G.M.	FR	5	BR	2	UA	1							8
Horley, P.P.	UA	2	MX	2									4
Iikawa, F.	CA	2	SE	1	FR	1							4
Jorio, A.	BR	3	DE	2	BE	1	US	1					7
Laroze, D.	CL	4	DE	1									5
Lavayen, V.	CL	2	BR	2	IE	1							5
Lima Jr., E.	BR	2	US	1	IT	1							4
López-López, M.	MX	2	DE	2									4
Malachias, A.	BR	4	DE	1									5
Massi, M.	BR	2	IT	1	BG	1							4
Medina, E.	ES	3	VE	1									4

[23] Country codes abbreviated according to ISO 3166-1 alpha-2. A list of countries and codes is available for example at http://en.wikipedia.org/wiki/ISO_3166-1#Current_codes

O'Dwyer, C.	IE	4	CL	1									5
Peeters, F.M.	BR	3	BE	2	RS	1							6
Persson, C.	IL	2	SE	1	BR	1							4
Poças, L.C.	FR	2	BR	2									4
Posada-Amarillas, A.	MX	2	GB	1	DE	1							4
Proetto, C.R.	AR	1	BR	1	??	1	US	1	FI	1			5
Raichev, O.E.	FR	2	BR	2	UA	1							5
Räsänen, E.	FI	2	DE	1	US	1							4
Reina, J.H.	GB	2	CO	2									4
Ribeiro, J.	FR	2	PT	1	BR	1							4
Rodríguez, J.A.	CU	1	US	3									4
Romero, A.H.	MX	3	IT	1	ES	1							5
Rubio, A.	DK	2	ES	2									4
Saito, R.	US	2	JP	2									4
Sari, H.	TR	5	FI	1									6
Terrones, H.	US	2	MX	2	JP	1							5
Terrones, M.	MX	4	BE	2	BR	1	DE	1	JP	1	US	1	10
Vargas, P.	DE	2	CL	2	ES	1	MX	1					6
Vega, A.	MX	2	ES	1	CL	1							4
Velumani, S.	MX	3	FR	1									4
Vieira, V.R.	PT	3	MX	2									5
Wiedmann, S.	FR	4	NL	1									5
Yate, L.	ES	2	MX	1	CZ	1	CO	1					5

Table 4.2-11 List of authors with at least 4 entries found with affiliation cities in ERA-CELAC co-publications 2003-2012 for nanotechnology and energy research (Source: Scopus+Web of Science). The sum of hits does not equal to the total number of publications per author, since not all records provide country information.

The authors with the highest numbers of entires matching with a country are M. Terrones and C. Duque with 10 hits each, while Terrones is also the author with the highest internationalization grade in terms of the number of affiliations in different countries.

4.2.4 Summary of Results

The analysis presented before offers an overview of co-publication patterns, scientific authors and affiliated organisations in nanotechonolgy research with focus on energy. Major findings of this analysis are as follows:

- For the time period 2003 to 2012, authors from CELAC[24] and ERA[25] are involved in 140 932 jointly published scientific publications. Thereof, 870 ERA-CELAC co-publications were published in the field of nanotechnology and energy.
- The most frequently involved partner countries on Latin-American side are Brazil, Mexico and Argentina, on European side the most frequently involved partner countries are Spain, Germany and France.
- The highest average impact can be found in co-publications involving authors from Peru, Sweden, and Turkey.
- Energy-related nanotechnology ERA-CELAC co-publications had a short stagnation in the early 2000s but were growing steadily until 2012.
- ERA-CELAC co-publications in nanotechnology and energy were published mostly in *Applied Physics, Fluids & Plasmas* and *Nanoscience & Nanotechnology* journals.
- In nanotechnology and energy, co-publications researchers affiliated in Mexico City, São Paulo, São Carlos, Madrid, Barcelona and Campinas are most actively involved.
- On institutional level CSIC and the Universitat de Barcelona in Spain and the Turkish Cumhuriyet Üniversitet are most frequently involved European partners in nanotechnology and energy co-publications with CELAC. On CELAC side the Universidade de Sao Paulo in Brazil, the Universidad Nacional Autonoma de Mexico and the Universidade Federal de Sao Carlos in Brazil are the most frequently involved institutions in nanotechnology and energy co-publications with Europe.

4.2.5 Interim Conclusions: Complementary results of the two bibliometrics analyses

As shown in the two bibliometric studies, the different approaches positively effect data quality and enable to create an enhanced picture of the collaboration ties and productivity in the research field of analysis.

While ReLANS' publication study focused on publications authored by at least one researcher affiliated in a Latin American or Caribbean country, based on data from Thomson Reuters' *Web of Science*, ZSI was Focusing on international **co-**publications sourcing from both, Web of Science and Elsevier's *Scopus* database.

[24] Latin American and Caribbean Countries as listed in 4.12.3.
[25] European Research Area: Countries in the European Union andassociated ones to the 7th Framework Programme.

With a more distinct definition of the kind of research specialties in energy-related nano-research under focus, the publication analysis roughly found 1,2 thousand articles, while the broader angle taken in the co-publication study, revealed 870 records co-published by both Europeans and authors from Latin America or the Caribbean.

While both studies identified similar rankings for the single countries' productivity, different focus could be layed on output numbers on institutional-level and on author-level:

The main institutions listed are similar, but with different importance in regional (South-American) or inter-regional (ERA-CELAC) involvement into studies: while the Universidade de Sao Paulo (Brazil) and the Universidad Nacional Autonoma de México (México) clearly rule the rankings in both studies, other institutions are following: highlighting the importance of Mexico and Brazil in the Latin-American context (in the publication study'sTable 4.2-8) and the comparably higher ranked Argentinian institution Universidad de Buenos Aires, the Colombian institution Universidad de Antioqua and the Chilean institution Universidad de Chile within the collaboration with Europe.

While the co-publication study can provide additional insight into the most important European actors involved (e.g.: Instituto de Cience de Materiales de Madrid, Universitat de Barcelona…), the publication study narrows down the focus to identified important research themes and is able to connect highly productive authors with their affiliated institutions by each theme (fossil fuels, photo-voltaic energy, etc.).

The main authors involved seem to differ significantly. This is, however, not surprising, since data cleaning on author-level is very complex and certain mobility blurs exact institutional affiliations of the authors involved. ZSI's study tries to cover this gap by drafting an overview on important authors' movements, as far as data was available. ReLANS's study does a great job in connecting authors and their institutions for the small sub-sets of the main research themes identified in advance. Combining the results of the two methods for identifying important authors, eventually a very comprehensive overview of active contributors, both on the American side and in collaboration with Europe, is being provided with this report.

Additionally, the overall development over time provides insight todynamics within the research specialisation: while the total number of publications increased constantly, the average amount of times cited per record did not: there are irregular differences between the different years of their publication, not necessarily correlating to the average number of authors involved.

RELANS' network graphs provide a useful overview on collaboration networks at stake. Based on ZSI's previous studies on Latin American nanotechnology publications with Europe, it was possible to analyse the relative importance of energy-research in nanotechnology per country and visualise this in maps. An idea of important topics being treated in the co-publications can be taken from the visualisation of author key-words in the tag-cloud.

Both studies describe the variety of sub-disciplines contributing to nano-technology and energy research according to the different logics of the classification systems in use: *Multidisciplinary Materials Science*, *Physical Chemistry* and *Applied Physics* according to the Web of Science Categories, and *Applied Physics*, *Fluids & Plasmas*, and *Nanoscience& Nanotechnology* according to the Science Metrix Ontology of Science's Sub-Fields, on the other hand.

4.3 Analysis by country

4.4 Brazil

4.4.1 Driving nanotechnology development in energy

Nanotechnology policy in Brazil has driven, across various multi-year annual plans, the application of this technology in the energy sector. The base document for the Nanoscience and Nanotechnology Development Program, incorporated into the 2004-2007 Multi-annual Plan of the MCT (Ministry of Science & Technology), identified the following research areas as relevant for the country's plan in the field of energy: a) power generation devices; electrodes and membranes for combustible cells; b) storage structures; supercapacitors and new batteries; and c) nano-chemical photovoltaic systems (MCT, 2003, 7).

The subsequent Multi-year Plan for Science, Technology and Innovation (2008-2011) established the field of nanotechnology as a strategic focus for the country. The energy sector, including petroleum and gas, was identified as a priority for development within the national nanotechnology program (MCT, 2007, 144).

The National Science, Technology and Innovation Strategy 2012-2015 continues highlighting nanotechnology as a strategic area. The specific document relating to the field, the Brazilian Nanotechnology Initiative, places energy among the country's priority sectors, as much for its potential to diversify the energy supply matrix, incorporating clean and renewable ways to produce energy, as for the increase in efficiency in the storage and consumption of energy. Specifically highlighted are the areas of bioenergy, hydrogen fuel cells, photovoltaic energy and LEDs, energy conversion systems and *smart grids* (Plentz, 2013).

Funding nano-energy research

The Ministry of Science, Technology and Innovation, via its key research supporting organization, the National Council for Scientific and Technological Development (CNPq), has funded various projects on energy. In

Table 4.4-1 the top competitions held between 2010 and 2013 are presented, which include the field of nanotechnology, and within it, the funding award to energy projects. The CNPq does not publish the amounts awarded to each project.

Support for nanotechnology projects related to energy between 2010-2013 can be seen as considerably unequal across the various calls for proposals. It is interesting to note that in cooperation projects with India and Mexico, as well as in projects designated for novice researchers, nano-energy accounted for one-quarter of the funded projects. The projects addressed various topics: biodiesel, photovoltaic cells, hydrogen fuel cells, and LEDs for illumination. This draws our attention to the lack of projects funded in the field of energy during the *Convocatoria 74/2010* that was particularly oriented toward problems with social relevance, especially those highlighted in the Millennium Development Goals.

Looking beyond nanotechnology-oriented convocations, we performed an accounting of the projects financed by CNPq with resources provided by the Energy Sector Funds[26] in fields labelled as priorities for nanotechnology policy between 2010 and 2013(Table 4.4-1). With this approach, a given project may not fall within those at the nano scale, although the themes tend to show a high probability that they do.

[26] The Energy Sector Fund aims to stimulate research and innovation in the sector. The resources come from a 0.75% - 1.0% tax on the incomes of businesses involved in the generation, transmission and distributions of electrical energy.

Call for Proposals	Year	Projects Funded	Nano-energy Projects	Project Title
Chamada N° 13/2013 - Cooperação MCTI-CNPq/DST (Índia) Investigación, Desarrollo e Innovación en diversas áreas incluyendo nanotecnología, energías renovables, eficiencia energética y tecnologías de bajo carbono	2013	14	4	1. Biocombustibles – título no especificado 2. Cavitation Reactor: Application in Biodiesel Production 3. Biocombustibles – título no especificado 4. Dispositivos fotovoltaicos- título no especificado
Chamada MCTI/CNPq N º 16/2012 – Pesquisadores Junior Tecnologías innovadoras en la producción, prototipado y aumento de escala en nanotecnología	2012	13	2	1. Desenvolvimento de nanomateriais à base de filmes ultrafinos de d-FeOOH dopados com Nb obtidos pela técnica de Lagmuir-Blodgett: aplicação em sistemas fotocatalíticos de produção de H2 por clivagem molecular da água 2. Desenvolvimento de substratos condutores, transparentes e flexíveis para aplicação em dispositivos orgânicos emissores de luz (OLEDs)
Chamada MCTI/CNPq N º 16/2012 – Pesquisadores Sênior Tecnologías innovadoras en la producción, prototipado y aumento de escala en nanotecnología	2012	11	0	
Chamada MCTI/CNPq nº 21/2011. Cooperação Brasil-México. Proyectos conjuntos de investigación, desarrollo e innovación en nanotecnología. (Energia es una de las áreas prioritárias).	2011	9	2	1. Desenvolvimento de nanocompósitos para conjunto membrana-eletrodo (MEA-membrane electrode assembly) para uso em células a combustível. 2. Transformação do glicerol para produção de hidrogênio e intermediários químicos valiosos: síntese e caracterização de óxidos nanoestruturados a base de ceria e alumina com aplicações catalíticas
Edital MCT/CNPq nº 74/2010– Apoyo a la formación de redes cooperativas de investigación y desarrollo en nanociência y nanotecnologia)Energia es una de las áreas prioritárias).	2010	17	0	

Source: CNPq, memoria de editais e Plataforma Lattes (base pública de currículos de investigadores).
Nota: CNPq publica solamente los nombres de los investigadores con proyectos aprobados y un enlace para sus currículos en la Plataforma Lattes. Los títulos de los proyectos sólo están disponibles cuando el investigador colocó esta información en su currículo, vinculada a la convocatoria correspondiente.

Table 4.4-1 Calls for proposals by CNPq for nanotechnology research in which nano-energy projects were approved

Call for Proposals	Year	Funded Projects	Project Title
Chamada MCTI/CNPq/CT-Energ Nº 49/2013 Línea I: Investigación, Desarrollo e Innovación en **Energía Solar Fotovoltaica**	2013	12	1. No informado 2. Desenvolvimento de um traçador e analisador de curvas I&V inovador para arranjos fotovoltaicos de grande porte em diferentes tecnologias 3. No informado 4. No informado 5. Obtenção de xerogel de sílica a partir da casca da castanha de caju para produção de substratos a serem utilizados em sistemas fotovoltaicos 6. Desenvolvimento de sistemas fotovoltaicos que mimetizam a fotossintese visando a melhoria da eficiência de células solares de TiO2/Corante 7. Estudo e desenvolvimento de dispositivos fotovoltaicos utilizando polímeros semicondutores e nanomateriais em substratos flexíveis. 8. No informado 9. Células solares orgânicas multicamadas baseadas em polímeros orgânicos, hidrocarbonetos aromáticos conjugados e nanoestruturas distintas de carbono e peptídios: alternativas para maior eficiência. 10.No informado 11.No informado 12.Pesquisa, Desenvolvimento e Inovação em Células Solares Sólidas Extrafinas Preparadas Usando Semicondutores Nanocristalinos Coloidais
Chamada MCTI/CNPq/CT-Energ Nº 49/2013 Línea II- LEDS, emisores de luz no convencionales y sistemas de iluminación	2013	12	1. No informado 2. Novos materiais luminescentes para aplicação em iluminação de estado sólido 3. Desenvolvimento de Dispositivos Emissores de Luz Eficientes e de Baixo Custo baseados em Pontos Quânticos de Materiais Semicondutores II-VI 4. No informado 5. No informado 6. LEDs orgânicos brancos e eficientes produzidos por métodos de baixo custo 7. No informado 8. Estudo espectroscópico e termo-óptico em vidros aluminosilicatos de cálcio (CAS) dopados com PR3+ e EU2+/PR3+: proposição de um novo material para geração de luz branca 9. Produção e caracterização de matrizes de [Y3Al5O12 (YAG) X- Y3Fe5O12 (YIG) 1-X] Y dopadas com Y= Yb +3 / Er+3 / Tm+3 para obtenção de LED branco.

			10.Nanopartículas e Filmes Finos para LEDs 11.No informado 12.No informado
Edital MCT/CNPq FNDCT Nº 05/2010 - Capacitação Laboratorial e Formação de RH em Fontes Renováveis Línea 4: Energia Solar Fotovoltaica.	2010	40	1. No informado 2. Desenvolvimento de Sistemas Fotovoltaicos Conectados à Rede 3. Desenvolvimento de filmes finos transparentes para contatos fotovoltaicos: avaliação do uso em células solares flexíveis 4. No informado 5. No informado 6. Estudo, Simulação e Implementação de Sistemas de Propulsão Elétricos Para Embarcações de Pequeno Porte 7. Fotogeração em Sistemas Fotovoltaicos de Semicondutores Orgânicos 8. Células Solares Fotovoltaicas Orgânicas e Sensibilizadas a partir da Meso-Porfirina Proveniente do Liquido da Casca da Castanha de Cajú 9. No informado 10.Desenvolvimento de Técnicas para Melhoria da Controlabilidade e Suportabilidade Aa Faltas de Sistemas de Geração Baseados em Fontes Renováveis de Energia, Interligados e Autônomos 11.No informado 12.Minirredes com acoplamento CA para atendimento de comunidades isoladas 13.Células Solares Poliméricas Para Geração de Energia Elétrica. 14.No informado 15.No informado 16.Estudos in situ das propriedades eletrônicas, estruturais e óticas de nanopartículas metálicas 17.Sistemas Solares Fotovoltaicos Conectados à Rede Elétrica Pública: medição e controle dos impactos na rede de distribuição urbana 18.No informado 19.No informado 20.No informado 21.No informado 22.No informado 23.No informado 24.Desenvolvimento de células solares orgânicas: Síntese de materiais avançados, caracterização, fabricação e otimização de dispositivos. 25.Espectroscopia de Impedância Aplicada ao Estudo de Eletrodos Nanoestruturados para Dispositivos Fotovoltaicos e Biossensores 26.Otimização da Eficiência de Células Solares Baseados no Desenvolvimento de Filmes Finos de

			Nanomateriais Semicondutores de SnO_2 e TiO_2 dopados, e Nanotubos de Carbono Funcionalizado 27.No informado 28.No informado 29.Produção e caracterização de telhas solares fotovoltaicas 30.Desenvolvimento de filmes nanoestruturados core-shell de TiO_2 e suas aplicações em células fotoeletroquímicas 31.Filmes Estruturados com Corantes Nanoparticulados para Sistemas Fotovoltaicos 32.No informado 33.Montagem de laboratório e formação de pessoal em condicionamento de energia oriunda de sistemas fotovoltaicos, conectividade entre sistemas fotovoltaicos e interconectividade com a rede elétrica usando controle local e independente. 34.No informado 35.Produção, caracterização e aplicação de cerâmicas transparentes como substrato de filmes finos semcondutores para sistemas fotovoltaicos. 36.Nanopartículas e Filmes Finos de Compostos Inorgânicos Fotocondutores 37.Pesquisa de Novos Materiais Orgânicos Visando o seu uso em Dispositivos Fotovoltaicos 38.Desenvolvimento de células solares fotovoltaicas utilizando filmes finos cristalinos de dióxido de titânio dopado com nitrogênio 39.Produção e Caracterização de Filmes Finos de homojunção de CdTe Eletrodepositados para Utilização em Sistemas Fotovoltaicos. 40.Pesquisa e Desenvolvimento de Células Solares MOS Utilizando Processamento Térmico Rápido (RTP)

Source: CNPq, memoria de editais e Plataforma Lattes (base pública de currículos de investigadores).
Note: CNPq publica solamente los nombres de los investigadores con proyectos aprobados y un enlace para sus currículos en la Plataforma Lattes. Los títulos de los proyectos sólo están disponibles cuando el investigador colocó esta información en su currículo, vinculada a la convocatoria correspondiente

Table 4.4-2 Projects funded by CNPq with resources from the Energy Sector Fund. 2010-2013 Period.

The *CT-Energía 2013* call for proposals included photovoltaic solar energy, LEDs and other unconventional devices for illumination among its priority areas. 12 projects in each research line were funded. In 2010, 40 projects were approved under the call for proposals funded by the same fund with the aim of creating laboratory infrastructure and training human resources in photovoltaic solar energy.

According to the Micro and Nanotechnology Coordinator for the MCTI, in 2013 the CNPQ dedicated R$ 83.33-million (approximately $38-million USD) to support energy research. Of this total, R$ 8-million was applied to projects on Smart Grids, R$ 6.5-million on hydrogen and fuel cell projects, R$ 10-million on wind energy and solar thermal; R$ 8-million on energy conversion technologies; R$ 8-million on solar photovoltaic and LEDs for illumination applications and energy efficiency; R$ 11.23-million on biofuel generation via microalgae; R$ 25.6-million on biodiesel research; and R$ 6-million on international cooperation projects in the field of energy (Plentz 2013, 313). One can see the emphasis on biodiesel research, which is in line with its importance in the national energy matrix, but at the same time, the new stimulus applied to researching emerging alternative energy sources.

Another relevant research funding source is FINEP (Funding Authority for Studies and Projects), also linked to the MCTI, whose focus is the promotion of research and development in business, frequently fostering cooperative projects between research centers and businesses. The calls for proposals in energy of FINEP have emphasized the petroleum, gas and biodiesel sector. We have identified only one call, *Inova Energía 2013*, which followed three R&D lines: alternative renewable energies (solar photovoltaic, thermo-solar and wind), smart grids and components for hybrid or electric vehicles. Those that were specifically funded in the alternative renewabe energies line were projects presented by 24 companies, in the form of grants and credit. The titles of the approved projects were not made public, only the names of the companies were revealed.

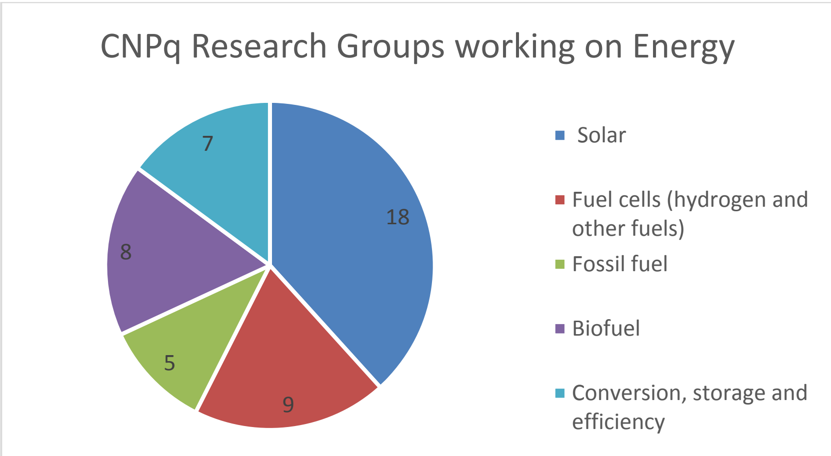
Other FINEP funding was directed to nanotechnology. Support in the form of grants covered some 40 projects between 2006 and 2010, including only one project in the area of nano-energy (Peixoto, 2013, 293).

4.4.2 Key research groups

In Brazil, the CNPq (National Council for Scientific and Technological Development) encourages the organization of researchers into research groups, including students who are pursuing their Master's and Doctoral degrees. We searched the Directory of

Research Groups at CNPq (http://dgp.cnpq.br/buscaoperacional/) with keywords *energy + nanotechnology* in the name of the group or in its states research description. Later a manual sorting was performed, case by case, keeping only those that had at least one significant component relating to the topic. In this way, we identified 37 research groups working on applications of nanotechnology in the field of energy. Ten of them research more than one kind of energy while the remainders are focused upon one specialized subject. In 13 research groups, energy is the core topic; the remainders follow a research line involving other topics pursued by the group.

As Figure 4.4-1 shows, 18 research groups cover nanotechnology applications in solar energy, 9 in fuel cells (hydrogen and other fuels); 8 in biofuels, 5 in fossil fuels and 7 in various applications of conversion, storage and energy efficiency.



Source: CNPq. Census of Research Groups.

Figure 4.4-1 Number of CNPq Research Groups working on nano-energy

The distribution of these groups' location (which may involve more than one institution) is strongly concentrated in the south-east region of the country, which encompasses the states of São Paulo, Minas Gerais, Rio de Janeiro and Espíritu Santo, with 62% of the groups (Figure 4.4-2).

Source: CNPq. Census of Research Groups

Figure 4.4-2 Distribution of CNPz research groups in nano-energy, by region

Table 4.4-3 shows the research groups that work on photovoltaic cells and fuel cells. Among those that research nanotechnology applications in solar energy, 10 groups are developing solar cells, 8 are focusing on the development of various materials for application to solar cells and one is following both lines. Among the groups that work on fuel cells, four are focused on hydrogen production, while four work on materials for use in fuel cells. The fuels utilized in the cells, apart from hydrogen, are those derived from biomass.

Group	Solar Energy	Fuel Cells (Hydrogen and other fuels)	Institution(s)	Leader/contact
Energia e Nanotecnologia	Produção e caracterização de filmes nanoestruturados com aplicações solares		Centro Federal de Educação Tecnológica de Minas Gerais (CEFET MG), Belo Horizonte MG	Weber Guadagnin Moravia; Rogério Antônio Xavier Nunes Tel (31) 3319-6823
Bioeletrônica, Dispositivos Fotovoltaicos e Química de Materiais	Desenvolvimento e caracterização de sensores bioeletrônicos e dispositivos fotovoltaicos orgânicos. Desenvolvimento de células solares empregando foto-sensibilizador orgânico a partir de extratos vegetais da Amazônia		Universidade Federal do Amazonas (UFAM), Manaus AM	Walter Ricardo Brito , Tel (92) 3305-2870
Conservação de Energia em Sistemas Térmicos	Utilização de nanofluidos como receptores de energia térmica em coletores solares.		Universidade Federal de Uberlândia (UFU), Uberaba MG	Enio Pedone Bandarra Filho; Ricardo Hernandez Pereira Tel. (34) 32294022
Energias Renováveis e Desenvolvimento Sustentável	Desenvolvimento de células solares de baixo custo	Estudo e desenvolvimento de nanoestruturas de óxidos semicondutores (fotocatalisadores) e sua aplicação na geração de hidrogênio pela quebra da molécula da água (water splitting).	Universidade Federal de Mato Grosso do Sur (UFMS), Campo Grande, MS.	Flavio Aristone; Heberton Wender Luiz dos Santos Tel. (67) 3345-7033
Física de plasma aplicada a novos processos de materiais	Aplicação de filmes baseados no dióxido de titânio (TiO2) para o desenvolvimento de células fotoeletroquímicas		Instituto Tecnológico de Aeronáutica (ITA), São José dos Campos, SP	Homero Santiago Maciel Gilberto Petraconi Filho Tel (12) 3947-5943
GEM - Grupo de Eletrônica Molecular	Desenvolvimento de células solares orgânicas de heterojunção		Universidade de São Paulo (USP), São Paulo, SP	Adnei Melges de Andrade: Fernando Josepetti Fonseca (n/i)
Grupo de Física Básica e Aplicada em Materiais Semicondutores	Células fotovoltaicas	Materiais nanoestruturados para produção de hidrogênio	Universidade Federal da Bahia (UFBA), Salvador BA	Antonio Ferreira da Silva Iuri Muniz Pepe Tel (71) 3283-6616

Grupo de Eletroquímica e Nanotecnologia		Desenvolvimento de nanopartículas para aplicações em células a combustível operando com álcoois. Catalisadores para uso de álcool em células de combustível	Universidade Tiradentes (UNIT), Aracaju, SE	Giancarlo Richard Salazar Banda Katlin Ivon Barrios Eguiluz, Tel (79) 3218-2190
Grupo de Mecânica de Nanocompósitos	Desenvolvimento de nanocompósitos para sistemas de aquecimento solares		Universidade Federal de Minas Gerais (UFMG), Belo Horizonte MG	Antonio Ferreira Avila Tel (31) 34095238
Grupo de Química de Materiais	Preparação de nanomateriais (nanotubos de carbono, grafeno, nanopartículas metálicas, nanocompósitos) visando aplicação em supercapacitores e dispositivos fotovoltaicos	Preparação de nanomateriais (nanotubos de carbono, grafeno, nanopartículas metálicas, nanocompósitos) visando aplicação em células de combustível e baterias.	Universidade Federal do Paraná, UFPR, Curitiba PR	Aldo José Gorgatti Zarbin, tel (41) 33613176
Laboratório de Nanomateriais e Nanotecnologia Aplicada LNNA		Desenvolvimento de materiais semicondutores nanoestruturados (nanotubos e nanofios de TiO_2, Fe_2O_3, ZnO) dopados para geração de hidrogênio a partir da quebra da molécula da água na presença de luz solar.	Universidade Federal do Mato Grosso do Sul (UFMGS), Campo Grande, MS	Heberton Wender Luiz dos Santos Tel (67) 33457030
Laboratório de Pesquisa em Materiais		Desenvolvimento de membranas poliméricas para aplicação em células a combustíveis. Avaliação da eficiência de eletrólitos poliméricos.	Universidade do Extremo Sul Catarinense (UNESC), Criciúma, SC.	Luciano da Silva s/i
Nanoengenharia eletrônica, diamante semicondutor e materiais nanoestruturados	Desenvolvimento de células fotovoltaicas solares com materiais de carbono		Universidade Estadual de Campinas (UNICAMP), Campinas, SP	Vitor Baranauskas Alfredo Carlos Peterlevitz Tel. (19) 3521 3851
Nanotecnologia Aplicada. Aplicações de		Desenvolvimento de membranas iônicas, permeáveis a hidrogênio para a fabricação de células de	Universidade de São Paulo (USP), São Paulo SP	Ronaldo Domingues Mansano, Tel (11) 30915660

Filmes finos		combustível.		
Processos Químicos		Seleção e modificações do suporte por meio da funcionalização da superfície a fim de melhorar o desempenho geral dos catalisadores empregados nas células do tipo PEM.	Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT), São Paulo SP	Wagner Aledia; Silas Derenzo, Tel. (11) 37674338
Química Supramolecular e Nanotecnologia	Geração de novos sistemas ou interfaces moleculares, visando atingir melhor desempenho de células solares fotoeletroquímicas, já produzidas no laboratório		Universidade de São Paulo (USP), São Paulo SP	Koiti Araki; Henrique Eisi Toma, Tel (11) 3091 8513
RECAT - Laboratório de Reatores, Cinética e Catálise		Produção de hidrogênio a partir de fontes renováveis, como bio-óleo e gaseficação da biomassa	Universidade Federal Fluminense (UFF,) Rio de Janeiro RJ	Fabio Barboza Passos Rosenir R. C. Moreira da Silva Tel (21) 26295600
Grupo de Fotoeletroquímica e Conversão de Energia	Propriedades de eletrodos de filmes finos de óxidos semicondutores e sua aplicação na conversão de energia solar. Células solares.		Universidade Estadual de Campinas (Unicamp), Campinas, SP	Claudia Longo Ana Flávia Nogueira Tel (19) 35213414
Grupo de Dispositivos Optoeletrônicos Orgânicos	Síntese e funcionalização de nanotubos de carbono, preparação e caracterização de compósitos com polímeros condutores e aplicação desses materiais como filme ativo em dispositivos fotovoltaicos de dupla junção e de heterojunção dispersa.		Universidade Federal do Paraná (UFPR), Curitiba PR	Ivo Alexandre Hümmelgen Tel (41) 33613645
Fotoquímica e conversão de energia: células solares e	Sistemas para armazenamento e conversão de energia solar, fotocatálise e sensores. Desenvolvimento de células solares	LECs (Light-Emitting Electrochemical Cells)	Universidade de São Paulo, (USP), São Paulo, SP	Neyde Yukie Murakami Iha, Tel (11) 30913326

fotossensores & LECs e OLEDs	(Dye-Cells),			
Grupo de Síntese, Química Biológica e Fotociências	Desenvolvimento de células solares sensibilizadas por corantes. Pesquisa em fotocatálise, fotointerruptores e nanossondas luminescentes.		Universidade Federal do ABC (UFABC), Santo André, SP	André Sarto Polo Rodrigo Luiz Oliveira R.Cunha Tel (XX) 49960150
Materiais Avançados	Sistemas de conversão e armazenamento na forma de células solares e baterias de lítio.		Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP), Bauru, SP	Carlos F. Oliveira Graeff Paulo Noronha Lisboa Filho Tel 31036084
Nanotecnologia-CETENE	Células solares utilizando novos corantes adsorvidos em filmes nanoparticulados de TiO2 y ZrO2		Centro de Tecnologias Estratégicas do Nordeste CETENE, Recife, PE	Giovanna Machado, Tel (XX) 33347231
LAB SEM (Laboratório Semicondutores)	Desenvolvimento de células solares		Pontifícia Universidade Católica do Rio de Janeiro (PUC Rio), Rio de Janeiro RJ	Patricia Lustoza de Souza; Mauricio Pamplona Pires Tel (21) 35271155

Source: CNPq. Census of Research Groups

Table 4.4-3 CNPq research groups working on solar cells and fuel cells

4.4.3 National C&T Institutes and other institutions conducting related research

The 122 National Institutes of Science and Technology (INCTs) spread out across the country were created in 2009, following a competitive call for proposals issued bythe CNPq, and have five-year funding commitments coming from various federal and state government agencies. The Institutes investigate a variety of areas at the leading edge of science and in strategic areas for the country's development, with the intent to advance scientific and technological development and innovation. Among these, 16 INCTs conduct research in nanotechnology, of which 5 work in the field of energy. Photovoltaic devices and fuel cells are the themes of greatest interest to those institutes (Table 4.4-4).

Institute / Location	Energy Research Area	Contact
Instituto de Ciência e Tecnologia de Nanomateriais de Carbono. Universidade Federal de Minas Gerais (UFMG)	Dispositivos fotovoltaicos e eletrodos para células.	Dr. Marcos Assunção Pimenta, coordenador mpimenta@fisica.ufmg.br
Instituto Nacional de Ciência e Tecnologia dos Materiais em Nanotecnologia Universidade Estadual Paulista (UNESP)	Novos materiais estruturados especificamente para células solares foto-eletroquímicas (PESC), dispositivos de íon lítio (LID), super capacitores e componentes de células a combustível de óxido sólido	Dr. Elson Longo, *coordenador* inctmn@gmail.com Fone/Fax: 16 3351 8214 – 3301 6643
Instituto Nacional de Eletrônica Orgânica Universidade de São Paulo (USP São Carlos).	Aplicações de eletrônica orgânica em células solares. Filmes e dispositivos orgânicos emissores de luz de alta eficiência.	Dr. Roberto Mendonça Faria, coordenador redeineo@gmail.com
Instituto de Ciência e Tecnologia de Materiais Complexos Funcionais Universidade Estadual de Campinas (Unicamp)	Fotoeletroquímica e Conversão de Energia. Materiais para conversão de energia: eletrodos de óxidos semicondutores para aplicação em células solares	Dr. Fernando Galembeck, coordenador Fone/fax (19) 3521-2906
Instituto Nacional de Catálise em Sistemas Moleculares e Nanoestruturados	Aplicações de sistemas catalíticos em oleoquímica e biodiesel	Faruk José Nome Aguilera, coordenador inctcatalise2008@gmail.com (48) 3721-6844 ramal 227

Source: MCTI http://nano.mct.gov.br/outras-acoes-de-fomento-a-nanotecnologia/incts/

Table 4.4-4 National Science and Technology Institutes with research in Energy

Two research institutions are of special relevance for the development of solar cells (Table 4.4-5). One of these is the Nanotechnology and Solar Energy Laboratory of the Chemistry

Institute at the Campinas State University (Unicamp), under the direction of Dr. Ana Paula Nogueira. This laboratory performs research in three areas:[27]

Organic and Hybrid Solar Cells

- Study of new or modified organic materials such as conducting polymers derived from polythiophene, poly (p-phenylene vinylene) and polyfluorene, porphyrins & phthalocyanines, carbon nanotubes, fullerenes and more recently graphene.
- Synthesis and application of inorganic semiconductors as electron transport/absorber materials in hybrid solar cells. The inorganic semiconductor nanoparticles are comprised of metal oxides such as TiO_2 and ZnO, as well as CdS and CdSe (in the form of spherical nanoparticles, nanotubes, and/or nanorods, etc).

Dye Sensitized Solar Cells

- Preparation and characterization of new polymer and gel electrolytes as substitutes for existing liquid electrolytes.
- Synthesis of new Ru(II) dyes based on polypyridine compounds and polymer conductors for hole transport.
- Synthesis and characterization of new coordination polymers.

Photocatalysis

- Research on the photocatalytic properties of several nanocomposites based on inorganic semiconductors for photocatalytic reduction of CO2 and water splitting.

This laboratory has strong ties to the Tezca Células Solares (Tezca Solar Cells) company, which produces and markets cells, and receives various inputs from the DyeSol company of Australia and Solaronix of Switzerland.

The North-East Center for Strategic Technologies (Cetene), an agency of the MCTI, develops, introduces and improves strategic technological innovations for the economic and social development of one of the poorest regions in the country. It focuses on three

[27]See http://lnes.iqm.unicamp.br

areas: biotechnology, nanotechnology and microelectronics. Within the NANO CETENE Network, several research efforts are underway on solar cells:[28]

Solar cells employing new adsorptive dyes in TiO2 and ZrO2 nanoparticulate films

- Development of a new photovoltaic system based on Ru composites and gold nanoparticles immobilized in nanoparticulate films, allowing for the creation of cutting-edge technology for the efficient and economical development of these technologies.

Structured films with nanoparticulate dyes for photovoltaic systems

- Development of new nanocrystalline nanostructured solar cells based on a multilayer process employing TiO2/Au or TiO2/CdSe films, or pure titanium dioxide (TiO2) nanotubes and with added dopants, thus seeking to increase the efficiency and performance of those devices. Apart from its innovative character, the project has a significant social and economic nature, leading to the development of a nanostructured photovoltaic systems market.

Nanostructured photochemical systems in the production of hydrogen for solar energy and its applications

- Technological development of a nanostructured photochemical system based on a multilayer process employing TiO2/Au or TiO2/CdSe films, or pure titanium dioxide (TiO2) nanotubes and with added dopants. The project is aiming for the stabilization of nanoparticles with CdTe and CdSe conductive polymers, as well as the functionalization among TiO2 nanoparticles and Quantum Dots (CdTe/CdSe). Various diameters of TiO2 nanoparticles and Quantum Dots were created through synthetic methods created in the CETENE.

Laboratory / Institution	Research areas	Contact	Industry links
Laboratório de Nanotecnologia e Energia Solar IQ/ Unicamp	• Organic and Hybrid Solar Cells • Dye Sensitized Solar Cells • Photocatalysis	Dr. Ana Flávia Nogueira anaflavia@iqm.unicamp.br Phone: +55 19 3521 3029 http://lnes.iqm.unicamp.br	Tezca Células Solares (Brazil) DyeSol (Australia) Solaronix (Swizerland)
Rede NANO CETENE. Centro de Tecnologías Estratégicas del Nordeste	• Células solares utilizando novos corantes adsorvidos em filmes nanoparticulados de	Dra. Giovanna Machado giovanna.machado@cetene.gov.br	

28 See http://www.cetene.gov.br/projetos/#topo

	TiO2 e ZrO2 • Filmes estruturados com corantes nanoparticulados para sistemas fotovoltaicos • Sistemas fotoquímicos nanoestructurados para produção de hidrogênio por energia solar e suas aplicações		

Source: Web search

Table 4.4-5 Institutions of special relevance in nano-energy research

4.4.4 Businesses working in nano-energy

The number of companies that are developing or using nanotechnology in Brazil is constantly growing. A survey of innovative companies conducted by PINTEC (2013) identified more than a thousand businesses that claimed to be doing so. However, few companies are involved in the application of nanotechnology to alternative renewable energies. In Table 4.4-6 we can see some of the businesses that are developing photovoltaic cells, fuel cells and related materials. We can see that these are primarily small businesses, some of them incubators in university technology centers or springing from university laboratories.

Company	Capital	City / State	R&D, product or process	Contact	Cooperation with Universities and Research Centers
Companhia Paranaense de Energia	Empresa Pública	Curitiba PR	Pesquisa em desenvolvimento de materiais poliméricos Pesquisa sobre geração de energia solar fotovoltaica isolada e conexão à rede de distribuição de energia	Henrique José Ternes Neto Diretor da Diretoria de Novas Energias da COPEL	Universidade Federal do Paraná Universidade Tecnológica Federal do Paraná
Eletrobrás - CEPel	Empresa de	Rio de Janeiro,	Tinta para absorver a luz		

(Centro de Pesquisa da Eletrobrás)	economia mixta (control mayoritario del gob. Federal de Brasil)	RJ	solar e gerar energia elétrica. Posse um Centro de Referência para Energia Solar e Eólica		
Eletrocell Células combustiveis	Nacional privado	São Paulo, SP	Células de combustible, periféricos y accesorios	Fone: 55 (11) 3039-8321/ 8309/ 8322 Fax: 55 (11) 3039-8337 http://www.electrocell.com.br/	Empresa incubada em el CIETEC, Universidad de São Paulo
Novo Filme	Nacional privado	Americana, SP	Placas Bipolares para Células a Combustível de Polímeros (PEFC	http://www.novofilme.com.br/ Valdemar Stelita Ferreira valdemar@novofilme.com.br tel 19 - 34073022	Laboratorio Nacional de Luz Sincrotron
Nanoselect	Nacional privado	Rio de Janeiro RJ	Desenvolve superfícies seletivas para coletores de energia solar, com alta capacidade de absorção de calor.	Nanoselect.com.br Luiz Carlos de Lima luiz@nanoselect.com.br 21 - 3733 1759	Incubada na REDETEC COOPE UFRJ
Tezca Pesquisa e Desenvolvimento de Células Solares LTDA	Nacional privado	Campinas, SP	Células solares de terceira geração (3G). Produz a célula solar TezcaFlexTM, utilizando uma nova concepção da tecnologia DSSC (Dye Sensitized Solar Cell), utilizada para a construção de módulos solares de vários portes e aplicações.	http://tezca.com.br/ Contato: Agnaldo de Souza Goncalves agnaldo.goncalves@tezca.com.br Polo tecnológico de Campinas	Laboratório de Nanotecnologia e Energia Solar (LNES) da Unicamp.
Horizon Fuel Cell technologies	Nacional privado	Curitiba PR	Desenvolvimento e promoção de tecnologias relacionadas às células a combustível de	horizonfuelcell-dna.html emilio @ horizonfuelcell.com	

			hidrogênio		
Solar Nanotecnologia Ltda (Ex Natucel)	Nacional privado	Fortaleza, CE	Células Fotovoltaicas Orgânicas ou Células Solares a Corantes Fotoexcitáveis		Incubada em PADETEC-Universidade Federal do Ceará (UFC) Colaboração com o Laboratório de nanotecnologia e Conversão fotovoltaica, UFC.

Source: Web search

Table 4.4-6 Businesses with nanotechnology applications in Alternative Renewable Energies

4.5 Mexico

The information related to nanotechnology R&D in Mexico is scattered, as no organization or institution tracks this information (see 3.5). The following report on the state of energy-related nanotechnology (nano-energy)[29] research in Mexico contains data that was gathered by exploring clusters of main institutions or organizations on a case-by-case basis.[30] In general terms, the search entailed the use of a set of key terms. We are aware that some information might have been left out in this report; unintentionally of course, as much of the information might have not been up to date or even available on line.

Most nano-energy research is located in seven clusters of organizations: Academic Clusters (AC) of the Ministry of Public Education–PROMEP, Research Centers of the National Council of Science and Technology (CONACYT), the National Polytechnic Institute (IPN), the National Autonomous University of Mexico (UNAM), the Center for Research and Advanced Studies (CINVESTAV) of the IPN, Research Institutions of the Mexican Government and private institutions. They will be analyzed in this order below. Since each cluster presents the information in a different way, the methodology was also adjusted for each case.

4.5.1 Academic Clusters (AC)–PROMEP

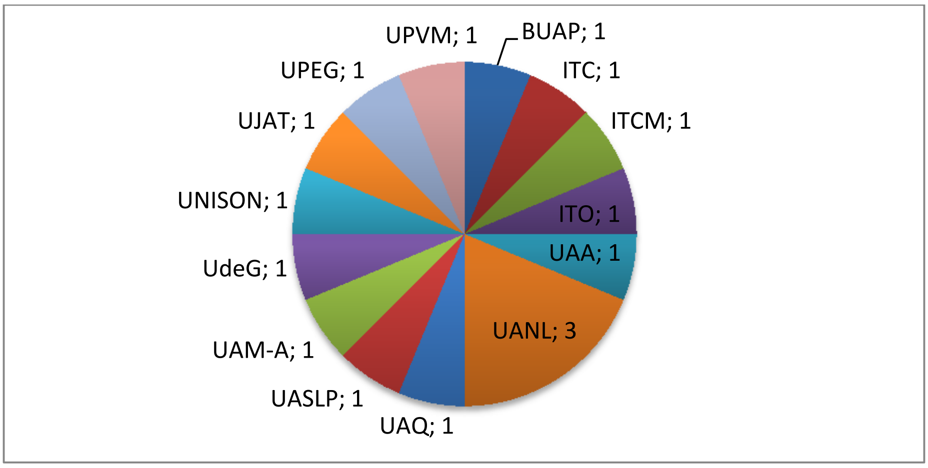
The AC program is an initiative of the Mexican Ministry of Public Education and is promoted simultaneously with the Professorship Development Program (PROMEP). The AC program was created to improve the research competence and scientific capabilities of the faculty attached to public universities, polytechnic universities and technological institutes (PROMEP, 2013). Each AC is brought together by a common research interest or topic with the main objective of generating new knowledge in the subject. Each AC is required to have at least 3 members and the program allocates resources to execute research plans, publish findings or encourage academic mobility (research visits, assistance to congresses, graduate studies). As of January 2013, 4 087 AC had been created (PROMEP, n.d.).

Methodology: First, we conducted a search using the AC program's search engine (http://promep.sep.gob.mx/ca1/) with the key word 'nano'. We obtained 106 AC that registered nano within their research area of interest. However, we eliminated five entries,

[29] For the purpose of this report, we did not include micro-electromechanical systems (MEMS) and nano-electromechanical systems (NEMS).
[30] By cluster we understand a group of institutions or research centers, part of a larger institution; or independent institutions that are part of an academic network.

as their research topic was not directly related to nanotechnology. We then explored each of the remaining 101 AC to assess the ones that were truly working with nano-energy. A quick search was performed using the following key words: energy, solar cells, photovoltaic, voltaic, hydrogen, fuel, catalyst, storage, batteries.[31] There are 66 researchers in 16 AC working with nano-energy related areas.

The 16 AC are distributed among 14 universities or institutions (Figure 4.5-1Figure 4.4-1). The Universidad Autónoma de Nuevo León (UANL) leads the way with 3 AC. All the other universities only have 1 AC. These are: the Benemérita Universidad Autónoma de Puebla (BUAP), the Instituto Tecnológico de Cancún (ITC), the Instituto Tecnológico de Ciudad Madero (ITCM), the Instituto Tecnológico de Oaxaca (ITO), the Universidad Autónoma de Aguascalientes (UAA), the Universidad Autónoma de Querétaro (UAQ), the Universidad Autónoma de San Luis Potosí (UASLP), the Universidad Autónoma Metropolitana-Azcapotzalco (UAM-A), the Universidad de Guadalajara (UdeG), the Universidad de Sonora (UNISON), the Universidad Juaréz Autónoma de Tabasco (UJAT), the Universidad Politécnica del Estado de Guerrero (UPEG) and the Universidad Politécnica del Valle de México (UPVM).



Source: Author's own research with PROMEP data (2014)

Figure 4.5-1 Number of AC per University or Institution working with nano-energy

16 AC have a research interest on nano-energy. Out of these, three are looking into solar energy (19%), another two are doing research in thermo-electrical properties of

[31] Unless explicitly specified, this set of key words will be later applied to the other centers/institutions.

nanomaterials and one is exploring the potential application of nanotechnologies in the fuel sector. The rest do not specify subtopic within nano-energy.All details are located inTable 4.13-1

4.5.2 Research Centers of CONACYT

The CONACYT´s Research Centers Platform clusters 27 research institutions in four broad areas of knowledge: exact and natural sciences, social sciences and humanities, technological innovation and development and graduate studies. To find all the research groups working with nano-enegy, we explored the CV´s of the personnel working at the Research Centers located in the exact and natural sciences, as well as the technologic innovation and development areas.

Methodology: We initiated the analysis by using a filter key word (nano*) in the search engine of each center. Then, we conducted a search (using the set of key words) to identify nano-energy related research. At the same time, we reviewed the CV´s of the researchers attached to the subdivisions that were most likely to have some interest with nanotechnology and energy (i.e., renewable energy, nuclear analysis, energy).

The Advanced Materials Research Center (CIMAV) has three researchers looking at the possible applications of new nanomaterials in the energy field. CIMAV also hosts a Doctorate in which nanotechnologies for energy is part of the curriculum. The Yucatan Center for Scientific Research (CICY) hosts researchers with an interest in advancing knowledge regarding nano-energy. The Potosi Institute of Scientific Research (IPICYT), the National Institute of Astrophysics, Optics and Electronics (INAOE) and the Center of Research and Technological Development in Electrochemistry (CIDETEQ), have an interest in advancing nano-energy research (explicit in some of their activities and statements); however, we could not pinpoint the names of the researchers looking at these issues (Table 4.13-2). 4 projects, out of 9 related to nano-energy, focus on solar energy.

4.5.3 National Autonomous University of Mexico (UNAM)

UNAM is the most important research institution in Mexico. Taking into account the number of students, faculty and funding, UNAM stands out as the largest university in Mexico and Latin America (with more than 340 000 students). In terms of nanoscience and nanotechnology publications, UNAM produces 25% of the total (Záyago Lau, Frederick, & Foladori, 2014).

Methodology: UNAM has several research centers or institutes with its own administration and resources. With this in mind, we decided to take a research route that required the use of each institute or center´s search engine. First, we used a website that provided the web addresses for all centers and institutes at UNAM (http://www.cic-ctic.unam.mx/cic/subsistema/institutos_centros.cfm). Later, we employed a basic filter key word (nano*) to find all data related to nanotechnologies. Then, we "cleaned" the results by using the set of key words to look for researchers, publications, presentations or research statements related to nano-energy.

The Institute of Renewable Energies (IER) concentrates most if its research on nano-energy. There are other centers that are also working in this area such as the Nanoscience and Nanotechnology Center (CNyN) in Ensenada, Baja California and the Center of Applied Physics and Advanced Technology (CFATA) (

Table 4.13-3). There are 18 research projects on nano-energy, out of which 14 are related to solar energy (78%). This illustrates the importance of solar energy in NT energy-applied research.

4.5.4 National Polytechnic Institute (IPN)

The IPN is the second most important research institution in Mexico. The IPN inaugurated, in 2009, the Center of Nanosciences and Micro and Nanotechnologies (CMN). The IPN, as part of the CMN, is nerve center of the Nanoscience and Micro-nanotechnology Network (NMN). This network has 146 members, all of them researchers of the IPN.

Methodology: We explored the CV´s of each member of the NMN (http://www.coordinacionredes.ipn.mx/redesip/rednano/Paginas/Miembros.aspx). In order to identify the research areas of interest for each scientist, we searched for any of the keywords previously used. We found that out of the 146 researchers, there are 21 that are doing research in nano-energy.

There are several centers that stand out. There is, for instance, the Research Center of Applied Science and Advanced Technologies (CICATA) in Altamira and the CICATA in Legaria; each one hosts four researchers looking at the potential application of NT in energy (

Table 4.13-4). The IPN has 32 projects on nano-energy; at least 18 of them (56%) are oriented towards advancing knowledge of NT applications for solar energy.

4.5.5 Center for Research and Advanced Studies (CINVESTAV) of the IPN

Initially, CINESTAV was created, in 1961, as a Research Center part of the IPN system; however, in 1982, it acquired financial, administrative and legal independence. Today is one of the most important research centers regarding the advancement of scientific knowledge in the country. It has 10 sub-centers in different states. It has 4 research areas: exact and natural sciences, biological and health sciences, technology and engineering and social sciences and humanities.

Methodology: We explored the profiles of each researcher in the following departments: exact sciences, biological and health and technology and engineering. The analysis included a search for the set of keywords previously used after an initial search of the term nano* and nanotechnology within the search engine of each site. We found two researchers with an interest in nano-energy, one in CINVESTAV-Merida and another in CINVESTAV-Saltillo, thus there are two projects related to nano-energy (Table 4.13-5)

4.5.6 Research Centers of the Mexican Government

The main institution overseeing energy policy and development is the Ministry of Energy (ME) of the Mexican Federal Government. The ME has subdivisions that are associated with matters of energy research and development (R&D). There is the Mexican Institute of Petroleum (IMP), which is the recipient of most funding to advance any innovation that would lead to maximize the benefit from oil exploitation. The IMP is closely tied to the State owned Oil Company, Petroleos Mexicanos (PEMEX). Another important institution is the Institute of Electrical Research (IIE), and similar to the IMP, is very close to another State owned company, the Federal Commission of Electricity (CFE). The National Institute of Nuclear Research (ININ) was another source of information.

Methodology: In addition to use the set of key words in each search engine, we explored the annual reports of each state-owned company (CFE & PEMEX). We also looked for information inside the websites of the IMP, PEMEX and the ININ. To obtain the data, we followed this strategy: first, we conducted a search for the key word nano*; later (within the results), we tried to identify any entry that would be energy related and then looked for any keyword to classify the data. We found three projects related to nano-energy: one is tied to the area of solar energy (Table 4.13-6).

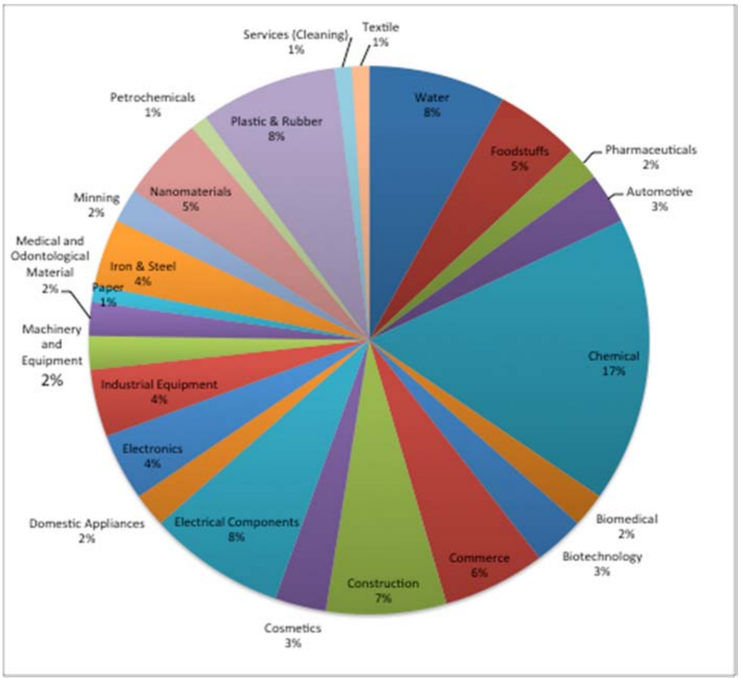
4.5.7 Private Institutions

There are only two institutions that we managed to identify that are working with nano-energy. One is KEMET, a U.S. based transnational corporation that has a subsidiary in Mexico. This company is part of a research network to advance nano-energy in Iberoamerica (Red Nanoenergía, n.d.). The other private institution is the Monterrey Institute of Technology and Higher Education (ITESM), which is developing fuel cell technology.

4.5.8 Additional Search Strategies

In order to expand the reach of the search strategies implemented in the latter sections, we dedicated some time to review the calls for funding in the area of nanotechnology. The most important source of this data were the calls made public by CONACYT. We were able to track all the grants allocated to foster nano-energy research in Mexico within public universities and centers by consulting the CONACYT website. It is worth mentioning, however, that the data only refers to the main researcher; thus it does not provide information if he or she was part of a larger research group.Table 4.13-7 shows the results of several calls to fund nanotechnology research projects. There are several modalities with a different set of information, and some of them did not have data available online at the time of the analysis. We ignore the amount of funding that each program allocated, as it was not available online. Only one fund issued calls explicitly for nanotechnology: FOMIX (Chihuahua 1; Morelos 1; Querétaro 1; Tamaulipas 3; Nuevo León 6). Table 4.13-7 also shows that only 1.3% of calls were intended for nanotechnology research; from those, only one project focused on nano-energy, sponsored by SENER and CONACYT.

Another indirect way of illustrating the importance of nano-energy research in Mexico is to take into account the number of companies per area. In 2012, a group of researchers (members of the Latin American Nanotechnology and Society Network (ReLANS)) conducted a survey to identify how many companies where using nanotechnology in their manufacturing process or were commercializing nanotechnology based products in Mexico (Záyago, Foladori, & Arteaga, 2012). The following figure shows the distribution per area of the 101 companies that were found. In this figure we observe only 1% of the companies are located in the petrochemical sector, which might be related to the energy field.



Source: (Záyago et al., 2012)

Figure 4.5-2 Percentage of companies working with nanotechnologies per sector in Mexico

4.6 Argentina

To uncover the groups and research projects in nano-energy, a collection of secondary sources were consulted, such as: the book *Who is who?*(FAN, 2012), reports, websites of the different science & technology bodies, lists of projects funded by the Ministry of Science, Technology and Productive Innovation and the National Agency for the Promotion of Science and Technology, among others. The searches were undertaken between the 3rd and 21st of March, 2014 and were based upon the standardized classification categories of developments in energy.

There is no organization that serves as a hub for these kinds of research in Argentina. Neither are there specialized events, and in many cases, even if a group works on the topic, there does not appear to be any institution specializing in it. The results are provided in Table 4.6-1. From the 28 research groups or projects, 6 of them (21%) focus on solar energy, another 21% in catalysis and 19% on storage.

Topic	Source: FAN (FAN, 2012) or indicated
Solar	Grupo Optoelectrónica. Universidad Nacional de Rio Cuarto (UNRC). Fernando Fungo ffungo@exa.unrc.edu.ar Otros participantes: Luis Otero, Miguel Gervaldo, Javier Durantini, Marisa Santo, Lorena Macor, Gabriela Marzari, Luciana Fernández, Edgardo Durantini, Daniel Heredia
Solar	Grupo Química de los materiales. Comisión Nacional de Energía Atómica. Galo Soller-Illa gsoler@cnea.gov.ar
Solar	Grupo solar. Centro Atómico Ezeiza, Comisión Nacional de Energía Atómica (CAA-CNEA). Félix Palumbo palumbo@cnea.gov.ar
Solar Cells	Departamento Energía Solar. Centro Atómico Constituyentes, Comisión Nacional de Energía Atómica (CAC-CNEA). Juan Plá jpla@tandar.cnea.gov.arwww.tandar.cnea.gov.ar/grupos/solar/
Solar Cells	Nanoproject-UNT. Universidad Nacional de Tucumán. David Comedi (Director), David Mario-Tirado, Mónica Cecilia, Di Carlo Paulo dcomedi@herrera.unt.edu.arhttp://www.herrera.unt.edu.ar/nano/publications.html
Solar Cells	Ciencia de los materiales. Universidad Nacional de Córdoba (UNC-Conicet). Noelia Bajales Luna bajalesluna@famaf.unc.edu.arwww.famaf.unc.edu.ar
Wind	Materiales Compuestos Matriz polimérica. Instituto de Investigaciones en Ciencia y Tecnología de Materiales (INTEMA-CONICET). Vera Alejandra Álvarez alvarezvera@fi.mdp.edu.ar
Fossil fuels	Laboratorio de caracterización de materiales. Diego Hernán Lamas diego_german_lamas@yahoo.com.arhttp://fainweb.uncoma.edu.ar
Fossil fuels	Lelio Da Silva ldasilvag@ypf.com(Gerente Dirección Tecnología de E&P en YPF S.A.). Desarrollo de Nanoproductos en Sist. Roca-Fluido Desarrollo de Nanoproductos para Ind. Petrolera FAN RP FS2012
Catalysis	Grupo División Celdas de Combustible de Óxido Sólido. Centro de Investigaciones en Sólidos (CINSO - UNIDEF - CONICET – MINDEF). Susana Adelina Larrondo slarrondo@citedef.gob.arwww.cinso-citefa.conicet.gov.ar

Catalysis	Grupo “NANOTEC” (Centro de Investigación en Nanociencia y Nanotecnología). Universidad Tecnológica Nacional-UNC. Andrea Raquel Beltramone abeltramone@scdt.frc.utn.edu.arwww.investigacion.frc.utn.edu.ar/nanotec/
Catalysis	Grupo “LAFMACEL (Laboratorio de fisicoquímica de Materiales Cerámicos Electrónicos)”. Grupo “Fisicoquímica-Área: Catálisis ambiental”. Universidad de Buenos Aires (FI – UBA). Silvia Elena Jacobo sjacobo@fi.uba.arhttp://laboratorios.fi.uba.ar/lafmacel/index.php
Catalysis	Eduardo Miró emiro@fiq.unl.edu.arwww.fiq.unl.edu.ar/incape/ UNL. Desarrollo películas micro y nanométricas para procesos catalíticos. Materiales nanoestructurados. Instituto de Investigaciones en Catálisis y Petroquímica (INCAPE). FAN RP: PICT-2008-1053.
Catalysis	Grupo “Investigaciones Aplicadas a la Petroquímica. Subgrupo Hidrogenaciones selectivas”. Instituto de Investigaciones en Catálisis y Petroquímica (INCAPE). Mónica Quiroga mquiroga@fiq.unl.edu.arhttp://www.fiq.unl.edu.ar/incape/gap/
Catalysis	Grupo “Computer Simulation of Nanomaterials”. Instituto de Investigaciones en Físico-química. Universidad Nacional de Córdoba. (INFIQC – UNC). Marcelo Mariscal marcelo.mariscal@conicet.gov.ar http://nanomaterials.yolasite.com/research.php
Bio-fuel	Grupo “Química de Nanomateriales”. Comisión Nacional de Energía Atómica. (CNEA DQIAyQF, FCEN, UBA). Pablo Scodeller scodeller@qi.fcen.uba.arwww.cnea.gov.ar
Hydrogen	Fisicoquímica - Área Hidrógeno – Membranas. Facultad Ingeniería Química. Universidad Nacional de La Plata (UNLP). Laura Cronaglia (dir.); Eduardo Lombardo lmcornag@fiq.unl.edu.ar; lombardo@fiq.unl.edu.ar
Electric-lighting	Nanoproject-UNT. Universidad Nacional de Tucumán. David Comedi (Director), Mario-Tirado, Mónica Cecilia, Di Carlo Paulo dcomedi@herrera.unt.edu.ar
Storage Lithium battery	Raúl Chialva, Raúl Cometto info@pla-ka.com.ar tel: (351) 451-6079. Pla-Ka S.A. Facultad de Matemática, Astronomía y Física (Famaf), Universidad Nacional de Córdoba (UNC). Daniel Barraco. barraco@fis.uncor.edu Company
Storage Lithium battery	Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas **(Inifta),** Universidad Nacional de La Plata (UNLP) Guillermo Garaventta. garaventa@inifta.unlp.edu.ar
Storage	Grupo “Vidrios Calcogenuros” Instituto de Tecnologías y Ciencias de la Ingeniería. Universidad de Buenos Aires (INTECIN-UBA – CONICET). Bibiana Arcondo barcond@fi.uba.arhttp://intecin.fi.uba.ar/grupos.php?grupo=14
Catalyze	Abel César Chialvo. Electrocatálisis a nanoescala aplicada a reacciones de interés en la conversión electroquímica de energí Conicet Project, PIP 2012- 2014 GI 11220110100674.a.
Storage	Grupo “Laboratorio de Patrones Cuánticos”. Instituto Nacional de Tecnología Industrial (INTI). atonina@inti.gob.ar
Storage	IND ARRA DTX. Empresa. info@indarradtx.comwww.indarradtx.com
Other non-specific	Oscar Anunziata. Diseño, síntesis y caracterización de Materiales Nanoscópicos y Nano-especies activas y sus aplicaciones en Energía, Medio Ambiente y Bioingeniería. Conicet Project. PIP 2013-2015 GI. 11220120100218.

Source: Author’s own research.

Table 4.6-1 Nano-energy research groups and researchers in Argentina (Research performed February–April 2014)

4.7 Chile

In Chile there is no database which identifies research groups in nanotechnology by topic. The following research was performed by revising publications on the topic and the websites of the key universities involved in nanotechnology research (Universidad de Chile, Universidad de Santiago de Chile, Universidad Técnica Federico Santa María, Universidad Andrés Bello, Pontificia Universidad Católica de Chile). The results of the study appear in the following Table 4.7-1. As might be anticipated, very few groups were identified:

Topic	Research Group	Contact
Storage Batteries	Centro de Innovación del Litio (CIL). http://www.pcil.cl/wp-content/uploads/2012/05/LIBRO-VERDE-PROYECTO-CENTRO-INNOVACION-DEL-LITIO-FEB-20111.pdf	• Edgar Mosquera. U. de Chile, edemova@ing.uchile.cl • Guillermo González. U. de Chile, ggonzale@uchile.cl • Tomás Vargas; U. de Chile. tvargas@ing.uchile.cl
Solar Cells	Department of Material Science. U. de Chile	• Francisco Martínez. U. de Chile polimart@ing.uchile.cl • Octavio Vázquez
Renewable energy	Cedenna. U. de Santiago	Contact director: Dora Altbir dora.altbir@usach.cl

Source: Author's own research.

Table 4.7-1 Nano-energy research groups and investigators in Chile (Research performed February–April 2014)

4.8 Colombia

The platform of Colciencias (ScienTI) offers a research mechanism for scientific research groups registered in Colombia. A search for research groups working on nanotechnology and nano-energy was performed using the Colciencias website (http://201.234.78.173:8083/ciencia-war/ and http://201.234.78.173:8083/ciencia-war/). This information was supplemented with other data drawn from university websites; further, information on research groups drawn from other sources was identified, as well as from personal knowledge, which the Colsciencias search effort did not initially reveal. The search of the Colciencias database (January & February 2014) using the prefix "nano" reported 25 research groups, and seven of them with research on nano-energy (Table 4.8-1). The Colombian groups participating in the NanoEnergy Cyted Network were added, raising the total to 19 groups working on nano-energy. The sub-area of nano-energy could not be identified in all cases.

Research Group	TopicTopic	Institution, Web page & coordinator

Grupo de Energía y Termodinámica	• Gasificación y Combustión • Gestión y Tecnología • Modelización y Simulación • Nuevas Tecnologías • Nanotecnología • Optimización y Uso Racional de Energía (URE) • Termodinámica Avanzada	Universidad Pontificia Bolivariana Whady Felipe Flórez Escobar whady.florez@upb.edu.co Vladimir Martínez
Laboratorio de investigación en combustibles y energía	• Biomasa y procesos de conversión • Carbón, procesos de conversión y carboquímica • Carbón activado, producción, caracterización y aplicaciones • Gas natural, combustibles sintéticos y síntesis de fischer –tropsch • Nuevos materiales y procesos • Nanotecnología • Petróleo, refinación y petroquímica • Recursos energéticos y medio ambiente	Universidad Nacional De Colombia José De Jesús Díaz Velásquez http://www.quimica.unal.edu.co jddiazv@unal.edu.co
Grupo de Nanociencia y Nanotecnología Universidad Javeriana	• Salud • Energía • Remediación ambiental • Nanomateriales	Pontificia Universidad Javeriana http://gnano.javeriana.edu.co Edgar Emir Gonzalez Jimenez egonzale@javeriana.edu.co
Fisicoquímica y bio y nanomateriales	• Bio y Nanomateriales para aplicaciones en Ingeniería • Electroquímica Básica y Aplicada • Fuentes de energía • Materiales y Procesos para tratamientos en Salud	Universidad del Valle (UNIVALLE) Rubén Camargo Amado ruben.camargo@correounivalle.edu.co Rubén Vargas
Materiales y nanotecnología	• Caracterización de materiales por microscopía de sonda de barrido • Caracterización y análisis de materiales por técnicas de barrido y espectroscopia • Crecimiento y caracterización de recubrimientos duros y superduros • Energía solar: Materiales, dispositivos y sistemas • Food Materials Science • Producción y caracterización de materiales por electroquímica	Universidad del Cauca (UNICAUCA) Wayner Rivera Márquez wrivera@unicauca.edu.co
Grupo de películas delgadas y nanofotónica	• Cristales Fotónicos • Energías renovables • Espectroscopía uv vis e ir • Física de Películas Optoelectrónicas • Instrumentación Tecnológica • Semiconductores orgánicos	Pontificia Universidad Javeriana Luis Jiménez cjimenez@javeriana.edu.co Juan Carlos Salcedo Reyes
REM (research in energy and materials)	• Aplicaciones de la ingeniería de materiales en el sector automotor • Nanomateriales	Universidad Antonio Nariño Diana Maritza Marulanda Cardona

	• Polímeros • Procesos de manufactura • Eficiencia energética • Desarrollos en control y automatización para el análisis de fallas usando Tomografía de Impedancia Eléctrica (TIE)	grupo.rem@uan.edu.co
Grupo en Combustibles Alternativos, Energía y Protección Ambiental	•	Universidad Nacional de Colombia Helmer Acevedo
Grupo de Investigación en Energía y Medio Ambiente	•	Universidad Industrial de Santander José Luis Chacón Velasco
Transiciones de Fase en Sistemas No-Metálicos GTFNM	•	Universidad del Valle Rubén A Vargas
Procesos Fisioquímicos Aplicados	•	Universidad de Antioquia Gloria Restrepo
Grupo de Automatización Industrial y Control	•	Universidad Tecnológica de Bolivar José Luis Villa
Materiales de Ingeniería	•	Universidad Eafit Alex Ossa
Grupo de Bionanoelectrónica	• Computational design of graphene-based digital circuits and nanosensors • Computational design of carbon-based nanomachines and carbon-based nanodevices for nano drug delivery systems	Universidad del Valle Jaime Velasco Medina jaime.velasco@correounivalle.edu.co http://bionano.univalle.edu.co/english/english index.html
Centro de Investigación Innovación y Desarrollo en Materiales	•	Universidad de Antioquia Franklin Jaramillo
Línea Micro y nanotecnologías	•	Universidad de los Andes Alba Ávila Bernal
Materiales Avanzados Grupo de Micro y Nanotecnología	•	Universidad Autónoma de Occidente Faruk Fonthal Rico
Grupo de Materiales Semiconductores y Energía Solar	•	Universidad Nacional de Colombia Gerardo Gordillo
Procesos Ambientales y Biotecnológicos	•	Universidad EAFIT Edison Gil Pavas

Source: Author’s own research, drawn from: http://201.234.78.173:8083/ciencia-war/

Table 4.8-1 Nano-energy research groups and investigators in Colombia (Research performed January–February 2014)

4.9 Uruguay

Uruguay has several research groups on nanotechnology. Although most in the Universidad de la República, there are also some other research centers underdoing nanotechnology and also nano-energy.

Methodology. The following websites were reviewed: The Nanotechnology, Chemistry and Material Physics Interdisciplinary Center of the Universidad of the Republica (CINQuiFiMa), which hosts a series of laboratories and institutes that work in nanotechnology (http://cryssmat.fq.edu.uy/CINQUIFIMA/index_archivos/Page600.htm); as well as the Faculty of Science, the Faculty of Engineering, and the Eastern Region University Center of the Universidad de la Republica; the Clemente Estable Biological Research Institute of the Ministry of Education and Culture (http://www.iibc.edu.uy/DPAN/docencia.htm); the Uruguay Technological Laboratory (LATU); the ORT University (Faculty of Engineering); the Montevideo Pasteur Institute; as well as documents on the topic, such as the report from the Promesur consultant on nanotechnologies (http://medios.presidencia.gub.uy/jm_portal/2012/noticias/NO_G524/) and the book *Nanotecnologías en Uruguay* (Universidad de la República, 2013). This information was compared with the curriculum vitaes of the researchers according to their self-identified field in nanotechnologies within the database of the National Agency for Research and Innovation (ANII) (http://www.anii.org.uy/web/node/67). The results of that effort are shown in Table 4.9-1. Uruguayan researchers were also identified who participate in the Nano-Energy Network of the CyTED. The research categories in nano-energy correspond in general terms to those used across Latin America. As we see, the great majority of the researchers within the area work on solar energy.

Research Center / Institution	**Department**	**Principal Investigator / Coordinator**	**Topic**	**Energy category**
Centro Universitario Regional del Este (CURE), UdelaR	Grupo de Semiconductores Compuestos	Laura Fornaro	Desarrollo de **celdas solares** híbridas polimérico-inorgánicas	Solar Cells
Facultad de Química. UdelaR	Departamento Estrella Campos (DEC) - Cátedra de Radioquímica	Mauricio Rodríguez Chialanza mrodrig@fq.edu.uy (Coordina Laura	Desarrollo de nanovitrocerámicos como convertidores espectrales para aumentar la eficiencia de celdas solares	Solar Cells

		Fornaro del CURE)		
Facultad de Química. UdelaR	Cátedra de Física/Laboratorio de Cristalografía /Centro NanoMat - DETEMA	Alvaro Mombrú amombru @ fq.edu.uy	Desarrollo de materiales para aplicación en celdas solares fotovoltaicas	Solar Cells
Facultad de Química. UdelaR	Cátedra de Física/Laboratorio de Cristalografía /Centro NanoMat – DETEMA	Helena Pardo hpardo@fq.edu.uy	Empleo de grafeno para la fabricación del electrodo de ventana y del contraelectrodo en Dye-sensitized solar cells (DSC); nuevos nanomateriales sensibilizados con tintas convencionales. (Red CYTED Nanoenergía)	Solar Cells
Facultad de Química. UdelaR	Cátedra de Física/Laboratorio de Cristalografía /Centro NanoMat – DETEMA	Ricardo Faccio rfaccio@fq.edu.uy	Se preparan titatanatos nanoestructurados como semiconductores , y se diseñan nuevas tintas/pigmentos para su uso en celdas solares. Diseño y preparación de materiales nuevos materiales conductores de Li+, cerámicos y nanoestructurados, para almacenamiento de Energía en baterías de litio	Solar Cells Batteries
Facultad de Química. UdelaR	DETEMA	Pablo Denis pabod@fq.edu.uy	Diseño de materiales derivados del grafeno para almacenar Hydrogene Celdas solares sensibilizadas por colorante (Dye Sensitized Solar Cells, DSSC)	Hydrogen storage Solar cells
Facultad de Química. UdelaR	Cátedra de Física/DETEMA	Leopoldo Suescun leopoldo@fq.edu.uy	Preparación y caracterización de nuevos materiales para IT SOFCS (celdas de combustible de óxido sólido de temperatura intermedia)	Fuel cells
Facultad de Ingeniería. UdelaR	Laboratorio de Física del Estado Sólido. Instituto de Física	Enrique Dalchiele	Materiales semiconductores nanoestructurados para aplicaciones en celdas solares fotovoltaicas	Solar cells
Facultad de Ingeniería. UdelaR	Laboratorio de Física del estado sólido - Instituto de Física	Ricardo Marotti	Materiales Nanoestructurados para Conversión de Energía (nanohilos -incluyendo nanotubos) semiconductores y estructuras compuestas. Potenciales aplicaciones de estos materiales para conversión de energía, principalmente para celdas solares fotovoltaicas, pero también en superficies selectivas para colectores solares.	Solar cells Solar collectors
Facultad de	Departament	Ariel	Células de óxido sólido para	Fuel cells

Ciencias. UdelaR	o de Física Aplicada y de Materiales - Instituto de Física	Moreno moreno@fisica.edu.uy	producción de energía a partir de fuentes renovables	
Facultad de Ciencias. UdelaR	Laboratorio de Biomateriales Instituto de Química Biológica.	María Fernanda Cerdá fcerda@fcien.edu.uy	Optimización de fotosensibilizadores naturales para su uso en celdas de Graetzel(DSSC)	Solar cells

Source: manual search on the database of ANNI by Cvitae of the researchers.
http://www.sni.org.uy/investigadores_sni?area=1; http://www.sni.org.uy/investigadores_sni?area=2

Table 4.9-1 Nano-energy research groups and investigators in Uruguay (Research performed March-April 2014)

4.10 Conclusions

In Latin America the research on nano–energy applications - as it was the case for health and water- is conducted by public institutions. There are a handful of companies (State owned or private), and the majority is located in Brazil.

In the first twelve years of this century, between 800 and 900 scientific articles were published, depending on the source. There is an evident growth after 2008, which shows the novelty of the field in the region.

The thematic distribution of the scientific articles is as follows: slightly more than one quart were articles about photovoltaic energy; slightly less than one quart on fossil fuels; followed by energy storage and energy transport with around 12% each.

The consistent growth, however, is observed in articles dedicated to photovoltaic research. In Brazil and Mexico more than half of the research projects of the most important institutions are focused on solar energy. Brazil, for instance, has 37 groups doing research in nano–energy areas, but almost 40% is looking at solar energy while 5 groups are focused on fossil fuels. Out of the 122 National Science and Technology Institutes in Brazil, 5 are doing research on nano–energy related areas, and 4 are advancing solar energy research. In Mexico, close to 80% of all research projects on nano–energy of the Universidad Nacional Autónoma de México are oriented towards solar energy; and the National Polytechnic Institute has more than half focusing in this area. Brazil leads the way in nano–energy related research, followed by Mexico and then Argentina.

The US is the main research partner of the region and for the case of the European Union both France and Spain stand out. Within the region most collaborations are between Brazil and Argentina

4.11 Annex A

List of member countries of the Latin American and Caribbean Community:

Antigua y Barbuda
Argentina
Bahamas
Barbados
Belize
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominica
Ecuador
El Salvador
Granada
Guatemala
Guyana
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Paraguay
Peru
Dominican Republic
San Cristóbal and Nieves
Saint Vicente and The Grenadines
Saint Lucia
Surinam
Trinidad and Tobago
Uruguay
Venezuela

4.12 AnnexB

Annex B is the reference appendix for the bibliometric analyses in 4.2.

4.12.1 Definitions

Affiliation: By affiliation we refer to a unique author-institution combination related to**one Record**. The same author can be affiliated with several institutions within one

Single record. If this is the case, we consequently count several affiliations. Therefore, publications with one author, but two affiliations, one in Mexico and one in France, are included in the analysis and considered a co-publication. The number of affiliations in the EU-LA co-publications therefore shall not be confused with the number of authors.

Categories and main categories: The two scientific literature databases used in this study assign the recorded books or periodicals to one or more thematic key words based on a classification system. In Elsevier's *Scopus* we have around 340 of these thematic keywords (as listed in the following). Only a small percentage of the scientific works is classified independently of the general classification of the periodical.

Co-publication: In the context of this study we refer to international scientific publications, indexed in literature databases, with the participation of at least two institutions/organisations in at least two different countries. For this study the term co-publication therefore is only used for international co-publications, unless explicitly stated otherwise.

Document types:*Scopus* assigns a certain document type to the tracked publications to better describe them. These types reach from articles over abstracts and conference papers to editorials, errata and even music, movie or software reviews.

Institute/Organisation: Because the scientific literature database *Scopus* used in this study relates authors to different organisational entities (i.e.: in one case the university as a whole is named, in another case we have detailed description of the institute or even the research group, etc.), we agreed on the usage of the label "institute" for the more detailed, subordinate level often called "organisational unit" (university institute, department, laboratory, sub entity of a company or international organisation) and the term "organisation" as the bigger entity, for example university, academy or intergovernmental organisation, etc.

4.12.2 Set of Keywords

"nano":scanning probe microscopy, nanoscience, nanoparticle, nanomaterials, nanomanipulation, nanoindentation, nanoimprint lithography, nanofiltration, nanofibers, nanocrystals, nanobiotechnology, molecular electronics microfluidics, microfabrication, mems, gold nanoparticles, electrospinning, electron beam lithography, chitosan; technology, carbon nanotubes, atomic force microscopy, nanotribology, nanorobotics, nanomachining, nanofluidics, nano-integration, nanosensors, nanochips, nanodevices, nanomagnetism, nano-optics, nanoelectronics, nanophysics, nanoscale fullerenes, nanoscale thin films, quantum wells, quantum wires, quantum dots, nanoclusters, nanocrystalline materials, nanocomposites, nanoprobes, nanofabrication, nanolithography, nems, nanoelectromechanical systems, nanotextiles, nanotoxicology, nanostructure, nanomedicine, nanomaterials, nanobiophysics, nanorods, nanoparticles, nanowires, nanotubes, nanotechnology

4.12.3 List of countriesfor ZSI's bibliometric study

ERA	CELAC
Austria	Antigua Barbuda
Belgium	Argentina
Bulgaria	Bahamas
Croatia	Barbados
Cyprus	Belize
Czech Republic	Bolivia
Denmark	Brazil
Estonia	Chile
Finland	Columbia
France	Costa Rica
Germany	Cuba
Greece	Dominica
Hungary	Dominican Republic
Ireland	Ecuador
Italy	El Salvador
Latvia	Grenada
Lithuania	Guatemala
Luxembourg	Guyana
Malta	Haiti
Netherlands	Honduras
Norway	Jamaica
Poland	Mexico
Portugal	Nicaragua
Romania	Panama
Serbia	Paraguay
Slovakia	Peru
Slovenia	Puerto Rico
Spain	Saint Kitts and Nevis
Sweden	Saint Lucia
Switzerland	Saint Vincent and the

Turkey United Kingdom	Grenadines Suriname Trinidad and Tobago Uruguay Venezuela

4.13 AnnexC

Annex C provides additional tables accompanying the analysis of research centers in nanotechnology and energy as treated in 4.5.

4.13.1 Tables for Mexico

AC #	Institution	Name of the AC	Area or science	Description	Members	sector
9	Instituto Tecnológico de Cancún	ITCAN-CA-1 - Turismo, Desarrollo y Tecnologías Sustentables	Ingeniería y Tecnología /manejo de recursos naturales y desarrollo sustentable	Desarrollo de tecnologías y materiales para el medio ambiente:	Ben Youseff Brants Cherifcherifby@itcancun.edu.mx -Guillen Arguelles Elisa elisaguillen@yahoo.com Koh Puga Fernando Antonio Ferkoh@Yahoo.Com.Mx - Torres Rivero Ligia Adelayda torlia@hotmail.com - Verde Gómez José Ysmael ysmaelverde@yahoo.com	Energy. Environmental remediation
15	Instituto Tecnológico de Oaxaca	Itoax-ca-4 - ciencia de materiales y química ambiental	Ciencias Naturales y Exactas/ciencias químicas	Desarrollo de materiales nanoestructurados.	Nd	Energy. Cells hydrogen. Environmental remediation
22	Universidad Autónoma de Aguascalientes	UAA-CA-106 - química y biorremediación	Ciencias Naturales y Exactas/químico ambiental	Química, organometálica y materiales:	Chavez Vela Norma Angelica Nachavez@Yahoo.Es - Jauregui Rincón Juan Jjaureg@Correo.Uaa.Mx -Medina Ramirez Iliana Ernestina Iemedina@Correo.Uaa.Mx	Energy Environmental remediation
27	Universidad Autónoma de Nuevo León	UANL-CA-29 - Física Aplicada	Ciencias Naturales y Exactas/física aplicada	Síntesis y caracterización de materiales nanoestructurados	Guerrero Villa Héctor Martín Zeromex88@Hotmail.Com -Obregón Guerra Ricardo Ricardo.Obregongr@Uanl.Edu.Mx -Rodríguez Ramírez Francisco Francisco_Rdz_Rmz@Hotmail.Com -Salinas Estevane Juan Pablo	Energy. Storage

					Jsestevanee@Yahoo.Com	
35	Universidad Autónoma de Nuevo León	UANL-CA-312 - Ciencias Aplicadas a la Ingeniería	Ciencias Naturales y Exactas/FÍSICA	Aplicaciones de la física moderna a la ingeniería	Basin Mikhail Valentinovich Mbasin@Fcfm.Uanl.Mx -Jiménez Lizárraga Manuel Alejandro Manalejimenez@Yahoo.Com -Kharissova Oxana Vasilievna Okhariss@Mail.Ru -Morones Ibarra José Rubén Rmorones@Fcfm.Uanl.Mx	Energy
37	Universidad Autónoma de Querétaro	UAQ-CA-111 - nanotecnología	Ingeniería y Tecnología /ciencia e ingeniería de materiales	Desarrollo de materiales nanoestructurados para ingeniería sustentable	-Ledesma Garcia Janet Janet.Ledesma@Uaq.Mx -Nava Mendoza Rufino Rufino@Uaq.Mx -Serroukh Ibrahim Ibrahim@Uaq.Mx	Energy. Environmental remediation
71	Universidad de Guadalajara	UDG-CA-676 - Energía y Medio Ambiente	Ciencias Naturales y Exactas/MEDIO AMBIENTE	Estudio de materiales para aplicaciones de conversión energética	-Carreon Alvarez Maria Alejandra Alejandra.Carreon@Profesores.Valles.Udg.Mx -Castañeda Valderrama Rocio Rcvalderrama@Profesores.Valles.Udg.Mx -Sanchez Moreno Lilia Francisca Lifrasan@Hotmail.Com -Sanchez Tizapa Marciano Masatster@Gmail.Com -Suarez Gomez Amaury Amaury.Sg@Gmail.Com	Energy. Environmental remediation
81	Universidad de Sonora	UNISON-CA-133 - física de radiaciones	Ciencias Naturales y Exactas/física	Estudio de las propiedades luminiscentes de materiales nanofosforos y microfosforos de alta eficiencia de recombinacion (superluminiscentes)	-Barboza Flores Marcelino Mbarboza@Cajeme.Cifus.Uson.Mx -Castañeda Medina Beatríz Del Carmen Bcastaneda@Correo.Fisica.Uson.Mx -Chernov Valery Chernov@Cifus.Uson.Mx -Meléndrez Amavizca Rodrigo Rodrigo@Ciencias.Uson.Mx -Pedroza Montero Martín Rafael Mpedroza@Cajeme.Cifus.Uson.Mx -Santacruz Gomez Karla Josefina Santacruzkarla@Gmail.C	Energy. Optic

					om	
95	Universidad Politécnica del Valle de México	UPVM-CA-2 - Ingeniería de Materiales y Procesos		Desarrollo y caracterización de materiales y nanomateriales	Juanico Lorán José Antonio Jjuanico@Upvm.Edu.Mx - Rangel Lara Saúl Mc_Saul@Hotmail.Com -Rodriguez Avila Jafeth Jafethra@Hotmail.Com - Vilchis Bravo Heber Heber_Vil@Hotmail.Com	Energy. Medical devices
7	Benemérita Universidad Autónoma de Puebla	BUAP-CA-275 - Semiconductores Nanoestructurados y Orgánicos	Ingeniería y Tecnología /semiconductores	Nanomateriales y nanoestructuras	-Carrillo López Jesús Jesus.Jecarril@Gmail.Com -Flores Gracia José Francisco Javier Pacofloresgracia@Gmail.Com -Hernández De La Luz José Álvaro David Joalvada1@Hotmail.Com -Luna López José Alberto Jose.Luna@Correo.Buap.Mx -Martínez Juárez Javier Javmartinez11@Gmail.Com -Sosa Sánchez José Luis Jose.Sosa@Correo.Buap.Mx	Solar cells
40	Universidad Autónoma de San Luis Potosí	UASLP-CA-24 - materiales optoelectrónicos (iico)	Ciencias Naturales y exactas/ciencia de materiales	Nanotecnología orgánica electroactiva: síntesis y caracterización de nanoestructuras. Aplicación a dispositivos orgánicos electroactivos. Fabricación y caracterización de celdas fotovoltáicas orgánicas nonoestructuradas.	-Balderas Navarro Raúl Eduardo Rbn@Cactus.Iico.Uaslp.Mx -Lastras Martínez Alfonso Alastras@Gmail.Com - Lastras Martínez Luis Felipe Lflm@Cactus.Iico.Uaslp.Mx -Ortega Gallegos Jorge Jortega@Cactus.Iico.Uaslp.Mx -Reyes Reyes Marisol Reyesm@Cactus.Iico.Uaslp.Mx	Solar cells

56	Universidad Autónoma Metropolitana (Azcapotzalco)	UAM-A-CA-79 - nanotecnologia y calidad ambiental	Ciencias Naturales y Exactas/química de polímeros	Catálisis ambiental y procesos de membranas	-Aguilar Pliego Julia Apj@Correo.Azc.Uam.Mx -Dominguez Soria Victor Daniel Vdds@Correo.Azc.Uam.Mx -Gutierrez Arzaluz Mirella Gam@Correo.Azc.Uam.Mx -Mugica Alvarez Violeta Vma@Correo.Azc.Uam.Mx -Noreña Franco Luis Enrique Lnf@Correo.Azc.Uam.Mx -Torres Rodriguez Miguel Trm@Correo.Azc.Uam.Mx	Hydrogen cells
94	Universidad Politécnica del Estado de Guerrero	UPGRO-CA-1 - Energía y Desarrollo Sustentable	Ingeniería y Tecnología /energía	Tecnologías de hidrógeno y celdas de combustible	Hernández Galvez Geovanni Geovannisg@Yahoo.Com -Ixtlilco Cortes Luis Ixtlilco@Hotmail.Com -Ocampo Fernandez Victor Manuel Victormanuel_58@Yahoo.Com.Mx -Rivera Martinez Mario Arturo Mrivera@Upeg.Edu.Mx -Sarracino Martínez Omar Osarracino@Upeg.Edu.Mx	Solar cells
13	Instituto Tecnológico de Ciudad Madero	ITCMAD-CA-5 - nanotecnología catalítica y biocombustibles	Ingeniería y Tecnología /ingeniería química	Desarrollo de nanoestructuras de carbón	-Castillo Mares Alfredo Castimar@Hotmail.Com -Melo Banda Jose Aaron Melobanda@Yahoo.Com.Mx -Ramos Galvan Claudia Esmeralda Cesmeralda@Hotmail.Com -Reyes De La Torre Adriana Isabel Adriana.Reyes@Itcm.Edu. -Silva Rodrigo Rebeca Rebsilva@Hotmail.Com	Bio-fuel
31	Universidad Autónoma de Nuevo León	UANL-CA-234 - Procesos Termofluidodinámicos y Sistemas Energéticos	Ingeniería y Tecnología /ingeniería	Análisis, modelado y optimización de máquinas térmicas	-García Yera Miguel Miguel.Garciayr@Uanl.Edu.Mx -Martínez Martínez Simón Simon_Martinez@Hotmail.Com -Mendez Diaz Santos Santos.Mendezdz@Uanl.Edu.Mx -Morales Fuentes Arturo Arturo.Moralesfn@Uanl.Edu.Mx	Thermo-electric Environmental remediation

85	Universidad Juárez Autónoma de Tabasco	UJAT-CA-175 - Investigación en Nuevos Materiales	Ciencias Naturales y exactas/ciencia de materiales	Síntesis y caracterización de nuevos materiales:	-Acosta Alejandro Manuel Manuel.Acosta@Ujat.Mx - Falconi Calderon Richart Richart.Falconi@Ujat.Mx -Mora Fonz José Miguel Morafonz@Yahoo.Com.Mx	Thermo-electric

Table 4.13-1 AC working with nano-energy in Mexico (2014).(Research performed February–April 2014)

Researcher name	Research Center/department	Research topic	Identification research term
Aguirre, Servando	CIMAV (Unidad Monterrey) www.cimav.edu.mx	Materiales nano electrónicos y foto voltaicos y ciencia de superficies	Electronic/Photovoltaic
Álvarez, Jaime	CIMAV (Unidad Monterrey) www.cimav.edu.mx	Transferencia de calor a escala nano métrica: Termoelectricidad, dispositivos electrónicos y térmicos.	Thermo-electric
Armando Reyes Rojas	CIMAV www.cimav.edu.mx	Desarrollo y Caracterización Microestructural de Celdas de Combustible SOFC, de Circonia Obtenidas Mediante Sol-Gel.	Cells/Fuel
Doctorado en Ciencia de Materiales (Programa de estudio)	CIMAV www.cimav.edu.mx	Desarrollo de nuevos materiales para almacenamiento y aprovechamiento de energía renovable, celdas fotovoltaicas y catálisis	Cells/ Photovoltaic
Ponce Marbán Donny Victor	Centro de Investigación Científica de Yucatán www.cicy.mx	Roadmap for Hydrogen Technology in Urban Public Transport in the Metropolitan area of Merida, Yucatan, 9th International Symposium on New Materials and nanomaterials for Electrochemical Systems and XII International Congress of the Mexican Hydrogen Society 2012	Hydrogen
Patricia Ocampo	Centro de Investigación Científica de Yucatán www.cicy.mx	Se cuenta con tecnología para la producción y caracterización de electro-catalizadores y soportes de alto desempeño para aplicaciones en la generación de energía (celdas de combustible tipo PEM y de alcohol directo), la síntesis de biocombustibles y tratamiento electroquímico de aguas contaminadas con compuestos no-biodegradables. Específicamente, se trabaja con nanopartículas de compuestos inorgánicos metálicos, bi y trimetálicos y poliméricos.	Cells/Fuel

INAOE	Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE) www-elec.inaoep.mx	Estudio de nuevos materiales para la fabricación de celdas solares	Solar cells
Ipicyt	Instituto Potosino de Investigación Científica y Tecnológica www.ipicyt.edu.mx/Materiales_Avanzados/areas_materiales_avanzados.php	Materiales y compuestos nanoestructurados. Fotocatalisis, nanocompósitos, generación de hidrógeno	Hydrogen
CIDETEQ	Centro de Investigación y Desarrollo Tecnológico en Electroquímica www.cideteq.mx/es/investigacion-y-postgrado/lineas-de-investigacion/energias-alternativas.html	Celdas de combustible Dispositivos fotovoltaicos Celdas fotovoltaicas sensibilizadas	Cells/Fuel/Photovoltaic

Table 4.13-2. CONACYT Research Centers working with nano-energy (2014). (Research performed February–April 2014)

Principal researcher	Research center	Project	Participating researchers	Ref. site	Identification research term
ND	Centro de Nanociencias Nanotecnología e Instituto de Física	Catalizadores para la producción de combustibles ultra bajo en azufre	ND	http://www.ccadet.unam.mx/informe2011/PDFS/PDFS_red/Presentacion.pdf	Cells/Fuel/Photovoltaic
Rodrigo Alonso Esparza Muñoz	Centro de Física Aplicada y Tecnología Avanzada	Síntesis de nanopartículas metálicas y bimetálicas para su aplicación como catalizadores en diferentes reacciones, principalmente en la oxidación de combustibles (hidrógeno, metanol, ácido fórmico, etc.) utilizables en fuentes	ND	http://www.fata.unam.mx/investigacion/departamentos/nanotec/esparza.html	Cells / Fuel / Photovoltaic

		de energía más limpias como celdas de combustible de intercambio protónico			
Rafael Quintero Torres	Centro de Física Aplicada y Tecnología Avanzada	Materiales para aplicaciones en energía solar.	ND	http://www.fata.unam.mx/investigacion/departamentos/nanotec/quintero.html	Cells / Fuel / Photovoltaic
Pedro Salas Castillo	Centro de Física Aplicada y Tecnología Avanzada	Desarrollo de nuevos materiales catalíticos para la industria química y petrolera. Procesos catalíticos en la refinación del petróleo.	ND	http://www.fata.unam.mx/investigacion/departamentos/nanotec/salas.html	Fuel
Felipe Perdomo Hurtado	Centro de Física Aplicada y Tecnología Avanzada	Estudio de nuevas formas de energía a partir de síntesis orgánica: Obtención de alcohol carburante, biogás, biodiesel y diesel sintético.	ND	http://www.fata.unam.mx/investigacion/departamentos/nanotec/perdomo.html	Fuel / bio-diesel / biogas
Gabriel Alonso Nuñez	CNyN	Síntesis de nanoestructuras con aplicación en celdas de combustible y sensores electroquímicos	ND	http://www.cnyn.unam.mx/archivos/informes/Informe2012.pdf	Cells / Fuel / Photovoltaic
Rafael Vázquez Duhalt Sergio A. Águila Puentes	CNyN	Diseño molecular de celdas enzimáticas	Martín Barragán Trinidad, Andrés Arrocha Arcos Ulises Cano, Roberto Flores	http://www.cnyn.unam.mx/archivos/informes/Informe2013.pdf	Cells / Fuel / Photovoltaic
Gabriel Alonso Núñez	CNyN	Nanotubos de carbono, metales, sulfuros y óxidos con propiedades electrocatalíticas.	Carlos Belman, Jassiel Rolando Rodríguez Barreras, Zaira Bedolla	http://www.cnyn.unam.mx/archivos/informes/Informe2013.pdf	Cells / Fuel / Photovoltaic
Gustavo Hirata	CNyN	Desarrollo de materiales luminiscentes y su aplicación en lámparas de luz blanca de bajo consumo de energía	ND	http://www.cnyn.unam.mx/archivos/informes/Informe2013.pdf	Cells / Fuel / Photovoltaic

Edgar Álvarez Zauco	ICN (Inst. de Ciencias Nucleares)	I focus on two lines, in the first one I continue working on fullerene films enhancing their electronic properties by functionalization with organic molecules, and, testing them as molecular templates with the intention of apply them on studies of synthetic life molecules. In the second one I study the interaction between carbon nanotubes and microwaves, in order to understand their energy absorption and behavior; these studies are focused to new fuel containers and to novel clean carbon nanotubes functionalization.	ND	http://www.nucleares.unam.mx/nanociencias/index.php/members/12-members/4-edgara	Fuel / energy
Marina Elizabeth Rincón González	IER(Inst. de Energías Renovables)	Laboratorio de Innovación Fotovoltaica y Caracterización de Celdas Solares y materiales y dispositivos de nanoescala para conversión y almacenamiento de energía	ND	http://xml.cie.unam.mx/xml/ms/siymc/merg/instpage.xsp	Cells / Fuel / Photovoltaic
Rogelio Morán Elvira	IER(Inst. de Energías Renovables)	Desarrollo de dispositivo de micro y nanoposicionamiento : dispositivo kelvin y generador termoionico	ND	http://xml.cie.unam.mx/xml/ms/siymc/rme/instpage.xsp	Cells / Fuel / Photovoltaic
Ana Karina Cuentas Gallegos	IER(Inst. de Energías Renovables)	Nano-aerogeles de Carbono decorados con óxidos moleculares para su aplicación como electrodos en celdas supercapacitivas	ND	http://xml.cie.unam.mx/xml/ms/siymc/akcg/instpage.xsp	Cells / Fuel / Photovoltaic
Dra. Julia Tagueña	IER(Inst. de Energías Renovables)	Celdas solares para la innovación social (nano)	ND	http://xml.cie.unam.mx/xml/tc/ft/jtp/instp	Solar cells

Parga				age.xsp	
Sebastian Pathiya Mattom Jospeh	IER(Inst. de Energías Renovables)	Celdas Solares Nanoestructuradas, Celdas Fotovoltaicas	ND	http://xiuhcoatl.cie.unam.mx/webCie2/baseCIE/informacion-institucional.php?id=35	Cells / Fuel / Photovoltaic
Sergio Alberto Gamboa Sánchez	IER(Instituto de Energías Renovables)	Desarrollo de catalizadores nanoestructurados para aplicaciones en sistemas electroquímicos de conversión y almacenamiento de energía	ND	http://xiuhcoatl.cie.unam.mx/webCie2/baseCIE/informacion-institucional.php?id=71	Cells / Fuel / Photovoltaic
Grupo de Inv. Coordinación solar-hidrógeno: celdas de combustible	IER(Inst. de Energías Renovables)	Celdas solares de películas delgadas y nanoestructuradas basadas en CuInSe2, CdTe y TiO2, Nanociencia y nanotecnología aplicada en síntesis de materiales, fabricación de dispositivos y generación de energía	Arturo Fenrnandez Madrigal, Sergio Gamboa Sanchez	http://xml.cie.unam.mx/xml/ms/shcdc/	Cells / Fuel / Photovoltaic
Grupo de Inv. Coord. de superficies, interfaces y materiales compuestos	IER(Inst.de Energías Renovables)	Síntesis de nanopartículas compuestas semiconductoras, en forma de emulsión y película delgada, para aplicaciones fotocatalíticas y fotoelectrolíticas (producción de hidrógeno).	Margarita Miranda Hernandez, Antonio Jimenez Gonzalez, Marina Elizabeth Gonzalez, Ana Karina Cuentas, Raúl Suarez Parra, Hailin Zaho Hu	http://xml.cie.unam.mx/xml/ms/siymc/	Cells hydrogen

Table 4.13-3. UNAM´s Researchers and Centers working with nano-energy (2014). (Research performed February–April 2014)

Principal researcher	Research center	Project or research line	Participating researchers	Ref.	Identification research term

Caballero Briones Felipe	CICATA Altamira	Estudio de materiales para celdas solares de película delgada basadas en cuinse2 y prospección fotovoltaica en el sur de Tamaulipas	Felipe Caballero Briones, Fabio Chale Lara, David Rivas Camargo, Eugenio Rodriguez Gonzalez, Rogelio Ortega Izaguirre	Http://www.cicataaltamira.ipn.mx/ofertaeducativa/Maestria/Documents/Nucleo-Academico-cvs/CVU-2013/Felipe-Caballero-Briones.pdf	Solar cells
Chalé Lara Fabio Felipe	CICATA Altamira	Efecto de los parámetros de crecimiento en películas delgadas de zno y zno. Posible aplicación en células solares	Fabio Felipe Chale Lara, Felipe Caballero Briones	Http://www.cicataaltamira.ipn.mx/ofertaeducativa/Maestria/Documents/Nucleo-Academico-cvs/CVU-2013/Fabio-Felipe-Chale-Lara.pdf	Solar cells
Torres Huerta Aidé Minerva	CICATA Altamira	Síntesis, caracterización y estudio de películas delgadas base zro2 mediante cvd, con aplicaciones en dispositivos de estado sólido y celdas solares.	CIQS , ESIQIE IPN, ICMUV, Tecnológico de Ciudad Madero	Http://www.coordinacionredes.ipn.mx/redesip/rener/Documents/ENERGIA/CICATALTAMIRA/35697%20TORRES%20HUERTA,AIDE%20MINERVA.pdf	Solar cells
Eugenio Rodríguez González	CICATA Altamira	Caracterizaciones ópticas en heteroestructura cuinse para aplicaciones en celdas solares	Eugenio Rodríguez González, Felipe Caballero Briones, Fabio Felipe Chale Lara, David Rivas Camargo	Http://www.cicataaltamira.ipn.mx/ofertaeducativa/Maestria/Documents/Nucleo-Academico-cvs/CVU-2013/Eugenio-Rodriguez-Gonzalez.pdf	Solar cells
	CICATA Altamira	Automatización de un sistema de fabricación de filmes finos, puntos cuánticos y materiales nano-estructurados	Nd	Http://www.cicataaltamira.ipn.mx/ofertaeducativa/Maestria/Documents/Nucleo-Academico-cvs/CVU-2013/Eugenio-Rodriguez-Gonzalez.pdf	Quantic points
Mantilla Ramírez Ma. De los Ángeles	CICATA Legaria	Síntesis, caracterización y evaluación de nanomateriales catalíticos para la obtención de combustibles ecológicos y remediación ambiental	María de Los Ángeles Mantilla Ramírez , Fernando Trejo Zarraga , Francisco Javier Tzompantzi Morales , Luis Lartundo Rojas	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Angeles%20Mantilla.pdf	Catalyzer
Reguera Ruíz Edilso Francisco	CICATA Legaria	Desarrollo de materiales para tecnologías de hidrógeno	ND	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Edilso%20Re	Hydrogen

				guera.pdf	
Trejo Zarraga Fernando	CICATA Legaria	Obtención de diesel renovable mediante hidrotratamiento catalítico de gasóleo y aceite	Fernando Trejo Zárraga , Rogelio Sotelo Boyás , Jorge Martínez Herrera	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Fernando%20Trejo.pdf	Catalyzer
Guadalupe Valverde Aguilar	CICATA Legaria	Proyecto multidisciplinario (20120129) desarrollo de materiales para tecnologías de Hydrogene	Edilso Reguera Ruiz , Guadalupe Valverde Aguilar	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Guadalupe%20Valverde.pdf	Hydrogen
	CICATA Legaria	Proyecto sip 20113905: desarrollo de na nocatalizadores para tecnologías de Hydrogene	Guadalupe Valverde Aguilar	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Guadalupe%20Valverde.pdf	Hydrogen
	CICATA Legaria	Proyecto ucmexus-conacyt cn-12-513 titulado: metallic catalysts supported on ce-modified mesoporous sol-gel matrices for hydrogen production	Eric Mcfarland	Http://www.cicata.ipn.mx/ofertaeducativa/MTA/nucleoacademico/Documents/Guadalupe%20Valverde.pdf	Hydrogen
Vidales Hurtado Mónica Araceli	CICATA Qro	Obtención y caracterización de un dispositivo electrocrómico fabricado con películas de óxido de tungsteno y/o óxido de níquel obtenidas por métodos químicos para aplicación en control solar térmico	Martin de Jesús Nieto Pérez; Arturo Mendoza Galván	Http://www.cicataqro.ipn.mx/wps/images/stories/curriculum_doctores/monicavidales.html	Solar
García Serrano Luz Arcelia	CIIEMAD	Funcionalización controlada de materiales fibrosos y de porosidad regulada con aplicaciones principalmente agronegocios, balística, electrónica, Ing. Civil y en la producción de combustibles de	ND	Http://www.ciiemad.ipn.mx/investigacion/Paginas/deptosociedad-luzarcelia.aspx	Fuel

		bajo impacto ambiental.			
Cortés Escobedo Claudia Alicia	CIITEC	Integración de sistemas fotovoltáico-electrolizador para complementar la instalación de la vivienda sustentable ICYTDF-IPN-SIP-Red Energía 2013	ND	Http://www.ciitec.ipn.mx/posgrado/doctos/Dr_Claudia_cv.pdf	Photovoltaic
	CIITEC	Diseño e integración de un stack de celdas de combustible para alimentar un sistema fijo de lámparas led Proyecto multidisciplinario IPN-SIP-2011 REG 1338	ND	Http://www.ciitec.ipn.mx/posgrado/doctos/Dr_Claudia_cv.pdf	Cell / Fuel
	CIITEC	Preparación de membranas compósitas de quitosán/óxidos activados para celdas de combustible tipo PEM CONACYT-2010, REG 157925,	ND	Http://www.ciitec.ipn.mx/posgrado/doctos/Dr_Claudia_cv.pdf	Cell / Fuel
	CIITEC	Caracterización y evaluación de nanofibras de carbono con partículas metálicas para su uso como catalizador en celdas de combustible tipo PEM IPN-SIP-2010 REG 20101269 (ene 2010-dic 2010), directora.	ND	Http://www.ciitec.ipn.mx/posgrado/doctos/Dr_Claudia_cv.pdf	Cell / Fuel / Catalyzer
	CIITEC	Estudio y caracterización de materiales nanométricos para su aplicación en sistemas	ND	Http://www.ciitec.ipn.mx/posgrado/doctos/Dr_Claudia_cv.pdf	Battery / Fuel

		electrolizador-pila de combustible tipo PEM que funcionan utilizando energías alternas, ICYTDF, REG PICS0837 (2009-2010)			
Vidales Hurtado Mónica Araceli	ESFM	High density hydrogen storage in nanocavities: Role of the electrostatic interaction	L. Reguera; J. Roque; J. Hernández; E. Reguera	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=JORGE+RICARDO+AGUILAR-HERNANDEZ&u_id=10&oe_id=1&o_id=100	Hydrogen
Aguilar Hernández Jorge Ricardo	ESFM	Photovoltaic modules processing of cds/cdte by CSVT in 40 cm2. Conference Record of the IEEE Photovoltaic Specialists	ND	Http://www.coordinacionredes.ipn.mx/redesip/rednano/Paginas/Miembros.aspx	Photovoltaic
Contreras Puentes Gerardo Silverio	ESFM	Solar Cells	ND	Http://www.experts.scival.com/ipn/experttrends.asp?N=GERARDO+SILVERIO+CONTRERAS-PUENTE&u_id=155&oe_id=1&o_id=4	Solar cells
Rodríguez Hernández Juan Ignacio	ESFM	Estudios DFT de par donador-aceptor de celdas solares orgánicas tipo hetero-unión-bulto	ND	Http://esfm.ipn.mx/~juan/	Solar cells
Tufiño Velázquez Miguel	ESFM	Photovoltaic structures based on Cu(In, Ga)Se 2 thin films prepared by thermal co-evaporation. Conference Record of the IEEE Photovoltaic Specialists	J. Sastré-Hernández; M.E. Calixto; M.L. Albor-Aguilera; M. Tufiño-Velázquez; G. Contreras-Puente; A. Morales-Acevedo; G. Casados	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=MIGUEL+TUFI%D1O-VELAZQUEZ&u_id=741&oe_id=1&o_id=4	Photovoltaic
	ESFM	Photovoltaic modules processing of cds/cdte by CSVT in 40 cm2. Conference Record of the IEEE Photovoltaic Specialists	Rogelio Mendoza-Pérez; Jorge R. Aguilar-Hernández; Jorge Sastré-Hernández; Miguel Tufiño-Velázquez; O. Vigil-Galán; Gerardo S.	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=MIGUEL+TUFI%D1O-VELAZQUEZ&u_id=741&oe_id=1&o_id=4	Photovoltaic

			Contreras-Puente; A. Morales Acevedo; A. Escamilla-Esquivel; Benito Ortega-Nájera; X. Mathew		
	ESFM	Study of chemical bath deposited cds bi-layers and their performance in cds/cdte solar cell applications	M. Estela Calixto; M. Tufiño-Velázquez; G. Contreras-Puente; O. Vigil-Galán; M. Jiménez-Escamilla; R. Mendoza-Perez; J. Sastré-Hernández; A. Morales-Acevedo	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=MIGUEL+TUFI%D1O-VELAZQUEZ&u_id=741&oe_id=1&o_id=4	Solar cells
	ESFM	Micro and nano-bricklayer building process of CDS films: Their optimal applications in CDTE solar cells	G. Contreras-Puente; M. Tufiño-Velázquez; M. Estela Calixto; M. Jiménez-Escamilla; O. Vigil-Galán; A. Arias-Carbajal; A. Morales-Acevedo; J. Aguilar-Hernández; J. Sastre-Hernández; F.N. Arellano-Guerrero	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=MIGUEL+TUFI%D1O-VELAZQUEZ&u_id=741&oe_id=1&o_id=4	Solar cells
	ESFM	Spectral response of cds/cdte solar cells obtained with different S/Cd ratios for the cds chemical bath	O. Vigil-Galán; A. Arias-Carbajal; R. Mendoza-Pérez; G. Santana; J. Sastré-Hernández; G. Contreras-Puente; A. Morales-Acevedo; M. Tufiño-Velázquez	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=MIGUEL+TUFI%D1O-VELAZQUEZ&u_id=741&oe_id=1&o_id=4	Solar cells

González Huerta Rosa De Guadalupe	ESIQIE	Electrocatalysis of oxygen reduction on carbon supported Ru-based catalysts in a polymer electrolyte fuel cell	R.G. González-Huerta; J.A. Chávez-Carvayar; O. Solorza-Feria	Http://www.experts.scival.com/ipn/printpage_cv_ctrl.asp?N=ROSA+DE+GUADALUPE+GONZALEZ-HUERTA&u_id=286&oe_id=1&o_id=10	Cell / Fuel
Hernández Pérez Ma. de Los Ángeles	ESIQIE	Películas de semiconductores para celdas solares y sensores químicos	ND	Http://www.sepi.esiqie.ipn.mx/Documents/Metalurgia/Curriculum/CV-HERNANDEZPEREZ.pdf	Solar cells
Hernández Pichardo Martha Leticia	ESIQIE	Caracterización de electrocatalizadores a base de nanopartículas metálicas para celdas de combustible tipo pem.	ND	Http://www.coordinacionredes.ipn.mx/redesip/rener/Documents/ENERGIA/ESIQIE/36663%20PICHARDO,MARTHA%20%20LETICIA.pdf	Cell / Fuel
Navarro Clemente María Elena de la Luz	ESIQIE	Método para el desarrollo de pastas para serigrafía utilizadas en celdas solares de silicio	J. A. Godines, A. Palafox y M.E. Navarro, CINVESTAV, IPN	Http://www.informatica.sip.ipn.mx/esiqie/PDF/CURRICULO-MODIFICADO%20%20MA.%20ELENA.pdf	Solar cells
Paredes Carrera Silvia Patricia	ESIQIE	Síntesis y caracterización de óxidos 12/2008 y calcogenuros semiconductores y materiales relacionados, para aplicaciones en fotocatálisis, celdas solares y sensores de gases.	Carmen Reza San German, Silvia Paredes Carrera, Lucia Díaz Barriga Arceo, Patricia Santiago Jacinto	Http://www.coordinacionredes.ipn.mx/redesip/rener/Documents/ENERGIA/ESIQIE/37605%20%20PAREDES%20CARRERA,SILVIA%20PATRICIA.pdf	Solar cells

Table 4.13-4 Researchers of the IPN working with nano-energy (2014). (Research performed February–April 2014)

Researcher name	Research Center/department	Research topic	Identification research term
Francisco Javier Rodríguez Varela	CINVESTAV (Unidad Saltillo)	Electrocatálisis; desarrollo de nuevos materiales electrocatalíticos; celdas de combustible; energías alternativas; desarrollo de nanotubos de carbón y fases de magneli como soporte para catalizadores.	Cell / Fuel

Gerko Oskam	CINVESTAV (Unidad Mérida) Física Aplicada	Síntesis y caracterización de nanomateriales de óxidos de metales, y la relación entre sus propiedades y el desempeño en celdas solares fotoelectroquímicas	Solar cells

Source: Author's own research (2014)

Table 4.13-5 Researchers of CINVESTAV working with nano-energy (2014). (Research done during February, March/April 2014)

Institution	Research topic	Researchers		Identification research term
Instituto Mexicano del Petroleo (imp)-laboratorio de microscopía electrónica de ultra alta resolución	Caracterización estructural volumétrica, química y de superficie, a nivel micrométrico, nanométrico y atómico, de materiales para su diseño y utilización en el desarrollo de tecnologías y productos con alto valor para la industria petrolera. Adicionalmente buscamos la satisfacción de las necesidades del cliente, proponiendo continuamente soluciones que se adelanten a sus requerimientos de mediano y largo plazo	Eduardo Palacios González, Eduardo Terres Rojas, Florentino Leyte Guerrero, Sadott Pacheco Alcalá, Vicente Garibay Febles .	http://www.imp.mx/investigacion/microscopia/ http://www.imp.mx/comunicacion/gaceta/?imp=nota&nota=120328esp-1a	Oil / Energy
Instituto Mexicano del Petróleo (IMP)-Pemex	Un material a base de nanotubos de óxido de titanio que elimina el nitrógeno y azufre contenidos en gasóleos y en combustibles (Gasolinas y diesel), fue creado por un grupo de investigadores de la Coordinación de Ingeniería Molecular del Instituto Mexicano del Petróleo (IMP)El adsorbente está hecho a base de óxido de titanio con morfología nanotubular, en el cual las estructuras tridimensionales en forma de partículas o nanopartículas, fueron manipuladas hasta hacerlas nanotubulares, lo que permitió incrementar el área de contacto y generar sitios	José Antonio Toledo Antonio, María Antonia Cortés Jácome, Gerardo Ferrat Torres, Carlos Ángeles Chávez, Luis Francisco Flores Ortiz, María de Lourdes Araceli Mosqueira Mondragón, Esteban López Salinas, José Escobar Aguilar, Rodolfo Juventino Mora Vallejo, Fernando Álvarez Ramírez,	http://www.ref.pemex.com/octanaje/o75/frm.htm	Oil / Energy

	específicos que al entrar en contacto con gasolina o diesel atraen a aquellas moléculas de nitrógeno y de azufre contenidas en los mismos. De esta manera los combustibles reducen sustancialmente el contenido de dichos contaminantes.	Yosadara Ruiz Morales y Marcelo Lozada y Cassou		
Instituto Nacional de Investigaciones Nucleares (ININ)	Materiales nanoestructurados (plata, oro,) para aplicación el industria eléctrica y de energía	Claudia E. Gutiérrez Wing, Demetrio Mendoza Anaya, Gilberto Mondragón Galicia, Raúl Pérez Hernández, Ma. Eufemia Fernández García, Mario Pérez Álvarez	http://www.inin.gob.mx/documentos/publicaciones/contridelinin/Cap%C3%ADtulo%2026.pdf	Energy / voltaic

Table 4.13-6 Research Centers of the Mexican Government. (Research done during February, March/April 2014)

Name of the fund	Time period	Total approved	Nanotechnology projects	Nano-energy
FORDECyT	2009-2012	71	1	
CIAM*	2004-2012	39	19	
FIC Equipment support	2009-2012	218	16	
FIC –Infrastructure for GMOs	2011	10	0	
FIC. Equip. for Research Groups	No data	0	0	
Basic Research SEP-Conacyt	2004-2012	5381	340	
Complementary support for SNI I	2006-2011	1617	61	
CIBIOGEM	2005-2013	40	0	
IDEA	Discontinuated	0	0	
FOMIX	2004-2010	356	45	
SECTORIAL FUNDS				

ASA-CONACYT	2005-2012	37	0	
CONAGUA-CONACYT**	2006-2012	41	2	
INIFED-CONACYT	2012	1	0	
CONAFOR-CONACYT***	2005-2012	69	2	
CONAVI-CONACYT	2007-2011	43	1	
INMUJERES-CONACYT	2008-2012	38	1	
SAGARPA-CONACYT	2005-2012	80	0	
SSA/IMSS/ISSSTE-CONACYT	2005-2012	1113	8	
SE-CONACYT	2007-2012	586	11	
SEGOB-CONACYT	-------	0	0	
SEMAR-CONACYT	2005-2013	11	0	
SEMARNAT-CONACYT	2006-2008	106	0	
SENER-CONACYT	----	0	0	1
SENER-HIDROCARBUROS-CONACYT****	2009-2012	118	1	
RELACIONES EXTERIORES-CONACYT	2006-2012	38	3	
SECTUR-CONACYT	2010-2012	13	0	
INEGI-CONACYT	2011-2012	10	0	
TOTAL		2304	29	

Note: Search terms in titles: nano+nano-energy terms. Only one fund issued calls explicitly for nanotechnology: FOMIX (Chihuahua 1; Morelos 1; Querétaro 1; Tamaulipas 3; Nuevo León 6)

Acronyms

FORDECyT. Fondo Institucional de Fomento Regional para el Desarrollo Científico, Tecnológico y de Innovación.
CIAM. Fondo Institucional Ciencia. Convocatorias Convenios de Cooperación Proyecto Colaboración Interamericana en Materiales.
FIC-Equipo. Fondo Ins titucional Ciencia. Apoyo complementario para actualización de equipo científico.
FIC-OGM. Fondo Institucional Ciencia. Apoyos para infraestructura para confinamiento de organismos genéticamente modificados
FIC-CA y GI. Fondo Institucional Ciencia. Apoyos para cuerpos académicos y grupos de investigación.
SEP-Conacyt. Convocatoria de investigación básica SEP-Conacyt
FIC-SNI1. Fondo Institucional Ciencia. Complementario a Investigadores en proceso de consolidación SN1
CIBIOGEM. Fondo para el fomento y apoyo de la investigación científica y tecnológica en bioseguridad y en biotecnología.
IDEA. Incorporación de científicos y tecnólogos mexicanos en el sector social y productivo del país. (Descontinuado)
FOMIX. Fondos Mixtos Conacyt-Gobiernos de Estado
ASA-Conacyt. Investigación para el desarrollo aeroportuario y la navegación Aérea
CONAGUA-Conacyt. Investigación y desarrollo sobre el agua
INIFED-Conacyt. Infraestructura Educativa
CONAFOR-CONACYT. Investigación, desarrollo e innovación tecnológica forestal
CONAVI-CONACYT. Desarrollo Científico y Tecnológico para el Fomento de la Producción y Financiamiento de la Vivienda y el Crecimiento del Sector Habitacional.
INMUJERES-CONACYT. Investigación y Desarrollo
SAGARPA-CONACYT. Investigación en materias agrícola, pecuaria, acuacultura, agrobiotecnología y recursos fitogenéticos
SSA/IMSS/ISSSTE-Conacyt. Investigación en Salud y Seguridad Social

SE-CONACYT. Innovación tecnológica. Secretaría de Economía-Conacyt
SEGOB-CONACYT. Investigación y Desarrollo. Secretaría de Gobernación-Conacyt
SEMAR-CONACYT. Investigación y Desarrollo en Ciencias Navales
SEMARNAT-CONACYT. Investigación ambiental
SENER-CONACYT. Sustentabilidad Energética. Secretaría de Energía.
SENER-HIDROCARBUROS-CONACYT.
SER-CONACYT. Secretaría de Relaciones Exteriores-Conacyt
SECTUR-CONACYT. Secretaría de Turismo. Conacyt.
INEGI-CONACYT. Instituto Nacional de Geografía y Estadística-Conacyt

Table 4.13-7. Main Federal Call for Project sources and approved projects in nanotechnology by sector. México 2004-2012. (Research performed January–April 2014).

5 Water sector

Access to potable water is one of the most pressing world health problems. According to the United Nations (UN), “85% of the world population lives in the driest half of the planet. 783 million people do not have access to clean water and almost 2.5 billion do not have access to adequate sanitation" (UNESCO, 2013).

The water crisis arises from varied and interrelated causes (demographic growth, increasing agricultural demand, climate change, geographic concentration of demand, inadequate management, lack of recycling, etc.). Despite the many causes of the scarcity of drinking water, in some contexts technical alternatives could prove to be of use in addressing the problem.

Nanotechnology research related to water is rapidly advancing, and offers solutions in some cases over conventional solutions (Theron, Walker & Cloete, 2008). According to an OECD report, "The market for nanotechnology used in water and wastewater worldwidereached USD 1.6 billion in 2007 and is expected to reach USD 6.6 billion in 2015" (OECD, 2011, p. 17). Nano-water applications can be grouped by various criteria. For the purposes of this study, we have chosen the following categories: water desalination; contaminated water remediation; and water potabilization. Each of these groups can, by themselves, be subdivided further, such as the distinction between contamination sensors and filtration mechanisms. Due to the fact that it is not always possible to identify in greater detail via scientometric sources and the information found on websites of the research centers, we have chosen the three categories previously mentioned. The OECD estimates that "Filtration was the dominant application in 2007 at about 43%, but desalination and irrigation are expected to deliver the most revolutionary results by 2015 and thereafter" (OECD, 2011, p. 17).

A quantitative and qualitative research was done. Due to the very different data sources, each item will explain the methodology used. The data obtained covered Latin America as a whole and certain countries in particular: Argentina, Brazil, Colombia, Chile, Mexico and Uruguay. The bibliometric research made use of the Web of Science and Scopus database. The manual research examined websites - in each of the selected countries - of all the top universities and/or nanotechnology research centers. In cases where a more reliable database existed, it was consulted.

The investigation also incorporated secondary information from various bibliographic sources that were identified through a reading of articles from various countries and from personal knowledge of the research networks in each country (and the region as a whole). In both, the bibliometric and manual research efforts, once the nanotechnology articles or research groups were identified, the second phase began, which consisted of identifying those who worked in the area of nano-water. To that end, a list of categories was developed from a reading of key works on the topic. The following table summarizes those categories:

English	**Spanish**
braskish	salobre
desalination	desalinización
filtration	filtración
pollution pollutant	contaminación contaminante
natural	natural
pesticide remediation	pesticidas remediación
reverse osmosis	osmosis
purification	purificación
treatment	tratamiento
wastewater	drenaje
desinfection	desinfección
groundwater	agua subterranea
membrane filtration	filtración membranas
dendrimer filtering	filtración dendrímeros
freshwater	agua fresca
nanoporous polymeric material	materials poliméricos nanoporosos
saltwater	agua salobre
seawater	agua de mar marina

5.0 1 Search categories in nano-water

5.1 Bibliometric Analysis. Web of Science

This report focuses on the mapping of scientific production in the nanotechnology field within the various water sectors in the Latin American and Caribbean (LA+C) region.

This section has centered on an analysis of the scientific articles produced in the region with the aim of uncovering some indicators that could provide us with an overview of the development of these technologies in the countries of Latin America and the Caribbean.

5.2 Methodology

The results shown in this report have been obtained from a consultation of the Web of Science (WoS), specifically the databases Science Citation Index, Social Science Citation Index and the Arts & Humanities Science Citation Index. The bibliometric data search in the field of nanotechnology and the water problematic employed a search strategy composed of three search equations composed of keywords that are representative of the various areas in the field of knowledge of nanotechnology related to the remediation of contaminated water, to the potabilization of water and water desalination. The equations employed for each of the topics are shown inTable 5.2-1.

Area	Keywords
Contaminated water remediation	(("treatment" or "wastewater" or "disinfection" or "pollutant" or "pollution" or "groundwater" or "pesticide remediation") and water and nano*)
Water potabilization	(("membrane filtration" or "dendrimer filtering" or "purification" or "filtration" or "freshwater" or "natural" or "reverse osmosis" or "drink*") and water and nano*)
Water desalination	(("nanoporous polymeric materials" or "reverse osmosis" or "nanofiltration") and ("brackish" or "desalination" or "saltwater" or "seawater") and nano*)

Table 5.2-1 Topics and keywords used in the database search for nanotechnology related to the water problematic

To identify those scientific publications produced in Latin American and Caribbean countries, the database search made use of a list of CELAC-community countries (See 5.12.) The timeframe examined in this study included publications up to the year 2012 and the WoS consultation uncovered a total of 481 published documents, of which 435 were scientific articles that is the total figure we will work with.

Bibliometric data access was done with the support of the Acces informatics tool. The tables and graphs were created with Excel and the images of maps and networks were created with MapPoint, Pajek, NetDraw and VOSviewer.

5.2.1 Results

The three areas that we identify in this study in the field of nanotechnology and the water problematic and the results of the articles identified in the database search are shown in Table 5.2-2. These results show that the area of *contaminated water remediation* has received the most attention, with a total of 257 published articles, or 59.08% of the total articles in the field of nanotechnology within the Latin America and Caribbean region. The issue of *water potabilization* is the second-most developed area with 52.18% of the total articles published and *water desalination* has been the subject of fewer studies, with only 3 published articles identified. As several articles could be classified in more than one area, since much of the funded research in nanomateriales, sensors, membranes, etc., with multiple uses can be applied to the decontamination of water but also to the potabilization of water, and, by the same token, the articles could be classified in both areas, the relative numbers does not sum up 100%.

Áreas	Artículos publicados	% de 435
Remediación de aguas contaminadas	257	59.08%
Potabilización de agua	227	52.18%
Desalinización de agua	3	0.69%

Table 5.2-2 Frequency of published articles in nanotechnology across the various areas related to the water problematic in Latin America and the Caribbean to 2012.

A second indicator that is of interest to examine is the evolution of the production of new knowledge in the three areas or topics that we have identified in nanotechnology and the water problematic. The results obtained support the view that the emergence of this field in the region is nascent, since on the topic of water potabilization the first publications in the region appeared during the 1990s, and on the topic of remediation, the first articles began to be published in the following decade (2000s).

The evolution of the production of new knowledge in the three areas or topics that we have identified in this study on nanotechnology and the water problematic are shown in Figure 5.2-1. The timeframe analyzed in this graphic begins in the year 2000, since it is in this year that the publication of articles in this field in the Latin American and Caribbean region became more frequent. The behavior of the curves show that the emergence of the top two identified topics have seen a significant increase despite the three observed instances where they decreased. The first drop –hardly visible– occurred in the year 2003 and the second in 2008 in both cases. The topic of contaminated water remediation showed a third, very marked decrease in 2010.

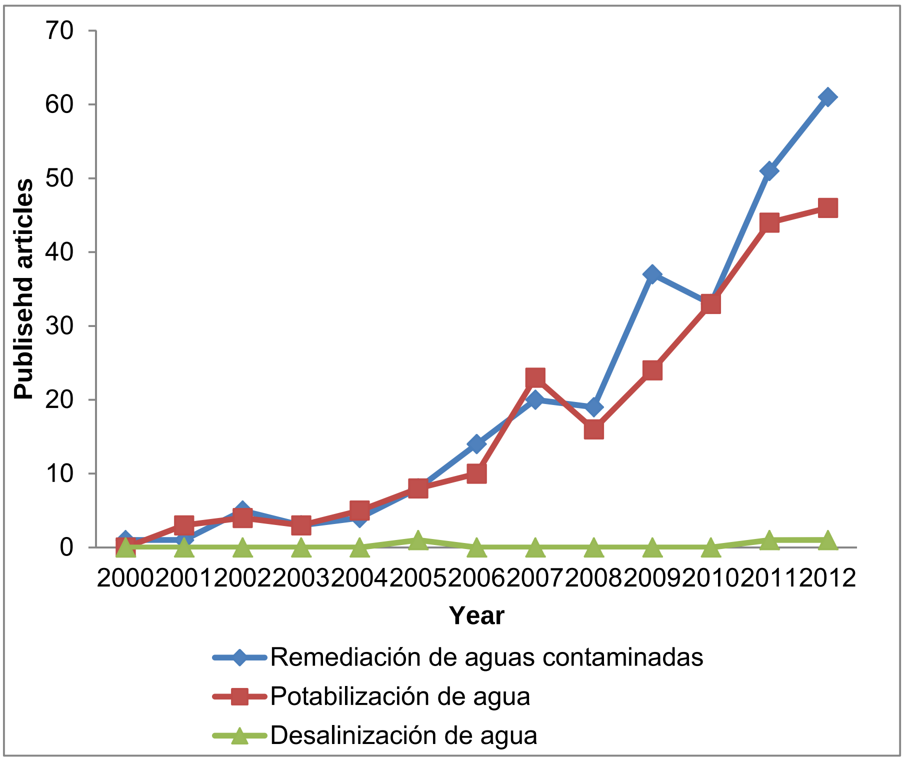


Figure 5.2-1 Evolution of publications across the various areas in the field of nanotechnology and the water problematic in Latin America and the Caribbean (2000–2012)

In tabulating the countries in which the scientific articles identified in this study were published, we find that 13 countries in the Latin America and Caribbean region were present. The full accounting included 54 countries, the list of which and the frequency of their article production are shown in Table 5.2-3. Of the countries within Latin America and the Caribbean, Brazil has produced the largest quantity of scientific articles.

The production of 360 articles in this country reveals a significant concentration of the activities from the region in the field of nanotechnology and the water problematic. The second country on the list is Mexico, with 136 identified articles, followed by Argentina with 90 articles. Chile is next, with 56 articles, and the remainder of the countries in the region have published less than 5% of the total articles identified.

Furthermore, in the same Table 5.2-3 we see the countries with which the identified articles have been published with a co-author. The key scientific collaborator is the United States, with which 75 articles have been co-authored. In the following list we make particular note of European countries such as Spain (37 articles), France (34 articles), Portugal (23 articles) and Germany (19 articles), among others:

País	Artículos	% de 435	País	Artículos	% de 435
Brazil	**360**	**82.76%**	Switzerland	3	0.69%
Mexico	**136**	**31.26%**	**Costa_Rica**	**2**	**0.46%**
Argentina	**90**	**20.69%**	Denmark	2	0.46%
USA	75	17.24%	**Ecuador**	**2**	**0.46%**
Chile	**56**	**12.87%**	Israel	2	0.46%
Spain	37	8.51%	Saudi Arabia	2	0.46%
France	34	7.82%	Scotland	2	0.46%
Portugal	23	5.29%	South_Africa	2	0.46%
Colombia	**19**	**4.37%**	Taiwan	2	0.46%
Germany	19	4.37%	Austria	1	0.23%
Italy	14	3.22%	Bangladesh	1	0.23%
Venezuela	**10**	**2.30%**	**Barbados**	**1**	**0.23%**
Cuba	**9**	**2.07%**	Belgium	1	0.23%
Canada	8	1.84%	Byelarus	1	0.23%
England	8	1.84%	Croatia	1	0.23%
Japan	8	1.84%	Egypt	1	0.23%
Uruguay	**8**	**1.84%**	Greece	1	0.23%
China	7	1.61%	**Grenada**	**1**	**0.23%**
India	7	1.61%	Iran	1	0.23%
Czech_Republic	5	1.15%	Malaysia	1	0.23%
Norway	5	1.15%	Morocco	1	0.23%
Peru	**5**	**1.15%**	Netherlands	1	0.23%
South Korea	5	1.15%	Philippines	1	0.23%
New_Zealand	4	0.92%	Russia	1	0.23%
Sweden	4	0.92%	Senegal	1	0.23%
Australia	3	0.69%	Tunisia	1	0.23%
Finland	3	0.69%	Turkey	1	0.23%

Table 5.2-3 Countries and published article frequency in the field of nanotechnology related to the water problematic in Latin America and the Caribbean to 2012.

Figure 5.2-2 Geographic distribution of scientific activities in the field of nanotechnology related to the water problematic in Latin America and the Caribbean to 2012.

With regard to the institutions where the identified articles were produced, Table 5.2-4 shows the list of institutions where more than 10 scientific articles have been produced in the area of nanotechnology and the water problematic up to the year 2012 in Latin America and the Caribbean. Brazilian institutions dominate the list, with the top three institutions in the country: Sao Paulo University, University of the State of Sao Paulo and Campinas State University. The fourth university on the list is the National Autonomous University of Mexico (UNAM). The remainder of the institutions in the region have published fewer than 10% of the scientific production in this field, while the list does not contain any institution that is not from Latin America and the Caribbean.

Institución	País	Artículos	% de 435
Univ Sao Paulo	Brazil	82	18.85%
Univ Estadual Paulista	Brazil	51	11.72%
Univ Estadual Campinas	Brazil	49	11.26%
Univ Nacl Autonoma Mexico	Mexico	45	10.34%
Univ Fed Sao Carlos	Brazil	28	6.44%
Consejo Nacl Invest Cient & Tecn	Argentina	27	6.21%
Univ Fed Rio Grande do Sul	Brazil	26	5.98%
Univ Concepcion	Chile	23	5.29%
Univ Fed Rio de Janeiro	Brazil	21	4.83%
Univ Buenos Aires	Argentina	18	4.14%
Embrapa Instrumentacao Agropecuaria	Brazil	16	3.68%
Ctr Invest Mat Avanzados SC	Mexico	14	3.22%
Univ Fed Santa Catarina	Brazil	14	3.22%
Univ Autonoma San Luis Potosi	Mexico	14	3.22%
Univ Fed Minas Gerais	Brazil	13	2.99%
Univ Autonoma Metropolitana	Mexico	12	2.76%
Univ Fed Parana	Brazil	11	2.53%
Univ Autonoma Nuevo Leon	Mexico	11	2.53%
Ctr Invest & Estud Avanzados	Mexico	11	2.53%
Comissao Nacl Energia Nucl	Brazil	11	2.53%
Comis Nacl Energia Atom	Argentina	11	2.53%
Univ Fed Ceara	Brazil	10	2.30%
Univ Fed Uberlandia	Brazil	10	2.30%
Univ Nacl San Luis	Argentina	10	2.30%
Inst Potosino Invest Cient & Tecnol	Mexico	10	2.30%

Table 5.2-4 Institutions with more than 10 published articles in the field of nanotechnology related to the water problematic in Latin America and the Caribbean to 2012.

5.2.2 Scientific collaboration networks in nanotechnology related to the water problematic in Latin America and the Caribbean

Another indicator that we are interested in exploring in this study lies with scientific collaborations in the field of nanotechnology and the water problematic. In this section, we map the configuration of scientific networks that we have been able to identify through article co-authorships. This is analyzed at the country level. In the following three images we show the collaboration networks among the countries of Latin America and the Caribbean, as well as the networks linking countries to the European Union and with countries in the rest of the world. The nodes represent the various countries, the lines are the relationships of scientific collaboration, and the thickness of the lines is determined by the frequency of co-authorship. The first collaboration network shows the co-authorships between countries in the Latin American and Caribbean region (see Figure 5.2-3), in which the strongest collaborations exist between Mexico and Cuba, Mexico and Chile and Chile with Argentina. Regarding Brazil, despite its being the country that has produced the most scientific articles in the region, its collaborations with other countries in the region are fewer than those of other countries with Mexico, Argentina and Chile. Furthermore, Mexico and Chile are the countries in the region that have sustained greater collaboration relationships in this field with other countries in the region. On the other hand, this calls attention to the three countries in the region that have collaborated with none of their neighbors.

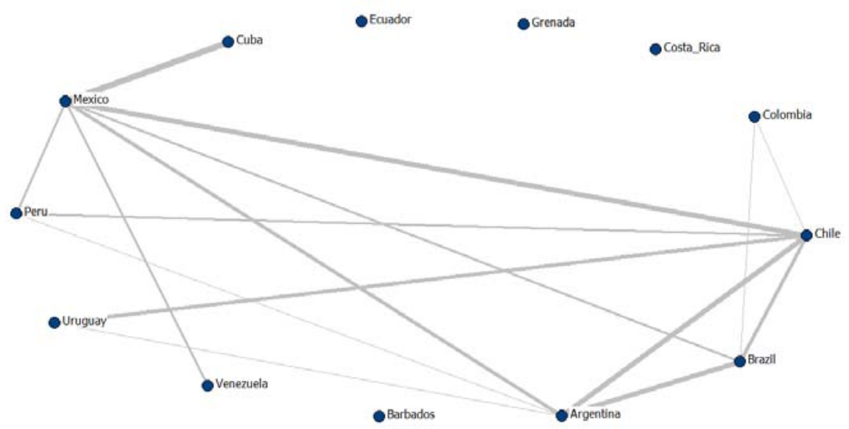


Figure 5.2-3 Scientific collaboration networks in the field of nanotechnology related to the water problematic in the region of Latin America and the Caribbean to 2012.

Figure 5.2-4 shows the networks produced by an analysis of article co-authorships with countries in the European Community. The structure of these collaboration networks shows that Portugal has maintained fairly significant collaborations with Brazil (thick line between those two nodes), while Spain has maintained relationships with far fewer, but more broadly distributed among countries in the region (it has collaborated with at least 9 countries). The other countries which have also maintained significant relations are France and Germany. The two countries in the region that have not formed scientific relationships with Europe are Granada and Barbados. It is also worth noting that Brazil, in contrast to the existing regional scientific networks, has maintained scientific collaborations with a larger number of European countries than with countries in the region.

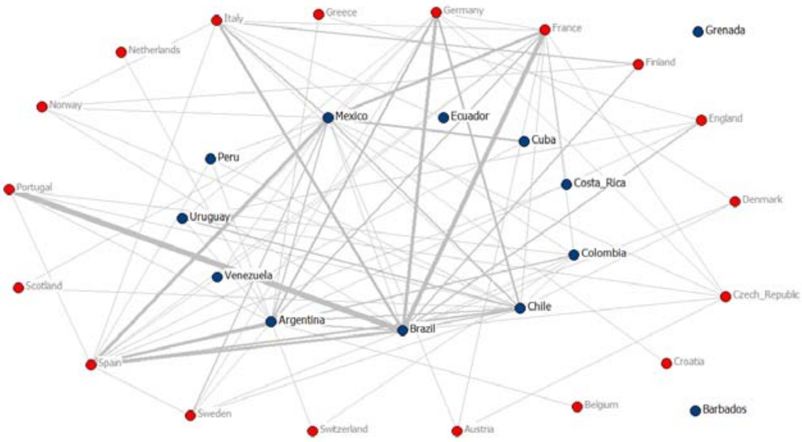


Figure 5.2-4 Scientific collaboration networks in the field of nanotechnology related to the water problematic in the region of Latin America and the Caribbean with Europe to 2012.

Figure 5.2-5 shows the last of the scientific collaboration networks that this study maps at the country level, revealing the collaborations with countries that are not a part of the European Union. The results confirm the prominent position occupied by the United States in scientific collaborations in the field of nanotechnology, maintaining scientific relationships by way of co-authorship of articles with the key countries of Latin America and the Caribbean: Brazil, Mexico and Argentina. The relationships established by the United States with these three countries are significant in terms of the frequency of collaboration, which is greater than that of the countries in Latin America and the Caribbean with the rest of the countries shown in the image, which show little significance in the structure of the networks.

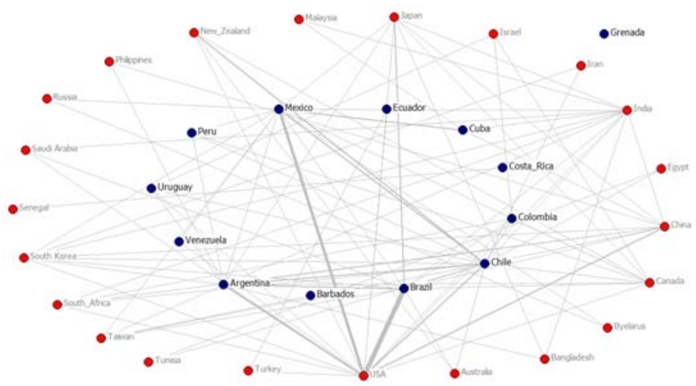


Figure 5.2-5 Scientific collaboration networks in the field of nanotechnology related to the water problematic in the region of Latin America and the Caribbean with the world excluding Europe to 2012.

5.2.3 Key scientists in the development of the field of nanotechnology related to the water problematic in Latin America and the Caribbean

Another goal of this study is the identification of the key scientific authors of articles on the identified themes. The results of that search are presented in this section. The objective is to identify the most productive authors in each of the topical areas, which may prove the premise that the scientists with greatest productivity are leaders in their collaboration groups. In the following tables the list of the researchers with the greatest article production in each of the areas studied are presented.

It is important to advise the reader that the authorship of the articles have not been authenticated, as such a task represents considerable time and effort that in this study we have not the resources to pursue in an exhaustive way at this time.

Autores	Artículos	Institución	País
Zanoni, MVB	10	Univ Estadual Paulista	Brazil
Alves, OL	5	Univ Estadual Campinas	Brazil
Machado, SAS	5	Univ Fed Sao Carlos	Brazil
Mattoso, LHC	5	Univ Estadual Maringa	Brazil
Paschoal, FMM	5	Univ Estadual Paulista	Brazil
Tay, FR	5	Univ Sao Paulo	Brazil
Anderson, MA	4	Univ Wisconsin	USA
Jardim, WF	4	Univ Estadual Campinas	Brazil
Lopez, T	4	Ctr Invest & Estud Avanzados	Mexico
Rangel-Mendez, JR	4	Inst Potosino Invest Cient & Tecnol	Mexico
Ribeiro, C	4	Embrapa Instrumentacao Agropecuaria	Brazil
Rodriguez, J	4	Inst Peruano Energia Nucl	Peru
Souza, AG	4	Univ Estadual Campinas	Brazil

Table 5.2-5 Researchers who have published at least 4 articles in the area of contaminated water remediation with nanotechnology in Latin America and the Caribbean to 2012.

Autores	Artículos	Institución	País
Machado, SAS	7	Univ Sao Paulo	Brazil
Cavalheiro, ETG	5	Univ Sao Paulo	Brazil
Cesarino, I	5	Univ Sao Paulo	Brazil
Izaguirre, I	5	Univ Buenos Aires	Argentina
Martinez, LD	5	Univ Nacl San Luis	Argentina
Tarley, CRT	5	Univ Fed Uberlandia	Brazil
Allende, L	4	Univ Buenos Aires	Argentina
Borsali, R	4	CNRS / Univ Bordeaux	France
Mascaro, LH	4	Univ Fed Sao Paulo	Brazil
Masini, JC	4	Univ Sao Paulo	Brazil
Moraes, FC	4	Univ Sao Paulo	Brazil
Rangel-Mendez, JR	4	Inst Potosino Invest Cient & Tecnol	Mexico
Rivas, BL	4	Univ Concepcion	Chile
Vargas, CA	4	Univ Concepcion	Chile
Zucolotto, V	4	Univ Sao Paulo	Brazil

Table 5.2-6 Researchers who have published at least 4 articles in the area of water potabilization with nanotechnology in Latin America and the Caribbean to 2012.

Autores	Artículos	Institución	País
Perez-Moreno, V	1	Univ Autonoma Queretaro	Mexico
Bonilla-Suarez, C	1	Univ Autonoma Queretaro	Mexico
Fortanell-Trejo, M	1	Univ Autonoma Queretaro	Mexico
Pedraza-Aboytes, G	1	Univ Autonoma Queretaro	Mexico
Caporgno, M	1	Univ Tecnol Nacl	Argentina
Schneider, R	1	Univ Sao Paulo	Brazil
Ferreira, L	1	Univ Sao Paulo	Brazil
Binder, P	1	Univ Sao Paulo	Brazil
Ramos, J	1	Perenne Equipamentos & Sistemas Agua Ltda	Brazil

Table 5.2-7 Researchers who have published at least 1 article in the area of water desalination with nanotechnology in Latin America and the Caribbean to 2012.

5.2.4 Overview of research in the field of nanotechnology related to the water problematic in Latin America and the Caribbean

In addition to visualizing the scientific collaboration networks that show us a vision of the structure of the science in the field of nanotechnology and the water problematic, another interesting issue lies with visualizations of the current state of the science. One of these ways of seeing the science concerns the disciplines that converge in emerging fields of science and technology. Here, we analyze the categories by which the identified articles have been indexed within the Web of Science. There are 82 categories within specialized disciplines among scientific publications (scientific journals) where the articles and scientific documents have been published. It is important to note that in the Web of Science databases, journals can be indexed by at least one category and the articles may be classified in one or more categories once they are published. The analysis we performed applied the method of similarity mapping and visualization supported by the Pajek and VOSviewer programs (Waltman and Van Eck, 2012), which bases the analysis in social networks and in similarity clusters applied to the categories. The result of this analysis is a visualization of the structure of scientific knowledge in disciplinary terms. These visualizations can be interpreted as a reflection of the current state of scientific knowledge.

The result of our analysis of the 82 categories of the Web of Science in which the articles have been classified is shown in Figure 5.2-6.In this image a total of 17 clusters appear, that is, the disciplines present converging similarities across 17 different groups. In the resulting visualization, we see that the key disciplines, according to the size of the node that is determined by the frequency of the discipline's appearance, are Materials and Physical-Chemical Sciences. To a lesser extent, Applied Physics and Chemical Engineering, Condensed Material Physics and Environmental Sciences also appear.

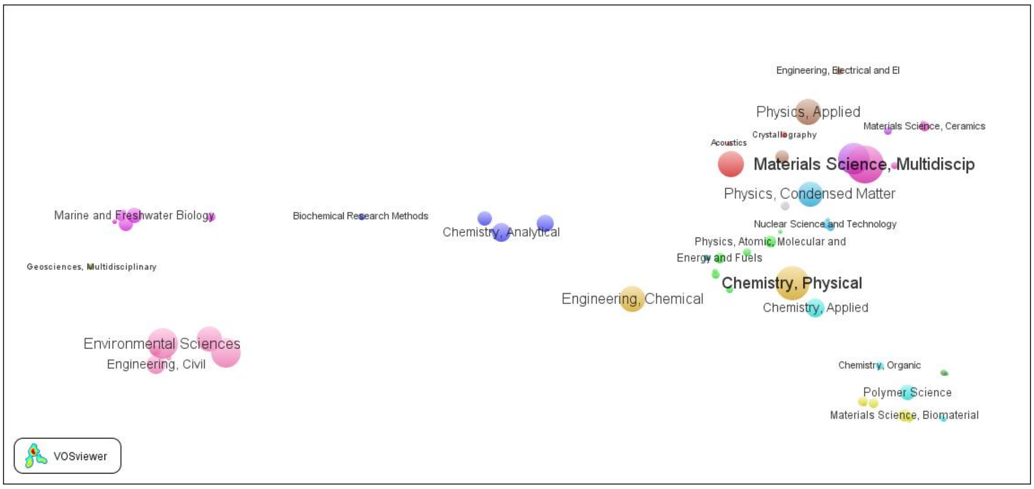


Figure 5.2-6 Overview of the field of nanotechnology related to the water problematic in the region of Latin America and the Caribbean in terms of knowledge (WoS categories) to 2012.

5.3 Bibliometric Analysis. Unified data from Web of Science and Scopus

5.3.1 Introduction

This following bibliometric analysis embodies a co-publication that has been conducted by ZSI and which covers co-publication activity between Latin American and Caribbean countries[32] and the countries within the European Research Area[33] in the thematic fields of nanotechnologies and water. It identifies the quantity of publications in and co-publications between these regions. It also provides key institutions and individual researchers that are involved in EU-LA nano-research topics with focus on water treatment. The methodology deployed combines the two most common scientific citation databases: Elsevier's Scopus and Thomson Reuteurs' Web of Science. Data was retrieved in October 2013 and covers co-publications from 2003 to 2012.

The data gathered was analysed according to the following dimensions:

- total numbers of co-publication output in nano-technology
- total numbers for the two specific areas in focus (water treatment) and their comparison with overall co-publication output per country
- the development of co-publications in the two thematic focus areas over time
- important thematic fields according to the Science-Metrix Ontology of Science
- analysis of author keywords
- cities that are important in terms of their co-publication output in the analysed research areas
- relevant institutions (operationalised as the top 40 "affiliations" = Institution-author relations according to Scopus)
- *relevant authors* and the most important links of *authors and affiliation cities*, where data was available

The chapter is structured as follows: At first we commit ourselves to a brief description of the methodological framework used for the present study in terms of data retrieval and analysis. The subsequent and core chapter shows the analysis results regarding the different dimensions. This is followed by data visualisation to understand developments in

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[32] For the list of countries included to this study please see 5.14.3

[33] As associated to the 7th Framework Programme of the European Union

keyword usage. Finally, we offer an outlook and attach further details on definitions, queries and keyword-lists in5.14.

5.3.2 Methodology

5.3.2.1 Data sources

This bibliometric analysis covers co-publications of the region Latin America with the region Europe (countries in and associated with ERA) as well as publications in each geographic region in the area of nanotechnologies (keyword based). The data analysed in this study has been sourced from the two best known and most comprehensive multi-disciplinary academic citation data bases:

- Elsevier's Scopus and
- Thomson Reuter's Web of Science (WoS).

Data has been retrieved in autumn 2013 for the time period 2003 to 2012. Data of all document types were retrieved, but restricted for the impact analysis to citable material published in scientific journals or conference proceedings (no letters, articles in press …). As a result of the data retrieval we obtained a series of database extracts (in different batch sizes) in BibTeX format with partly different field names and different quality (depending on the data source). A bundle of software tools and algorithms was especially developed to assure (1) that the formats of the data allow unification and (2) the increase of quality of metadata of publications tracked in both sources. The steps involved are described in detail in the next section. The results of these processes at first are database-specific tables, into which parsed BibTeX data are inserted. The four resulting tables containing records and affiliations for Scopus and WoS separately are then unified into one record table and one affiliation table.

5.3.2.2 Data cleaning and consolidation of data sources

On the basis of raw data tables retrieved from Scopus and WoS in BibTeX format, a unified data set was created using a series of processing steps in our SQL database and with a specifically developed web interface for a multi-stage data cleaning process (e.g. duplicate detection, raw data correction, journal classification - if they are not already classified by Science Metrix,…) including both, automatic and manual steps.

Import of raw data

After importing the data-chunks in our data base, they are imported in a SQL-database (PostgreSQL) with specifically adjusted Parsers. At first the BibTEX-data are imported in a raw data table as key-value-pairs, where every record has an Import-ID, a specific Import-Date (which is important e.g. for analysing Impact and citation counts), information of data source (Scopus or WoS), an identifier, the key-value-pairs and a marker, if data is manually corrected or not. Simultaneously the key characteristics (normed fields as DOI, author, title, journal, year, volume, number, pages, document type) are written in a separate table for the search of duplicates.

Duplicate Detection

The identification of records from both sources describing the same publication is led through by searching for conformities in the following variables: DOI, title, year, begin page, ISBN and begin page, journal ID or ISSN and begin page, year and author. With a specific algorithm, adapted to the sometimes poor data quality, those duplicates can be identified and unified automatically. In the Web Interface those automatically identified records, which may be duplicates but are still doubtful, are manually revised.

Raw data correction

After the automatically check of raw data - conducted with regular expressions (e.g. invalid values for DOI, space between characters and in fields) -, possible raw data errors have to be corrected manually as well. Because this study does not analyse affiliation of authors, these raw data errors could be ignored. All other fields as year, volume, DOI, ISSN, etc. were corrected entirely and every manual correction was registered in our database.

Classification

The record table contains a column with Journal_ID, which refers to another table with journals. In this journal table all journal names contained in WoS records are imported from Science-Metrix -ontology, that classification, which we use for disjunct attribution of one journal to one category. As a next step all Journal-names, which are only covered by Scopus, are added and if necessary, classified manually. Additionally there are always some Journals not classified in Science Metrix which also have to be assigned to a Science-Metrix sub-field. After the manual classification of all unclassified journals every journal has a distinct classification. For this study, we had to classify more than 4 000 unclassified Journals.

Data Unification

The corrected data sets are distributed across different tables: authors, affiliations, normed and full data sets. On the basis of the normed data sets and with a complex matching-algorithm data sets from Scopus are identified with those from Web of Science and therefore unified. Following steps are necessary for data unification of both data sources:

- In a first step journal names are unified. Many records appear in Scopus and WoS, but with different spelling, institution or author notation, etc. After normalising syntax and spelling of journal names detected as identical (e.g. with differing capitalization) in a second step all records are unified using a matching-algorithm between normalized author names.
- To identify identical records we use Document Object Identifiers (DOI) of all records in our database. Those DOIs are unique (disregarding typos in the original databases, whose rate of occurrence lies at roughly 1%) for any registered publication worldwide (but unfortunately often are missing).
- If DOIs are missing or wrong they are unified with combination of better available data (e.g. address from Web of Science, author list from Scopus) using different complex algorithms to search for counterparts through ISBN, author names, title, year, pages, etc.
- Ambiguous cases are reworked manually.

For the data unification the corrected data sets are distributed across different tables: authors, affiliations, normed and full data sets. Merging the two data sources in our experience typically leads to an enlargement of data stock by around 20%. Figure 1 depicts the data processing work flow, but as this study does not include analysis on affiliation-level, some of the steps shown were not undertaken (org-strings, authors, affiliations, organisations).

After these data cleaning steps it can be shown which benefits the consultation of both data sources can offer for the present analysis: Scopus listed 133 214 records for co-publication involving at least one author affiliated in CELAC and one affiliated in ERA in the period of 2003 to 2012, WoS 104 759. After the unification process 140 932 co-publications could be identified as unique. 19 948 co-publications were listed in WoS only and 48 403 in Scopus only. These figures show the remarkable gain in data coverage through consulting both databases as data retrieval sources.

5.3.2.3 Thematic Areas

Each cleaned record not only contains keywords given by the author(s) but has also been assigned with the journal subject categories of the respective source database(s). Unfortunately the two thematic classification systems in Web of Science and in Scopus not only distinguish themselves in the way of assignment, but also in the set of the used categories. Each database classifies each listed journal with one or more journal subject categories (249 in Web of Science) or with the help of All Science Journal Classification numbers (ASJC; 334 categories in Scopus). Because of the benefits of the Science-Metrix Ontology – more complex but more reasonable classification, respected in the bibliometrics-community and is classified per journal and disjunct – we use this classification. More than 15 000 journals are assigned to distinct sub-fields from Science-Metrix, and therefore it could easily be adopted for most of the Journals appearing in this study. But some Journals were not classified by Science-Metrix and therefore in sum around 4 000 had to be integrated manually in this Ontology.

For extracting those co-publications, relevant for the fields of nanotechnology and the thematic specialsiations of energy- and water-related research, the following methodology was applied:

Just as in the previous study for health, "nano" was defined by an expert-vetted set of keywords developed by a study lead by Peter Haddawy (UNU) in 2011 (list of author keywords attached).

This set was crossed with a keyword set for water (drinking ~, brackish ~, desalination, drink, filtration, fresh~, fresh~ pollution, ground~, natural ~s, pesticide remediation, reverse osmosis, salt~, sea~, ~ pollution , ~ purification, ~ treatment) and energy (energy; power) each.

5.3.2.4 Restrictions and error estimates

There are a few things to be kept in mind when interpreting the results and data presented:

- Data and results presented unfold their full potential by triangulating them with additional qualitative data and complementary analyses, such as expert consultations or other activities outlined in task 2.1.
- We have put a lot of effort in data cleaning and processing. Depending on the type of analysis (overall figures, subject areas, impact data, etc.), a rough analysis of possible

errors points to an error probability of 1-5%. This may become especially important for those results, which are based on only a small number of publications.

- Caution is necessary with impact measures (average times cited counts) in subject areas with a small number of co-publications. The outliers are more likely to have a significant impact in these cases.
- Impact data is a snapshot at a given point in time. While the number of publications in the two databases is stable approximately half a year after the end of the year of publication, times cited counts are naturally constantly changing.
- We measure publications, not the work behind those publications. In case a specific piece of research is published via multiple channels in similar ways, there is no way at the meta level to identify this and control for this kind of duplicates. Despite considerable data processing and cleaning efforts, there will always be a certain margin of error in the data. More specifically, errors can stem from one of the following circumstances (or combinations of those):
    - Some of the ERA-CELAC co-publications might not be retrieved when looking for publications by ERA or CELAC-based authors in Scopus and Web of Science in case the country is not or not correctly assigned. This error, however, can be estimated as not higher than 2-3 % based on previous comparable studies.
    - Duplicates might be wrongly corrected or not identified. This error can be estimated at around 0,1-0,2 %.
    - Errors in the raw data: Out of the around 100 000 raw data records that we retrieved (Scopus and Web of Science), between 1 000 and 2 000 have raw data errors of different kinds (missing document object identifiers, wrong author-institution-links, etc.). The most relevant of these errors have been corrected.
    - Unification: When unifying data from Scopus and Web of Science, two errors can occur: Records that should be unified are not; records that should not be unified are unified. The combined error amounts to below 1 % according to previous experience and studies.
    - Limitations are being faced when it comes to benchmarks to other countries or

total publications counts of whole countries or regions, since the huge amount of records cannot be cleaned, unified and standardised to the same extend like the data set within this study. The set for analysis in the present study therefore is hardly comparable with total sums published in other studies, since they usually only use one data source. If benchmarks have to be made, figures by Scopus/SCImago are being used, but direct comparison has to be read with caution.

- Another comparability problem is at stake when it comes to research fields. The different citation databases use different classification systems based on different logics for categorisation (e.g.: multiple assignment, single classification). For as the Science-Metrix Ontology of Science was used for analysis here, comparison with All Science Journal Classification fields used in Scopus or Web of Science categories remains blurred and normalized field citation scores published by Thomson Reuters are difficult to drawn upon and used as a benchmark in this context.

5.3.3 Results

5.3.3.1 Co-publication ties: an overview

The following data are included for a better overview on the data situation and are taken from a similar study for the ALCUE NET project. The full report is available on the project website[34].

For this time period, authors from CELAC and ERA are involved in 140 932 jointly published scientific publications between 2003 and 2012. Brazil has the most co-publications involving at least one author from ERA compared to all other CELAC countries, followed by Mexico, Argentina, Chile, Colombia and Venezuela (see

Table 5.3-1). From the ERA countries' perspective, Spain is involved the most in co-publications with authors from CELAC, followed by France, Great Britain, Germany, Italy and the Netherlands (Table 5.3-2). Whereas Brazil is involved in nearly 40% of all CELAC and ERA co-publications and all the other CELAC countries do have a percentage of the overall CELAC and ERA co-publications below 20%, the percentages of the most active ERA countries involved in CELAC and ERA co-publications do not differ that much: Spain

[34] http://alcuenet.eu

is involved in 28 % of all ERA and CELAC co-publications, France in 21%, Great Britain in 19% and Germany in 18 %. Portugal ranks on place 8 with around 5% of the co-publication share.

CELAC country	Numbers of co-publications with ERA 2003-2012	Overall publication output according to SCImago (2003-2012)	Share of co-publications with ERA regarding overall publication output
Brazil	56,005	373,360	15.00%
Mexico	27,909	126,404	22.08%
Argentina	21,647	84,121	25.73%
Chile	18,102	51,538	35.12%
Colombia	9,286	30,957	30.00%
Venezuela	4,695	18,800	24.97%
Cuba	4,188	16,809	24.92%
Peru	2,703	7,512	35.98%
Uruguay	2,434	7,261	33.52%
Ecuador	1,840	3,645	50.48%
Costa Rica	1,499	4,727	31.71%
Bolivia	1,363	1,939	70.29%
Panama	1,131	2,436	46.43%
Puerto Rico	780	8,064	9.67%
Trinidad and Tobago	525	2,891	18.16%

Table 5.3-1: CELAC countries - co-publications with ERA and overall output, 2003-2012 (Sources: WoS+Scopus; SCImago)

ERA country	Numbers of co-publications with CELAC 2003-2012	Overall publication output according to SCImago (2003-2012)	Share of co-publications with CELAC regarding overall publication output
Spain	39,476	568,836	6.94%
France	30,139	878,307	3.43%
Great Britain	26,834	1,308,900	2.05%
Germany	26,473	1,223,419	2.16%
Italy	17,212	684,238	2.52%
Netherlands	8,615	388,568	2.22%
Switzerland	7,951	282,454	2.81%

Portugal	7,676	113,400	6.77%
Belgium	7,353	214,924	3.42%
Sweden	5,890	253,839	2.32%
Poland	3,774	256,110	1.47%
Austria	3,592	155,941	2.30%
Denmark	3,483	146,630	2.38%
Israel	2,984	150,499	1.98%
Czech Republic	2,915	124,111	2.35%

Table 5.3-2: ERA countries - co-publications with CELAC and overall output, 2003-2012 (Sources: WoS+Scopus; SCImago)

For the 15 most active ERA countries in co-authorship with CELAC countries, the share of co-publications with CELAC countries in their overall publication output is below 10%. In more than 6% of all publications involving Spanish or Portuguese author(s) an author affiliated in a CELAC country is involved. More than 3.4 % of France' and Belgium's publications involve at least one CELAC country, for Switzerland and Italy this applies for more than 2.5% of their publication output. For all other countries the share of co-publications with CELAC in their overall publication output is below 2.5% (seeTable 5.3-2).

Looking at the 15 CELAC countries most active in co-publications with ERA countries, only Puerto Rico has less than 10% of their overall publications with ERA affiliated authors involved. All other countries have a share of co-publications with ERA countriesover 15% (in some cases considerably more). For the five countries with the highest overall publication output in CELAC more than 15% of their overall publications involve at least one author from an ERA country: Brazil (15%), Mexico (22%) and Argentina (25%), Colombia (30%) and Chile (35%). Venezuela (25%) and Cuba (25%) do have a quite similar share of co-publications with ERA (compared to their overall publication output). Some research communities with a lower overall output show even shares of co-publications with ERA far beyond the 15% benchmark: more than 46% of Panama's publications involve an author from an ERA country, Ecuador reaches more than 50%, in Bolivia even 70% of all indexed publications involve at least one author from ERA (seeTable 5.3-3).

It has to be kept in mind that the numbers of the overall publication outputs of ERA and CELAC countries are drawn from SCImago (based on Scopus database) and are not unified data from Scopus and Web of Science. Thus it has to be considered that the numbers for the overall publication outputs of the different countries are lower than if they had been unified and retrieved from both databases.

5.3.3.2 Total publication counts in nanotechnologies

According to the nano-related keyword query, there are 63 578 publications in this area in the European Research Area (ERA) and 6 549 publications in the CELAC-region in all years tracked by Scopus. Thus, ERA's output in nano-science has been so far almost 10 times higher than the output in Latin American countries.

With a sum of more than 115 000 co-publications between ERA and LAC, the share of nano-research in this collaboration is almost 1,2 %. Looking at the total output in these regions and comparing it to each region's output in nano-research, these shares differ between the two regions: ERA (> 14 Mio publications) and CELAC (> ½ Mio publications) have a share of nano-related research of approximately 0,4% and 1,1% respectively.

5.3.4 Water Research

There were 343 records on co-publications between CELAC and ERA countries in the period of 2003-2012 found in the two consulted databases combined. They were published in 197 different journals with an average impact of 15.2 citations per record. A nanotechnology-water publication in these regions is authored by about 6 authors from 2.5 countries on average.

5.3.4.1 Publication strengths per country

Within ERA-CELAC collaboration in nano+water research, not surprisingly Brazil (144), Mexico (79) and Argentina (61) are the most productive partners for Europe as shown inTable 5.3-3. Highest citation rates can be observed in co-publications with Columbia (20.24 times cited per record on average).

CELAC-Country		Co-publications with ERA	Mean citation rate / record
Brazil		144	15.15
Mexico		79	14.09

Argentina		61	13.48
Chile		20	15.1
Colombia		17	20.24
Venezuela		10	31.8
Costa Rica		7	7.43
Cuba		6	16.67
Peru		5	16
Uruguay		5	14.4
Puerto Rico		3	10.67
Bolivia		1	7
Ecuador		1	7.7
Panama		1	13

Table 5.3-3: Co-publications on nanotechnology with focus on water with ERA per CELAC-country and their average citations, 2003-2012 (Sources: WoS+Scopus)

For Latin-America, the most important European partners for nano+water research are Spain (116), France (92) and Germany (61), with highest impact rates in Dutch and Hungarian collaboration networks (see

Table 5.3-4).

ERA-Country	Co-publications with CELAC	Mean citation rate / record
Spain	116	13.14
France	92	19.77
Germany	61	15.85
Portugal	22	11.59
Italy	21	14.3
Great Britain	11	4.73
Switzerland	10	8.52
Sweden	9	8
Belgium	8	11.63
Hungary	7	21.14
Netherlands	6	21.33

Table 5.3-4: Co-publications on nanotechnology with focus on water with CELAC per ERA-country and their average citations, 2003-2012 (Sources: WoS+Scopus)

Compared to the total research output jointly published with partners from CELAC or ERA countries, those players that are strong in water-related nano-research are also those that are generally strong within the cooperation, as depicted by Figure 5.3-1.

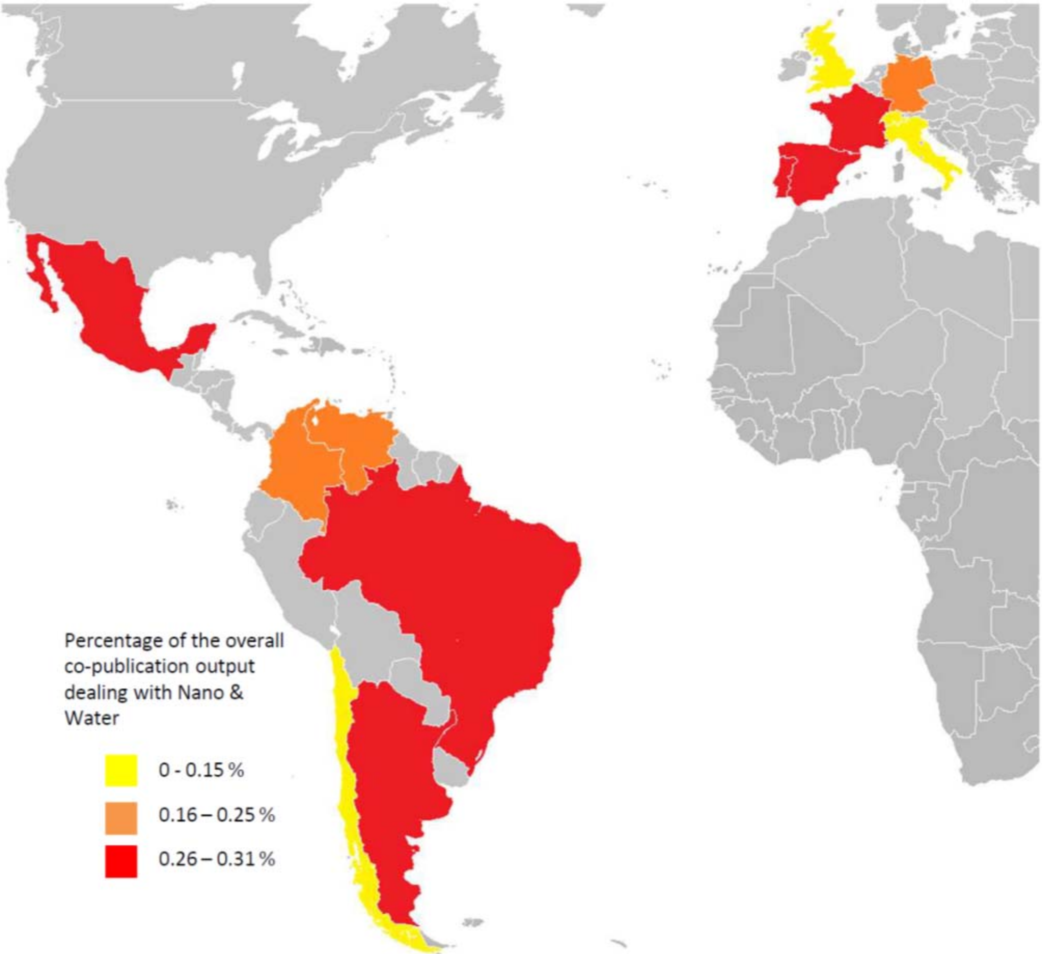

Figure 5.3-1: Percentage of the overall co-publication output between ERA and CELAC countries dealing with nanotechnology and water, 2003-2012 (Sources: WoS+Scopus)

5.3.4.2 Development over time

Water-related research in nanotechnology has not been increasing steadily. There was a slump in 2005 and stagnation in 2007-2008. Yet, the research output in 2012 was more than 5.5 times higher than in 2003.

Year	Co-publications	mean citation rates / record	Mean author count
2012	72	3.38	6.5

2011	66	8.25	5.79
2010	47	16.3	5.94
2009	38	15.82	5.87
2008	32	16.63	5.34
2007	32	24.44	6.28
2006	20	34.4	6.5
2005	8	40.63	5.88
2004	15	31.87	5.8
2003	13	19.46	5

Table 5.3-5 Development over time: ERA and CELAC co-publications on nanotechnology with focus on water and their average numbers on citations and involved authors, 2003-2012 (Sources: WoS+Scopus)

5.3.4.3 Science Metrix sub fields

Unlike energy-related nanotechnology research where sub-fields in Physics are more relevant, in water-related areas the chemical sub-fields are stronger: *Chemical Physics, Nanoscience & Nanotechnology* and *Phyical Chemistry*. There are also other disciplines involved, like *Chemical Engineering* (field: *Engineering*), *Pharmacology & Pharmacy* (field: *Clinical Medicine*), *Environmental Sciences* (field: *Earth & Environmental Sciences*)and *Food Sciences* (field: *Agriculture, Fisheries & Forestry*). We therefore may conclude, that water-related research in nanotechnology has a higher degree of interdisciplinarity as other nano-related research. Highest impact rates can be observed in Fields related to Chemistry – for details see

Table 5.3-6.

Science-Metrix Sub-Field	Publications	Mean citation count
Chemical Physics	44	13.42
Nanoscience & Nanotechnology	38	17.64
Physical Chemistry	34	14.76
Materials	29	14.97
Polymers	28	20.46
Applied Physics	20	13.3
Chemical Engineering	15	8.07
Organic Chemistry	13	15.2
Energy	12	22.62

Pharmacology & Pharmacy	10	13.2
Analytical Chemistry	9	19.11
Environmental Sciences	8	14.71
Food Science	7	17.71
General Chemistry	7	29.89
Fluids & Plasmas	7	5.86

Table 5.3-6 Science Metrix sub-fiels of ERA-CELAC co-publications on nanotechnology with focus on water, 2003-2012 (Sources: WoS+Scopus)

5.3.4.4 Nanotechnology and water keywords

Figure 5.3-2 shows the keywords assigned to ERA-CELAC nanotechnology and water co-publications by their authors in the time period 2003 to 2012. The size of the letters indicates the frequency of the keyword. In this case "nanoparticles" is the most frequent used keyword with 21 entries. The keywords with the least entries displayed in

Figure 5.3-2 are mentioned twice. It has to be kept in mind, that

Figure 5.3-2 does not quote all the author-keywords assigned to the ERA-CELAC nanotechnology-water co-publications and that there are many more author keywords than those displayed below (957 in total, whereof more than 800 are only mentioned once).

Figure 5.3-2 Author-Keywords in ERA-CELAC nanotechnology and water co-publications, 2003-2012 (Sources: WoS+Scopus; n=108(957); threshold=2; max=21)

5.3.4.5 Most active Institutions and Authors in EU-LA co-publications

Since data cleaning on institutional level is not possible with the given resources, we offer three attempts for approximating a valid overview on the most important actors involved in the field:

1. A list of the most frequent cities as indexed in affiliation data
2. Top 40 Institutions in the field as listed by Elsevier Scopus
3. The most active authors and traces of their mobility according to their affiliation cities

The figures presented do not offer definite amounts of publications, but rather weigh their relative importance to the other entities, since different data sources have been used and institutional information could not be exhaustively cleaned and standardised.

Table 5.3-7 shows the most frequent cities in both areas with the number of co-publications they are listed in. For orientation American cities are marked green and those on the European side in blue colour.

City	Participations in co-publications
Mexico City	73
São Paulo	45
São Carlos	27
Buenos Aires	26
Madrid	25
Barcelona	23
Rio de Janeiro	23
Araraquara	19
Santiago de Chile	19
Grenoble	18
Paris	17
Florianópolis	15
Gif-sur-Yvette	14
Sevilla	14
Campinas	13
La Plata	13
Lisboa	13
Concepción	12
Mar del Plata	11
Bogota	10

Table 5.3-7 Most frequently publishing cities in ERA-CELAC co-publications in nanotechnology + water 2003-2012 (Source: WoS+Scopus). Green lines mark American cities, blue lines are European cities.

Researchers in Mexico City, São Paulo, São Carlos and Buenos Aires co-publish most actively with European partners in the field of nanotechnology and water, followed by Spanish cities as their transatlantic counterparts (Madrid and Barcelona).

Please note, that in cases where several institutions from the same city are mentioned within one record, the city is only counted once in the above calculations.

5.3.4.6 Most frequent institutions in ERA-CELAC collaboration on nanotechnology and water

As listed by Elsevier Scopus (only), amongst the top 40 players in nanotechnology and water on the American side are Brazilian, Mexican and Chilean institutions, represented by the biggest universities of each. More information can be retrieved from

Table 5.3-8:

Institution	Country
Universidade de Sao Paulo	BR
UNESP-Universidade Estadual Paulista	BR
Universidade Federal do Rio de Janeiro	BR
Universidad Nacional Autonoma de Mexico	MX
Universidade Federal do Rio Grande do Sul	BR
Universidade Estadual de Campinas	BR
Universidad de Chile	CL
Universidade Federal de Minas Gerais	BR
Universidad de La Habana	CU
Universidad Nacional de Mar del Plata	AR
Universidade Federal de Sao Carlos	BR
Universidade Federal de Santa Catarina	BR
Universidad de Costa Rica	CR
S. C. CIMAV	MX
University of Concepcion - Chile	CL
Universidad de Buenos Aires	AR
Universidad de Guadalajara	MX
Universidade de Tras-os-Montes e Alto Douro	BR
Universidade Federal de Sao Paulo	BR
Universidade Fernando Pessoa	BR
Universidade de Brasilia	BR
Universidade Federal de Juiz de Fora	BR

Instituto Potosino de Investigacion Cientifica y Tecnologica	MX

Table 5.3-8Most relevant institutional players in nanotechnology+water amongst the top 40 on the American side (Source: Scopus)

Amongst the top 40 players in nanotechnology and water on the European side we identified Portugual with the Instituto Superior Tecnico and the Universidade do Porto, followed by the German Universität Paderborn as the most productive institutions in the partnership (

Table 5.3-9).

Institution	Country
Instituto Superior Tecnico	PT
Universidade do Porto	PT
Universität Paderborn	DE
Universite Paris-Sud XI	FR
Universidad Complutense de Madrid	ES
Aarhus Universitet	DK
Universidad Politecnica de Valencia	ES
Universidad de Burgos	ES
Universidad Autonoma de Madrid	ES
Universidad de Santiago de Compostela	ES
CSIC - Instituto de Ciencia y Tecnologia de Polimeros ICTP	ES
Universite Joseph Fourier	FR
CIBER Bioingenieria, Biomateriales y Nanomedicina	ES
Grenoble Institute of Technology	FR
Universidad Carlos III de Madrid	ES
The Royal Institute of Technology KTH	SE
Universidad Jaume I	ES

Table 5.3-9 Most relevant institutional players in nanotechnology+water amongst the top 40 on the European side (Source: Scopus)

5.3.4.7 Most active authors and their affiliation country, acknowledging mobility:

As typical for co-publication analysis on author-level, certain error has to be incalculated since there might be cases where two authors by coincidence have exactly the same surnames and initals. The exact numbers and ranking has to be cautiously interpreted, since unique author-identification is very tricky, due to orthographic problems (e.g.: special characters), spelling mistakes, marriages with name changes, number and space for (middle) initials, or simply identical names and name combinations.

Table 5.3-10 lists the top 50 authors found in the set of co-publications as ranked by their publication numbers. Of the more than 1 600 author names found in the dataset, the researcher listed most often was C.V. Santilli, with 13 entries in sum. There were 49 authors with 3 publications found - so the 21 authors listed amongst the top 50 below were selected due to their alphabetical order.

Authors	Records	Authors	Records
Santilli, C.V.	13	Radivoy, G.	4
Pulcinelli, S.H.	12	Roso, L.	4
Briois, V.	11	Scaffardi, L.B.	4
Borsali, R.	9	Torchia, G.A.	4
Rodríguez, J.A.	7	Antonucci, V.	3
Dufresne, A.	6	Aricò, A.S.	3
Evans, J.	6	Arriaga, L.G.	3
Alonso, F.	5	Azzaroni, O.	3
Bredow, T.	5	Baglio, V.	3
Galembeck, F.	5	Bahnemann, D.	3
Hrbek, J.	5	Baudelet, F.	3
Mendive, C.B.	5	Bekássy-Molnár, E.	3
Ribeiro, S.J.L.	5	Bergmann, C.P.	3
Tokumoto, M.S.	5	Blanchandin, S.	3
Yus, M.	5	Blesa, M.A.	3
Graciani, J.	4	Bourgaux, C.	3
Hernández, A.	4	Bras, J.	3
Lee, L.-T.	4	Bundschuh, J.	3
Liu, P.	4	Caiut, J.M.A.	3
Messaddeq, Y.	4	De Andrade, M.J.	3
Moglie, Y.	4	Dexpert, H.	3
Moreno, P.	4	Dexpert-Ghys, J.	3
Piñeiro, Á.	4	Fort, S.	3
Prádanos, P.	4	García, N.L.	3
Pulgarin, C.	4	Giacomelli, F.C.	3

Table 5.3-10 First 50 authors in ERA-CELAC co-publications on nanotechnology+water 2003-2012 ranked by their number of records (approximations; Source: WoS+Scopus)

Table 5.3-11 below lists those authors that have more than two publications linked to an affiliation city in the field of water-relevant nanotechnology research in 2003-2012 in co-publications between authors affiliated in ERA and CELAC. To be precise, we list authors that are involved in at least four affiliation-record links, not necessarily *publications*. What

Table 5.3-11 rather tries to depict is how authors move and therefore covers better the overall productivity in the described certain field. Because of this individual mobility it is possible that one author has more than one affiliation within the same record and therefore is over-represented in his publication strength. Yet the higher number signals certain strength in international connectedness and supposedly experience in international collaboration, which is how

Table 5.3-11 and the figures given have to be read. It has to be noted, that due to data cleaning issues not all author entries had information on the affiliation country. Therefore the sum of entries found does not correspond to the overall publication numbers, since there are not for all records country information available.

Author Name	Country I[35] + records		Country II + records		Country III + records		sum
Blesa, M.A.	DE	2	AR	1			3
Borsali, R.	FR	2	BR	1			3
Bras, J.	FR	2	BR	1			3
Bredow, T.	DE	3	AR	2			5
Bundschuh, J.	AU	1	AR	1	DE	1	3
Caiut, J.M.A.	FR	2	BR	1			3
De Andrade, M.J.	BR	2	DE	1			3
Giacomelli, F.C.	BR	2	CZ	1			3
Lee, L.-T.	BR	3	FR	1			4
Lima, M.D.	DE	2	BR	1			3
Litter, M.	TW	1	AR	3			4
Mendive, C.B.	DE	4	AR	1	EG	1	6

[35] Country codes abbreviated according to ISO 3166-1 alpha-2. A list of countries and codes is available for example at http://en.wikipedia.org/wiki/ISO_3166-1#Current_codes

Moglie, Y.	AR	3	LB	1			4
Nava, R.	ES	2	MX	1			3
Pulcinelli, S.H.	FR	2	BR	1			3
Rivas, B.L.	CL	2	FR	1			3
Rodriguez, J.A.	ES	1	US	2			3
Santilli, C.V.	FR	4	BR	2			6
Scaffardi, L.B.	AR	2	ES	2			4
Torchia, G.A.	AR	2	ES	1			3
Torres, F.G.	PE	2	ES	1			3
Videla, F.A.	AR	2	ES	1			3

Table 5.3-11 List of authors with at least 4 entries found with affiliation cities in ERA-CELAC co-publications 2003-2012 for nanotechnology and water research (Source: Scopus, Web of Science). The sum of hits does not equal to the total number of publications per author, since not all records provide country information.

The authors with the highest numbers of entries matching with a country are C.V. Santilli and C.B. Mendive with 6 hits each. The later together with J. Bundschuh are tracked as the most mobile authors with three affiliation countries each.

5.3.5 Summary and Conclusions

The analysis presented in this document offers an overview of co-publication patterns, scientific authors and affiliated organisations in nanotechonolgy research with focus on water. Major findings of this analysis are as follows:

- For the time period 2003 to 2012, authors from CELAC and ERA are involved in 140 932 jointly published scientific publications. Thereof, 343 ERA-CELAC co-publications were published in the field nanotechnology and water. The most frequently involved partner countries on Latin-American side are Brazil, Mexico and Argentina, on European side the most frequently involved partner countries are Spain, Germany and France. For the nantechnology and water co-publications the highest average impact can be found in co-publications involving authors from Colombia, the Netherlands, and Hungary.

- Water-related research in nanotechnology did not grow steady over the years, the co-publication output in 2012 was 5.5 times higher than in 2003.

- ERA-CELAC co-publications in nanotechnology and water were strongly published in journals classified in chemical sub-fields: *Chemical Physics, Nanoscience*

&Nanotechnology and *Phyical Chemistry*. It could be observed that water-related research in nanotechnology has a higher degree of interdisciplinarity than other nano-related research.

- In nanotechnology and water co-publications, researchers affiliated in Mexico City, São Paulo, São Carlos, Buenos Aires, Madrid and Barcelona are most actively involved.
- On institutional level, for nanotechnology and water co-publications with CELAC the most frequently involved European institutions are the Instituto Superior Tecnico and the Universidade do Porto in Portugal and the German Universität Paderborn on the side of ERA. On CELAC side for nanotechnology and water co-publications the most frequently involved institutions are all from Brazil: Universidade de Sao Paulo, UNESP-Universidade Estadual Paulista and Universidade Federal do Rio de Janeiro.

5.4 Analysis by country

5.5 Brazil

5.5.1 Stimulating the development of nanotechnology in water treatment

The Nanoscience and Nanotechnology Development Plan, which guides the first national nanotechnology policy in the Multi-Year Plan (2004-2007) of the Ministry of Science and Technology (MCT) makes no specific mention of the issue of water. However, the document does highlight the potentials arising from the application of nanotechnology in addressing environmental problems, which is specified as one of the goals to be achieved, and identifies the national capabilities to act in this field. Among the research topics highlighted in the document as relevant, we find some that deal directly with water treatment, such as membranes, sensors, nanomaterials and functional materials (MCT 2003).

The Science, Technology and Innovation Multi-Year Plan (2008-2011) established the field of nanotechnology as strategic for the country. The applications of nanotechnology to water, or more generally, the environment, received no special attention in that document (MCT 2007).

The National Science, Technology and Innovation Strategy (2012-2015) lists the environment among its objectives (MCT, 2012). Some areas with potential application in the treatment of water are defined as priorities, such as the development of sensors and environmental monitoring systems and the treatment of effluents and residuals. It is important to note that within the framework of the 2012-2105 Strategy, the SisNANO (National Nanotechnology Laboratory System) was created, with the environment being one of the strategic areas considered within this system (Plentz, 2013). The following key topics for nanotechnology research and development (R&D) with environmental applications are proposed: pollution treatment, effluents, environmental problem mitigation and the treatment of water. Due to their potential to contribute to the resolution of these kinds of problems, research in the following areas are highlighted: filters based on nanostructured materials; nanomembranes for recycling and the elimination of residuals and the treatment of urban and industrial effluent; nanoclays, nanoceramics, nanocomposites for desalination and water potabilization without the need for treatment plans; and portable, low-costand high-efficiency systems (SISNANO, 2013).

5.5.2 Funding nano-water research

A search was carried out of the projects in nanotechnology funded by the key agency in national research funding, the National Council for Scientific and Technological Development (CNPq), over the past five years (2008-2013). We began by selecting those calls for proposals in research oriented toward nanotechnology (excluding general calls that might take up the matter of nanotechnology via other areas). The results appear inTable 5.5-1. From the list of researchers with resources (the total number of funded projects is indicated in column 3, a further search of their profiles in the Base Lattes/CNPqwas performed, and the proposed project was identified along with the title and description.

Research Calls	Funded projects (all)	Funded projects on nano-water	Title of the project
Chamada MCTI/CNPq N º 16/2012 -expansão e consolidação de competências nacionais em nanotecnologia/ Jóvenes Investigadores	13	0	
Chamada MCTI/CNPq N º 16/2012 - expansão e consolidação de competências nacionais em nanotecnologia / Investigadores Senior	11	0	
Chamada MCTI/CNPq nº 21/2011 - Apoio à execução de projetos conjuntos de pesquisa,	9	1	Título não identificado (tema: contaminação ambiental, aquática)

desenvolvimento e inovação e Nanotecnologia no âmbito da cooperação internacional Brasil-México.			
Chamada MCTI/CNPq N º 74/2010 Formação de redes cooperativas de pesquisa e desenvolvimento em Nanociência e Nanotecnologia.	17	1	Processamento e caracterização de superfícies funcionalizadas com nanopartículas antimicrobianas para tratamento de agua
Chamada MCT/CNPq Nº 62/2008 - apoio à pesquisa fundamental em Nanociências, preferencialmente voltada a fomentar a inovação e impulsionar aplicações tecnológicas/ Jovens Pesquisadores	175	5	Desenvolvimento de Materiais Nanoestruturados aplicados à Eletrocatálise da Reação de Redução de Oxigênio para fins de Geração de Energia Elétrica e Remediação Ambiental (tratamento de águas residuárias) Modificação de TiO2 com Metais e Óxidos para Desenvolvimento de Foto-Reatores Protótipos para Purificação de Água Processos de adsorção e catálise ambiental na despoluição de águas residuárias têxteis: um estudo comparativo entre os tratamentos convencionais e sistemas com uso de materiais nanoestruturados Síntese e estudos estruturais de catalisadores a base de óxidos metálicos nanoestrutura dos para degradação de compostos poluentes Desenvolvimento de Material Magnético para Remoção de Petróleo Derramado em Ambiente Aquático usando a Glicerina Gerada na Produção de Biodiesel

Source: CNPq Results; Call for Proposals, Research Projects and Researcher Profiles (lattes.cnpq.br)
Note: Only those research proposals specific to nanotechnology were considered. Only those projects whose titles or descriptions referred explicitly to applications of nanotechnology to water were considered (e.g., “Development of sensors with multiple applications” which could eventually be used in the monitoring of water contamination, were not considered).

Table 5.5-1 Research projects on water funded through calls for proposals in nanotechnology research, 2008-2013

We note that research oriented toward the development of nanotechnology applications in the potabilization, desalination, decontamination and monitoring of water have taken up less space on the Brazilian research agenda. This coincides with the relatively meager relevance that the issue has had in nanotechnology policies until very recently.

Among the seven projects examined in this period, the theme of waterway decontamination is prevalent. Overall, it is important to note that much of the funded research in nanomaterials, sensors, membranes, etc., with multiple uses, can be applied to the decontamination of water and the production of potable water.

5.5.3 Nano-water research groups

An examination in the database of research groups of the CNPqwas performed, searching for groups that are investigating nanotechnologies in the treatment of water. The following keywords were employed: water + nano; nano + adsorption; nano + membranes; nano + photocatalysis; nano + bactericide; nano sensors + water; nano + desalination.[36]

18 research groups were identified that are active in the following areas: desalination, potabilization, environmental remediation and sensors/monitoring. Although some of the technology could be used for more than one purpose (e.g., membranes for environmental remediation or potabilization), according to the information provided by these groups, 15 of them prioritize one of these research areas while three of them say they work in more than one area. As Figure 5.5-1 shows, research groups in Brazil dedicated to environmental remediation dominate the field (12 groups), particularly in research in the recovery of effluent contaminated by heavy metals and organic materials. Four groups are researching water desalination, four others address sensors and water quality monitoring and two examine water potabilization.

In

Table 5.5-2 further detail is provided on the research topics, the key researchers and the institutions to which they belong. With regard to their location within the country, 11 groups are situated in the south-east region, in which science and technology (S&T) activities have historically been concentrated; 5 are in the north-east, one in the south and one in the center-west (Figure 5.5-2). Groups in the northern region have not been identified. It is interesting to note that of the four groups that undertake research in water desalination, two are located in the north-east, a region perpetually afflicted by droughts, but which possesses salty subterranean water sources much like a great ocean coastal area. The researchers involved in the remediation of contaminated water, although with a greater presence in the south-east with 7 research groups, are found as well throughout the country.

[36]In all cases, the expanded term ‘nanotechnology’ was used to address a fault in the database.

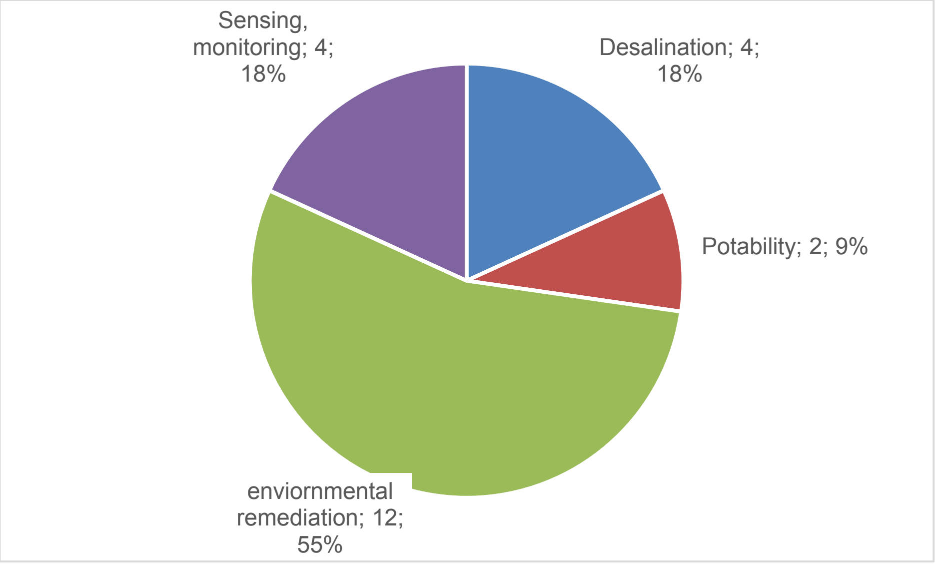

Figure 5.5-1 Nano-water research groups' areas of activity

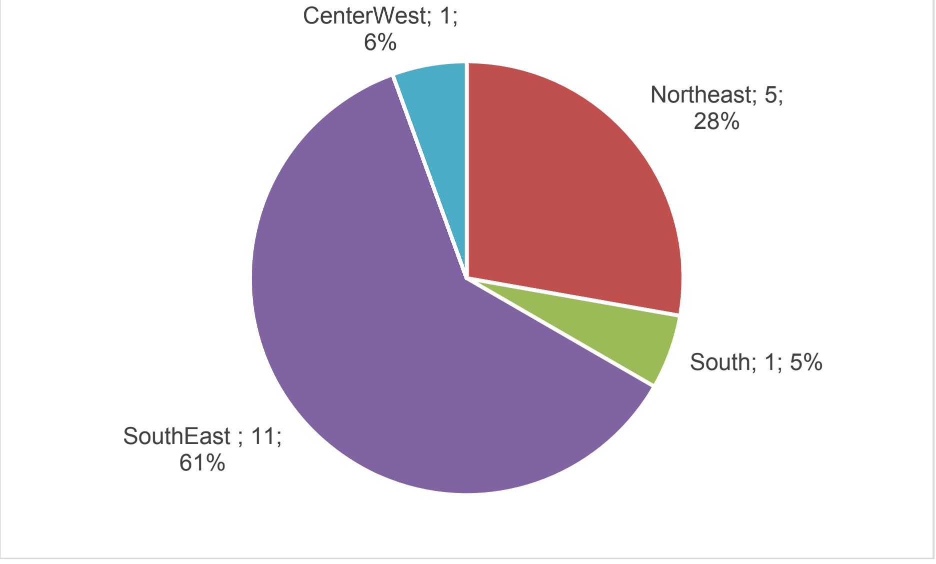

Figure 5.5-2 CNPq Research Groups by geographical distribution

Finally, note that the research in nano-water is performed in public research institutions. Only one research group operates within a private university, while 12 groups are based in state and federal public universities, and four in public research centers.

Research Group	Desalination	Potability	Environmental remediation	Sensing, monitoring	Institution	Leader/ contact
Biotecnologia e Ciência dos Materiais Aplicadas à Tecnologia Mineral e ao Meio Ambiente			Tratamento de efluentes da exploração de minérios: sulfato, mangenês e arsênico. Bactérias Redutoras de Sulfato; Biolixiviação de sulfetos metálicos		Universidade Federal de Ouro Preto (UFOP), Ouro Preto, MG	Versiane AlbisLeão; Anderson Dias Tel (31) 3559-1102
Física de plasma aplicada a novos processos de materiais			Tratamento de água por tecnologia de ozônio com propósitos ambientais		Instituto Tecnológico da Aeronáutica, São José dos Campos, SP	Homero Santiago Marciel, Tel (14) 3947-5943
Grupo de Arquitetura de Nanodispositivos Fotônicos				Dispositivos bio inspirados para monitoramento ambiental. Sensores para detecção de poluentes	Universidade Federal de Pernambuco, Recife, PE	Petrus D Amorim Santa Cruz Oliveira, tel (81) 2126-7458
Laboratório de Tecnologia Mineral e Ambiental			Materiais sorbetes para remoção de contaminantes; tratamento de águas e efluentes contendo metais pesados e compostos		Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS	Jorge Rubio, Tel (51) 3308-9483

			orgânicos			
Materiais Magnéticos de Separação			Materiais magnéticos funcionais com aplicação em meio ambiente e em bio ensaios; Resíduos de biomassa como bios sorventes para o tratamento de águas residuárias; Zeólita magnética como adsorvente magnético; ferritas como adsorventes inorgânicos		Comissão Nacional de Energia Nuclear (CNEN), São Paulo SP	Mitiko Yamaura; Ruth Luqueze Camilo Tel (11) 3133-9340
RECAT-Laboratorio de Reatores, Cinética e Catálise			Catalisadores ativos e seletivos para remoção de nitratos em águas contaminadas utilizando o método de hidrogenação catalítica.		Universidade Federal Fluminense (UFF), Rio de Janeiro RJ	Fabio Barboza Passos; Rosenir Rita de Cassia Moreira da Silva Tel (21) 2629-5600
Grupo de Eletroquímica e Nanotecnologia			Sistemas para purificação de águas residuais com poluentes orgânicos por foto catálise heterogênea utilizando eletrodos de filme poroso de TiO2. .		Universidade Tiradentes (UNIT) Aracajú, SE	Giancarlo Richard Salazar Banda; KatlinIvon Barrios Eguiluz tel 32182190
Grupo de Pesquisa, Desenvolvimento e Inovação em Minerais	Síntese e modificação de zeólitas e argilas para tratamento de águas				Universidade Federal do Ceará UFC,	Lindomar Roberto Damasceno da Silva, tel 33669436

não Metálicos	interiores com fim de potabilização para uso em irrigação e consumo humano e animal. Dessalinização de águas na região do Semiárido.				Fortaleza CE	
Nanotecnologia aplicada ao agronegocio				Desenvolvimento e uso de sensores eletroquímicos e bios sensores paraavaliação de solos e águas.	EMBRAPA, São Carlos, SP	Luiz Henrique Capparelli Mattoso; Odilio Benedito Garrido de Assis, Tel 21072800
Tratamento avançado de águas		Remoção de microcistina de águas para abastecimento com emprego de sistema constituído por unidade de flotação seguida de membranas de nanofiltração			Universidade de São Paulo, USP, São Carlos, SP	José Roberto Campos; Marco Antonio Penalva Reali; Tel (11) 3373-9571; email: mapreali@sc.usp.br
Grupo de Pesquisa em Tecnologias Ambientais da UFMS			Membranas poliméricas; nanofiltração; ultrafiltração para tratamento de efluentes industriais		Univesidade Federal do Mato Grosso do Sul (UFMS) Campo Grande MS	Carlos Nobuyoshi Ide; Luiz Augusto Araujo do Val, tel 3457491

Processos e Tecnologia de Membranas			Tratamento de efluentes utilizando dialise; nanofiltração; osmose inversa; ultra filtração.		Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, RJ	Rodrigo Azevedo dos Reis, tel 21 23340563
Membranas e Meios Porosos Filtrantes	Desenvolvimento de novos materiais para filtração. Membranas para uso em potabilidade e dessalinização de águas.	Desenvolvimento de novos materiais para filtração. Membranas para uso em potabilidade e dessalinização de águas.			Instituto Nacional de Tecnologia, Rio de Janeiro, RJ	José Carlos da Rocha, tel 21231189
Materiais Magnéticos de Separação			Uso de nanopartículas magnéticas de ferritas, com propriedades de adsorventes magnéticos para tratamento de águas residuárias conta-minadas por metais pesados/radioativos e poluentes orgânicos		Comissão Nacional de Energia Nuclear - CNEN São Paulo SP	Mitiko Yamaura; Ruth Luqueze Camilo ; Tel (11) 31339249; myamaura@ipen.br
GAMN- Grupo de Química Analítica/Ambiental e Materiais Nanoestruturados			Novos materiais baseados em sílicas gel, sílicasmeso-porosas e argilas organo modificadas e		Universidade Estadual Paulista Júlio de Mesquita Filho	Newton Luiz Dias Filho; Devaney Ribeiro do Carmo; tel 37431078

			nanomateriais seletivos para adsorção, separação, purificação e recuperação de componentes orgânicos e metais de soluções aquosas		(UNESP), Ilha Solteira, SP	
Fisico quimica de materiais	Membranas cerâmicas a base de SnO2 com aplicações em processos de separação por nano e ultra filtração, que apresentam capacidade de retenção salina superior a 85% e podem ser usadas na dessalinização de águas.				Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP) Araraquara, SP	Celso Valentim Santilli; Sandra Helena Pulcinelli; tel (016) 33019692; santilli@iq.unesp.br
Materiais aplicados a biossistemas			Aplicação de nanotecnologias para o monitoramento da qualidade de águas e sua descontaminação		Universidade Federal da Paraiba (UFPB), Joao Pessoa PB	Eliton Souto de Medeiros; Juliano Elvis de Oliveira; eliton_s@yahoo.com
Estudo e desenvolvimento de processos para soluções de problemas do meio ambiente	Sistemas de dessalinização via osmose inversa de pequeno, médio e grande porte; dessalinização via		Preparação e caracterização de membranas poliméricas e cerâmicas para fins de purificação de águas e efluentes industriais.	Análise, manutenção e monitoração remota.	Universidade Federal de Campina Grande (UFCG), Campina Grande,	Kepler Borges França, Tel 21011116 LABDES http://www.labdes.ufcg.edu.br

	osmose inversa usando painéis fotovoltaicos ; dessalinização via eletro-diálise; sistemas híbridos pra purificação de água via osmose inversa e resinas trocadoras de íons.				PB	

Table 5.5-2 Grupos de Investigación CNPq en nano-agua.

5.5.4 Relevant laboratories

Desalination Reference Laboratory (LABDES) – This laboratory is located in the Department of Chemical Engineering at the Federal University of Campina Grande (State of Paraíba), with the support of the Secretary of Hydro Resources of the Environment Ministry. It coordinates the National Desalination Program promoted by that Ministry, which furthered the implementation of water desalination via inverse osmosis systems to assist small- and medium-sized communities across various states in the semi-arid region of the country's north-east. The laboratory has developed systems that assist in the nationalization of that technology.

- Key researcher: Kepler Borges França.
- Web: http://www.labdes.ufcg.edu.br

Advanced Water Treatment and Re-use Laboratory (LATAR) – Located in the Department of Water and Sanitation of the São Carlos Engineering School, this laboratory supports the Advanced Water Treatment research group (See

Table 5.5-2). The laboratory's facilities offer leading-edge research in the development of treatment methods for water supply and sewage systems.

- Key researchers: José Roberto Campos, Marco Antonio Penalva

•Web: http://www1.eesc.usp.br/shs/index.php/area-1/19-latar

Mineral and Environmental Technology Laboratory – This laboratory in the Engineering School of the Rio Grande do Sul Federal University specializes in the decontamination of water polluted by contaminants from the mining industry, such as the recovery of some minerals from those waters.

- Key researcher: Dr. Jorge Rubio
- Web: http://www.ufrgs.br/ltm

5.5.5 Companies that make use of nanotechnology in water treatment

A small group of companies apply nanotechnology to the treatment of water in various areas: quality monitoring, filtration, desalination and effluent treatment. Three of these companies are spin-offs coming from university research groups.

1. Company:**Ocean Par (formerlyAquamare)**Location: Bertioga, São Paulo	
Capital: National	Segment: desalination/drinking water
Product: H2Ocean - Desalinated ocean drinking water. The desalination process using nanotechnology keeps the minerals and micronutrients of the ocean water that are beneficial for human health and eliminates the sodium chloride. The company first exported to the US, where it quickly passed regulatory controls, and is now selling the product in Brazil.	
Contact: contact@oceanpar.com• http://www.aquamarewater.com/	
2. Company: **PerenneEquipamentos e Sistemas de Água**Location: Feira de Santana, Bahia	
Capital: NationalSegment: treatment of water and effluent	
Product: Membranes for nanofiltration of water and effluent	
Contact: Tel: (55 11) 30226989• contato@perenne.com.br	
3. Company: **Ponto QuânticoNanodispositivos** Location: Recife, Pernambuco	
Capital:National, spin off of the UFPESegment: environmental monitoring	
Product: Sensors for the detection of pollutants in potable water.	
Contact:Tel: (81)21267099	
4.Company: **Contech ProdutosBiodegradáveisLtda** Location: Valinhos, São	

Paulo
Capital: National Segment: effluent treatment
Product: DEPT® - new eco-material for industrial effluent treatment.
Contact: Tel: 19-3881-7200• http://www.contechbrasil.com
5. Company: **POLICLAY – Nanotech Indústria e ComércioLtda** Location: Fortaleza, Ceará
Capital: National, spin off of UFCE, NUTEC incubatorSegment: desalination/drinking and irrigation water
Product:Aqua Soft – Ultra-fine, cheap powder that when mixed with salty water, desalinates. The powder is based on a clay capable of retaining magnesium and calcium.
Contact:Tel: (85) 8705.6765• email: marianacantidiomota@yahoo.com.br http://www.nutec.ce.gov.br/index.php/nutec-partec/empresas-incubadas/residentes/43491
6.Company: **H2Life Brasil** Location: Tatuapé, São Paulo
Capital: National Segment: water purification
Product:Super H2Life Portable water treatment system capable of purifying up to 6,000 liters per hour. Removes all types of physical, chemical or biological impurities to make potable any kind of water.
Contact: Tel 11 2592-1025 / 11 4561-2997 http://h2life.com.br/index.php?p=noticias&a=sistema-h2life

Table 5.5-3 Companies in nano water

5.6 Mexico

The information related to nanotechnology research and development (R&D) in Mexico is scattered, as no organization or institution monitors this information. The following report examines how much nanotechnology research in the country is associated with water. This study contains data that was gathered by exploring the activities of researchers, research networks and institutions on a case-by-case basis. The search entailed the use of a set of key terms to find the most number of entries. We are aware, however, that some information might have been left out in this report; unintentionally of course, as much of the information might have not been up to date, available on line or even publicly accessible.

Most nano-water research is located in seven clusters[37] of organizations: Academic Clusters (AC) of the Ministry of Public Education-PROMEP, Research Centers of the National Council of Science and Technology (CONACYT), the National Polytechnic Institute (IPN), the National Autonomous University of Mexico (UNAM), the Center for Research and Advanced Studies (CINVESTAV) of the IPN, Research Institutions of the Mexican Government and private Institutions. The information will be presented in this order. Each cluster presents the information to the public in different manner so our methodology to find it was adjusted accordingly.

5.6.1 Academic Clusters (AC)-PROMEP

The AC program is an initiative of the Mexican Ministry of Public Education and is promoted simultaneously with the Professorship Development Program (PROMEP). The AC program was created to improve the research competence and scientific capabilities of the faculty attached to public universities, polytechnic universities and technological institutes (PROMEP, 2013). Each AC is brought together by a common research interest or topic with the main objective of generating new knowledge in the subject. Each AC is required to have, at least, 3 members, and the program allocates resources to execute research plans, publish findings or encourage academic mobility (research visits, assistance to congresses, graduate studies). As of January 2013 there were 4 087 AC formed (PROMEP, n.d.).

Methodology: First, we conducted a search using the AC program's search engine (http://promep.sep.gob.mx/ca1/) with the key word nano. We obtained 106 AC that registered nano within their research area of interest. However, we eliminated 5 entries, as their research topic was not directly related to nanotechnology. Afterwards, we explored each of the remaining 101 AC to assess the ones that were looking at applications of nanotechnology on water. A quick search was performed using, first, "water" as a primary filter. Later on, we used a different set of key words to better understand the research focus: treatment, remediation, pollution, filtration and detection. There are 23 researchers distributed in 6 AC working with nano-water related areas.

The 6 AC are distributed among 6 universities or institutions. The Benemérita Universidad Autónoma de Puebla (BUAP), the Instituto Tecnológico de Cancún (ITC), the Instituto Tecnológico de Celaya (ITCEL), the Instituto Tecnológico Superior de Irapuato (ITESI),

[37] By cluster we understand a group of institutions or research centers, part of a larger institution; or independent institutions that are part of an academic network.

the Universidad Autonoma de Sinaloa (UNISON) and the Universidad Autónoma Metropolitana-Azcapotzalco (UAM-A). All AC are looking at nanotechnology applications for remediation and pollutant removal. All details are located inTable 5.13-1.

5.6.2 Research Centers of CONACYT

CONACYT clusters 27 institutions into a network of Research Centers. This network is divided according to four big areas of knowledge: exact and natural sciences, social sciences and humanities, technological innovation and development and graduate studies. To find all the research groups or individuals exploring the use of nanotechnology in water, we examined the CV´s of the scientists working at all the Research Centers except the ones attached to a social science or humanities center.

Methodology: We initiated the analysis by introducing a key word (nano*) into the web search engine in each center. Afterwards, we conducted a search (using a set of key words) to identify nano-water related research. At the same time, we reviewed the CV´s of the researchers attached to the subdivisions that were most likely to have some interest in the application of nanotechnology in water (i.e. pollution control, environmental assessment, contamination).

The Advanced Materials Research Center (CIMAV) has three researchers looking at the possible applications of nanotechnology in water. In all cases the focus is on the development of catalytic converters and the removal of pollutants. The Yucatan Center for Scientific Research (CICY) hosts two researchers with interest on advancing knowledge in this area. The Potosi Institute of Scientific Research (IPICYT) hosts one researcher, the Center of Research and Technological Development in Electrochemistry (CIDETEQ) another and the Mexican Corporation of Research on Materials (COMIMSA) sent one employee to do a research visit at the Center for Research and Advanced Studies (CINVESTAV) to study the use of nanoparticles in the removal of arsenic in water (see Table 5.13-2).

5.6.3 National Autonomous University of Mexico (UNAM)

UNAM is the most important research institution in Mexico. Taking into account the number of students, faculty and funding, UNAM stands out as the largest university in Mexico and Latin America (with more than 340 000 students). In terms of nanoscience and nanotechnology publications, UNAM concentrates 25% of the total (Záyago Lau, Frederick, & Foladori, 2014).

Methodology: UNAM has several research centers or institutes with its own administration and resources. As a result, we decided to take a research route that required the examination inside each institute and research center. First, we used a website that provided the web addresses for all centers and institutes at UNAM (http://www.cic-ctic.unam.mx/cic/subsistema/institutos_centros.cfm). Later, we use a basic filter key word (nano*) to find all data related to nanotechnologies. Afterwards, we "clean" the results by using the set of key words to look for researchers, publications, presentations or research statements related to water.

There are no specialized centers concentrating most efforts on nanotechnology and water. In fact, the distribution is disseminated in 3 institutes and 3 centers. On one hand, the institutes are the Engineering Institute (II), the Institute of Environmental Engineering (IIA) and the Institute of Materials Research (IIM); on the other, the centers are the following: the Center of Nanoscience and Nanotechnology headquartered in Ensenada, Baja California (CNyN), the Center of Applied Physics and Advanced Technology (CFATA) and the Center of Applied Science and Technology Development (CCADET) (see

Table 5.13-3). All the projects are on water remediation.

5.6.4 National Polytechnic Institute (IPN)

The IPN is the second most important research institution in Mexico. The IPN inaugurated, in 2009, the Center of Nanosciences and Micro and Nanotechnologies (CMN). The IPN, as part of the CMN, is the nerve center of the Nanoscience and Micro-nanotechnology Network (NMN). This network has 146 members, all of them researchers of the IPN.

Methodology: We explored the CV´s of each member of the NMN (http://www.coordinacionredes.ipn.mx/redesip/rednano/Paginas/Miembros.aspx. In order to identify the research areas of interest for each scientist, we searched for any of the keyword previously used. We found that out of the 146 researchers, only 4 are doing research in areas of nanotechnology related to water.

The Higher School of Chemical Engineering and Extractive Industries (ESIQIE) is the headquarter of three researchers. Each of them has different research interest: removal of pollutants in water, potable water treatment and desalinization of water. At the Research Center of Applied Science and Advance Technologies (CICATA), there is one researcher looking at the detection of pollutants in water

Table 5.13-4)

5.6.5 Center for Research and Advanced Studies (CINVESTAV) of the IPN

Initially CINESTAV was created, in 1961, as a Research Center part of the IPN system; however, in 1982, it acquired financial, administrative and legal independence. Today is one of the most important research centers regarding the advancement of scientific knowledge in the country. It has 10 sub-centers in different states. It has 4 research areas: exact and natural sciences, biological and health sciences, technology end engineering and social sciences and humanities.

Methodology: We explored the profiles of each researcher in the following departments: exact sciences, biological and health and technology and engineering. The analysis included the search for the set of keywords previously used after an initial search of the term nano* and nanotechnology within the search engine of each site. We found 3 researchers with interest in water, one at CINVESTAV-Saltillo, another at the Department of Biotechnology and Bioengineering and another at the Laboratory of Electrochemical and Characterization of Materials (for more detail see

Table 5.13-5). All the projects in water remediation.

5.6.6 Research Centers of the Mexican Government

The main institution overseeing water policy, administration, use, treatment and consumption of water is the National Water Commission (CONAGUA). However, there are 9 sub-local divisions located in strategic areas, as a result of high risks (rivers, floods and heavy rains) or just for facilitate the management of water[38]. In addition, within the public administration structure each state and municipality has control over its water resources.

Following everything that each of the 2 438 municipalities in Mexico has done in terms of nanotechnology applications for water is a challenge. We found out that most efforts in this regard have been directed towards the creation of filtration systems for water using nanocomponents. That is the case of the Municipal System of Potable Water of Guanajuato, which had an agreement with Rice University. However, the parts never managed to implement the filters and is unknown if the Municipality of Guanajuato installed the filters (Upn, 2010)

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[38] The sub-directorates are located at the Balsas river basin, the Yucatan Peninsula, the North Gulf, the State of Coahuila, South of the Mexican border, the Central Gulf, the Northeast Zone, the North Pacific and Tabasco.

5.6.7 Private Institutions

Private research universities or institutions do not have much participation in advancing knowledge related to the application of nanotechnology in water. The Monterrey Institute of Technology and Higher Education (ITESM), within its Bachelor of Science in Nanotechnology and Chemical Sciences, is one of the few (ITESM, 2014).

5.6.8 Additional Search Strategies

In order to expand the reach of the search strategies implemented in the latter sections, we dedicated some time to review the calls for funding in the area of nanotechnology. The most important source of these data was the calls made public by CONACYT. We were able to track most grants allocated to foster nanotechnology applications in water in Mexico, within public universities and centers by consulting the CONACYT´s web site. It is worth mentioning, however, that the data only refers to the researcher recipient of the funding and there is no more information.

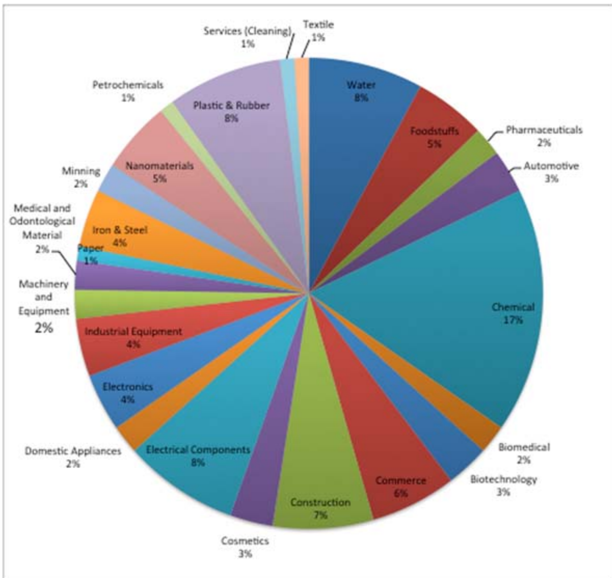
Table 5.13-7 shows the results of several calls to fund nanotechnology research projects. There are several modalities with a different set of information, and some of them did not have data available on line at the time of the analysis. We ignore the amount of funding that each program allocated, as it was not available on line.Table 5.13-7 Shows that only 1.3% of the entire calls were aimed to nanotechnology research; from those there were only 2 projects focusing on nano applications for water, sponsored by CONAGUA.

CONACYT also supports a program called “Fondos Sectoriales”, Sectorial Funds in cooperation with the Ministry of Public Education (SEP). The programs finances research projects to advance basic knowledge in diverse areas. As of January 2014, there are 6 813 projects, out of which 436 are related to nanotechnology, and only 2 projects are related to water (further details in Table 5.13-7). We followed the same research strategy to, first, identify nanotechnology projects and, later, examine the ones applied to water, which all of them relate to remediation.

5.6.9 Companies that make use of nanotechnology in water treatment

Another indirect way of illustrating the importance of nano-water research in Mexico is to take into account the number of companies in this area. In 2012 a group of researchers, members of the Latin American Nanotechnology and Society Network (ReLANS), conducted a survey to find how many companies where using nanotechnology in their manufacturing process or were commercializing nanotechnology based products in Mexico

(Záyago, Foladori, & Arteaga, 2012). The following figure shows the distribution per area of the 101 companies that were found. In this figure we observe that 8% of the companies are in the water sector.



Source: (Záyago et al., 2012)

Figure 5.6-1 Percentage of companies working with nanotechnologies per sector in Mexico

5.7 Argentina

The work to uncover groups and research projects in nano and water involved the consulting of various secondary sources, such as: the book *Quién es Quién* (Who's Who) (Fundación Argentina de Nanotechnología, 2012), reports, websites of many science and technology organizations, lists of projects funded by the Ministry of Science, Technology and Productive Innovation and the National Agency for the Promotion of Science and Technology. The search effort was undertaken from the 3rd to 21st of March 2014, and was basedupon the standard categories of classification of developments in energy.

There is no organization which oversees these kinds of investigations in Argentina. Neither are there any specialized events, and in many cases, while there are groups working on the topic, there do not appear to be any institutions which specialize in the area. The results are summarized in the following table:

Topic	Source: FAN (Fundación Argentina de Nanotecnología). (2012). Quién es quién. FAN, Buenos Aires	Source: Conicet Projects
Water treatment using chemicals	Group: Centro de Ingeniería en Medio Ambiente. ITBA. Fidalgo de Cortalezzi, María Elena. mfidalgo@itba.edu.ar. www.itba.edu.ar/cima	
Water treatment using chemicals	Group: Programa de Química Combinatoria de Materiales Avanzados. Fac. de Cs. Exac. Fisioquímica y Naturales. Universidad Nacional de Rio Cuarto. Miras, María Cristina mmiras@exa.unrc.edu.ar	
Water treatment using chemicals	Group: Fisioquímica Area de Catálisis ambiental. Materiales nanoestructurados. INCAPE. MIró, Eduardo Ernesto emiro@fiq.unl.edu.ar. WWW.fiq.unl.edu.ar/incape/	
Desinfection (using metallic nanoparticles)	Group: Laboratorio de especies altamente reactivas (LEAR). INIFTA, Mártire, Daniel. danielmartire@gmail.com www.lear.quimica.unlp.edu.ar	PIP 2013-2015. GI. 11220120100157. Treatment of rare contaminants in water through advanced oxidative and reductive processes based on nanoparticulate materials. Quinci, Natalia
Desinfection (using metallic nanoparticles)	Group: Nanopartículas Magnéticas /Lab Resonancias Magnéticas CAB-CNEA. Zysler, Roberto Daniel. zysler@cab.cnea.gov.ar http://física.cab.cnea.gov.ar/resonancias/	
Desinfection (using metallic nanoparticles)	Group: Fisioquímica Area de Catálisis ambiental. Materiales nanoestruturados INCAPE. Marchesini, Fernanda Albana. albana@fiq.unl.edu.ar WWW.fiq.unl.edu.ar/lincape	
Desinfection (using metallic nanoparticles)	Group: Laboratorio Programa de nanomateriales y mesomateriales. FCEFyN. UNRC. Barbero, César Alberto. cesarbarbero@gmail.com	
Desinfection (using metallic nanoparticles)	Group: Remediación de contaminantes. CNEA. UNSAM Litter, María Irene. litter@cnea.gov.ar	
Integrated monitoring and treatment systems	Group: Láser óptica de materiales y aplicaciones electromagnéticas (GLOmAe) FI. UBA. Pérez Quintián, Fernando. Fernando.perezq@fain.uncoma.edu.ar http://laboratorios.fi.uba.ar/glomae/	
Integrated monitoring and treatment systems	Group: Protección vegetal y medio ambiente Manejo de malezas y herbicidas. INTA. Montoya, Jorgelina Ceferina. jmontoya@anguil.inta.gov.ar www.inta.gov.ar	PIP 2012-2014. GI 11220110100458. Design and application of electrochemical biosensors to determine nanoparticulate toxicity levels and water quality. Corton, Eduardo

Table 5.7-1Research groups registered by FAN and Conicet Projects in nano-water. May, 2014

Argentina has various research efforts underway related to nano-water, as can be seen in the previous table. More than nine research centers were identified. All of the research is oriented toward the remediation of contaminated water.

5.8 Chile

The work to uncover groups and research projects in nano and water in Chile involved a review of the websites of the top institutions and research centers with projects involving nanotechnology.

Institution Research Center	Researcher	Topic	Web reference
Center for the Study of Nanoscience and Nanotechnology. CEDENNA	• Marcelo Rocco Salina Marcelo.rocco@usach.cl • Samuel Baltazar • María Angélica Rubio • Dora Altbir	Environmental remediation (metals) water potabilization	www.academia.edu/915380/Nanotecnología_para_Descontaminacar www.academia.edu/956785/Nanotecnologia_Innovacion_para_el_tratamiento_de_aguas http://mapuchenews.cl/index.php?option=com_content&view=article&id=563:-cientificos-prueban-nanotecnologia-para-eliminar-arsenico-y-potabilizar-agua&catid=58:titulares&Itemid=116
Department of Chemical Engineering Universidad de Concepción	Rodrigo Bórquez	Water desalination	www.youtube.com/watch?v=fZC7vYCpRho www.tribunadelbiobio.cl/portal/index.php?option=com_content&task=view&id=8531&Itemid=1

Table 5.8-1 Research groups identified within the websites of the main Research Centers and Universities on the topic of nano-water. May, 2014

Only three research projects on the topic of nano-water were identified. Unlike other countries, in the case of Chile each one of the projects relates to the three topics into which the nano-water research was grouped: remediation, desalination and potabilization.

5.9 Colombia

The Colciencias Science and Technology Platform (ScienTI) offers a search engine that covers research groups registered in Colombia. A search of that platform (performed in June 2014 via http://201.234.78.173:8083/ciencia-war/) for the prefix "nano" returned 10 research groups. From each of those groups, we extracted those that had research projects or publications related to water (search temrs "agua" and "water" were utilized). The result only revealed two research groups at two separate universities: the Javeriana University and the Medellín University. Both groups worked on topics related to environmental remediation.

Research group	Starting year	Institution, web site & coordinator	Nanowater topics
Nanoscience and nanotechnology	2006	Universidad Javeriana. http://gnano.javeriana.edu.co Edgar Emir Gonzalez Jimenez egonzale@javeriana.edu.co	Nanosensors for removal of cadmium, lead and other metals in contaminated water
Nanostructured materials and biomodelling	2011	Universidad de Medellín (UDEM). Francisco Caro fjcaro@udem.edu.co	Modelling of metal absorption in sewage water

Source: Own research based on data fromhttp://201.234.78.173:8083/ciencia-war/

Table 5.9-1 Research groups registered by ScienTI Platform with research projects on nano water. Colciencias. June 2014

Two research initiatives relevant to water remediation were identified at the Universities of Medellín and Javeriana, respectively.

5.10 Uruguay

Research centers at the University of the Republic, the Clemente Estable Biological Research Institute and the Montevideo Pasteur Institute were examined. Only one project relevant to the topic was found.

Institution	Researcher	Topic	Reference

/Research center			
NanoMat Center, Pando. Technology Cluster Chemistry Department. University of the Republic	Helena Pardo hpardo@fq.edu.uy	Graphene TiO2 composite materials for application to photocatalytic degradation of contaminated water	http://nanomercosur.org/docs/presentaciones/conferencias/martes//Pablo-Peraza-Helena-Pardo.pdf

Table 5.10-1 Research groups identified within the websites of the main Research Centers and Universities in the topic of nano-water. May, 2014.

In Uruguay only one research project relevant to contaminated water was found.

5.11 Conclusion

The field of nano-water (remediation, potabilization, desalination) is new to the region. The majority of the publications and formation of research groups occurred after 2000. Of the three themes under study, remediation is the most commonly represented (at 60%), both in terms of countries involved as in the number of authors that publish in scientific journals and by research groups at universities. This is followed by potabilization (approximately 50%);[39]while the area of desalination is practically nonexistent.[40]

As with the other topics analyzed in this project (nano-medicine and nano-energy), the case of water has, in Brazil, led the way in terms of the quantity of scientific publications and researchers dedicated to the field. It is also the only country where the topic of environmental water remediation (development of sensors and environmental monitoring systems and the treatment of effluents and residuals) is explicitly noted as one of the priorities of the National Science, Technology and Innovation Strategy (2012-2015). On the matter of published articles, for example, a little more than 10% of the total has been generated by no more than a dozen Brazilian researchers. In Brazil, the key institutions on this path are the universities located in the state of São Paulo (University of São Paulo, the

[39] Notice that some articles refer to more than one area, which makes the relative total over 100%
[40] There are some exceptions (see 5.5.3).

State University of São Paulo, and Campinas State University). The second country notable for its research is Mexico, where the National Autonomous University of Mexico (UNAM) takes the lead. Argentina and Chile follow with a lesser representation.

Practically all of the research in nano-water in Latin America and the Caribbean is performed in public institutions. The presence of private businesses and/or research centers are minimal.[41]

The study of networks shows that the key research linkages are not between countries in the region, but are primarily between each of the countries and the United States. When the relationships lie with Europe, the connection is primarily with Spain, France and Portugal. When the linkage is within the region, Mexico leads the way, with collaborations with Cuba, Argentina and Chile. The absence of Brazil among the top collaborations, despite its larger presence in those collaborations with the United States and Europe, may be due to a language barrier.

Of the three research areas analyzed (remediation, potabilization, desalination), the greatest presence is that of remediation. The table that follows (Note: A major presence is shown by the larger X or for just few cases, lower-case x.

Table 5.11-1 shows the presence of the topics across the various countries and according to the degree of presence.

Topic	Brazil	Mexico	Argentina	Chile	Colombia	Uruguay
Desalination	x	x	--	x	--	--
Potabilization	X	x	--	x	--	--
Remediation	X	X	X	x	x	x

Note: A major presence is shown by the larger X or for just few cases, lower-case x.

Table 5.11-1 Nano-research areas covered by country.

[41] There are some exceptions (see 5.5.5)

5.12 Annex A. List of member countries in the Community of Latin American and Caribbean States (CELAC)

Antigua and Barbuda
Argentina
Bahamas
Barbados
Belize
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominica
Ecuador
El Salvador
Grenada
Guatemala
Guyana
Haiti
Honduras
Jamaica
México
Nicaragua
Panamá
Paraguay
Peru
Dominican Republic
Saint Kitts and Nevis
Saint Vincentand the Grenadines
Saint Lucia
Surinam
Trinidad and Tobago
Uruguay
Venezuela

5.13 Annex B. Mexico

Institution	Academic Cluster	Description	Members	Key words
Benemérita Universidad Autónoma de Puebla	BUAP-CA-256 - Control de la Contaminación Ambiental	Análisis de procesos fisicoquímicos y microbiológicos para el control de contaminantes ambientales en suelo, aire y agua Fisicoquímica de superficies aplicados a la eliminación de contaminantes ambientales	Arriola Morales Janette janette.arriola@correo.buap.mx Mendoza Hernández José Carlos jcharlymh@yahoo.com Pérez Osorio Gabriela g_perez_osorio@yahoo.com.mx	Remediation
Instituto Tecnológico de Cancún	ITCAN-CA-1 - Turismo, Desarrollo y Tecnologías Sustentables	Desarrollo de tecnologías y materiales para el medio ambiente	Ben Youseff Brants Cherif cherifby@itcancun.edu.mx -Guillen Arguelles Elisa elisaguillen@yahoo.com -Koh Puga Fernando Antonio ferkoh@yahoo.com.mx -Torres Rivero Ligia Adelayda torlia@hotmail.com -Verde Gomez Jose Ysmael ysmaelverde@yahoo.com	Remediation
Instituto Tecnológico de Celaya	ITCEL-CA-11 - Química de nanomateriales	Materiales Avanzados En Tecnologías Amigables Con El Medio Ambiente	Almendárez Camarillo Armando armando@iqcelaya.itc.mx -Fierro González Juan Carlos jcfierro@iqcelaya.itc.mx -Martínez González Gloria Maria gloriam@iqcelaya.itc.mx	Remediation
Instituto Tecnológico Superior de Irapuato	ITESI-CA-4 - Micro y Nano Ciencias	Diseño Y Desarrollo De Micro Y Nanosistemas:	Cabal Velarde Javier Gustavo javelarde@itesi.edu.mx -Guzmán Altamirano Miguel Angel miguzman@itesi.edu.mx -Rebollo Plata Bernabé berebollo@itesi.edu.mx	Remediation
Universidad Autónoma de Sinaloa	UAS-CA-281 - INGENIERÍA DE CRISTALES Y AMBIENTAL	Hidrología Y Geohidrología A La Gestión Ambiental Y Políticas Públicas	Campos Gaxiola Jose De Jesus gaxiolajose@yahoo.com.mx -Cruz Enriquez Adriana cruzadriana@uas.edu.mx -Peinado Guevara Hector Jose hpeinado75@hotmail.com	Remediation

Universidad Autónoma Metropolitana (Azcapotzalco)	UAM-A-CA-79 - Nanotecnologia Y Calidad Ambiental	Catálisis Ambiental Y Procesos De Membranas	Aguilar Pliego Julia apj@correo.azc.uam.mx -Dominguez Soria Victor Daniel vdds@correo.azc.uam.mx -Gutierrez Arzaluz Mirella gam@correo.azc.uam.mx -Mugica Alvarez Violeta vma@correo.azc.uam.mx -Noreña Franco Luis Enrique Inf@correo.azc.uam.mx -Torres Rodriguez Miguel trm@correo.azc.uam.mx	Remediation

Source: Own research (2014)

Table 5.13-1 AC working with nano-water applications in Mexico (2014)

Research Center	Description	Researcher	Contact	Key word
Centro de Investigación Científica de Yucatán (CICY)	Catalizadores Para La Generación De Energía (tratamiento electroquímico de aguas contaminadas con compuestos no-biodegradables.)	Patricia Ocampo	Patricia Ocampo. vinculacion@cicy.mx	Remediation
Centro de Investigación Científica de Yucatán (CICY)	Sistemas de membranas para aprovechamiento y uso racional de agua en Yucatán.	Manuel de Jesús Aguilar Vega Gonzalo Canché Escamilla	ND	Potabilization
Centro de Investigación en Materiales Avanzados (CIMAV) (Materiales Nanoestructurados)	Investigación de Catalizadores en las reacciones de oxidación de p-XILENO, transesterificación de tereftalato de dimitilo, esterificación del ácido	Alfredo Aguilar Elgézabal	ND	Remediation

	tereftalítico, recuperación de ácidosacético y fórmico en aguas residuales			
	Tratamiento de aguas residuales y emisiones por métodos catalíticos.			Remediation
	Descontaminación de aguas residuales con luz solar por fotocatalítica"			Remediation
	Fotocatalizador para destrucción de compuestos orgánicos en agua y vapores o gases, así como eliminación y/o recuperación de metales en agua.			Remediation
Centro de Investigación en Materiales Avanzados (CIMAV) (Energías renovables y Protección del Medio Ambiente)	Preparación y caracterización de adsorbentes para remoción de metales en agua.	Guillermo González Sánchez	ND	Remediation
Centro de Investigación en Materiales Avanzados (CIMAV) (Energías renovables y Protección del Medio Ambiente)	FITO (Tecnología y su aplicación en la remediación de agua y sitios contaminados con metales y metaloides.	María Teresa Alarcón Herrera	ND	Remediation

Instituto Potosino de Investigación Científica y Tecnológica (IPICyT)	Síntesis y modificación de materiales adsorbentes con base en nanotecnología. - Grafeno - Nanotubos de carbono - Carbón activado - Fibras de Carbón activado - Algas marinas - Residuos agroindustriales - Resinas poliméricas	José René Rangel Méndez	rene@ipicyt.edu.mx Tel.+52 (444) 8342000 ext 2022Fax:+52 (444) 8342010	Remediation
	Desarrollo de soportes poliméricos para bio-compositos y nano-compositos con aplicaciones ambientales (remoción de contaminantes como fluoruros, cadmio, arsénico, disruptores endocrinos en corrientes acuosas y en corrientes gaseosas).	Vladimir Alonso Escobar Barrios	vladimir.escobar@ipicyt.edu.mx Tel.+52 (444) 8342000 ext 7246 Fax:+52 (444) 8342010	Remediation
Centro de Investigación y Desarrollo Tecnológico en Electroquímica (CIDETEQ)	Materiales para tratamiento de aguas (Micro y nano-estructuras)	José de Jesús Pérez Bueno	ND	Remediation
Corporación Mexicana de Investigación en Materiales (COMIMSA)	Estudio del uso de nanoestructuras de óxidos de hierro en la remoción de	Héctor Manuel Hernández García	ND	Remediation

	arsénico del agua potable (estancia de investigación en CINVESTAV)			

Source: Own research (2014)

Table 5.13-2 CONACYT Research Centers working with nanotechnology applications for water (2014)

Research center	**Description**	**Researcher**	**Contact**	**Key word**
Centro de Ciencias Aplicadas y Desarrollo Tecnológico (CCADET)	Evaluación de la contaminación y/o el riesgo de contaminación por compuestos emergentes en aguas y suelos	Laboratorio Universitario de Nanotecnología Ambiental	luna@ccadet.unam.mx	Remediation
Centro de Física Aplicada y Tecnología Avanzada (CFATA)	Desarrollo de nanoestructuras para adsorción de metales pesados en aguas residuales industriales	Dr. José Rogelio Rodríguez Talavera	Departamento de Ingeniería Molecular de Materiales Teléfono: (442) 238-1153 Correo Electrónico: rogelior@unam.mx	Remediation
Centro de Nanociencia y Nanotecnología (CNyN) - Fisicoquímica de Nanomateriales	Producir partículas de oro y plata en forma de cúmulos y nanopartículas para posteriormente analizarlas, tanto física como químicamente, para conocer su tamaño, distribución, sus propiedades catalíticas para ser utilizadas en medicinas, en procesos de purificación del	Nina Bogdanchikova, Mario Farías Sánchez, Miguel Ávalos.	ND	Remediation

	agua, convertidores catalíticos a bajas temperaturas.			
Instituto de Investigaciones en Materiales (IIM)	Sistemas cerámicos bactericidas y su aplicación en la depuración del agua.	Investigador: Dra. María Elena Villafuerte Castrejón.	Cubículo: B-006. Tel. 56 22 46 46. E-mail: mevc@unam.mx	Remediation
Instituto de Ingeniería (II)		María Laura Quezada Jiménez		Remediation
Instituto de Ingeniería (IIUNAM) - Ingeniería Ambiental	Desarrollo, caracterización de nuevos materiales para tratamiento de agua potable por el proceso de Nano fotocatálisis.	Rosa MaríaRamírez Zamora	Coordinación de Ingeniería Ambiental. RRamirezZ@iingen.unam.mx , rmrz@pumas.iingen.unam.mx ; Tel. 56 22 36 00, ext. 8657	Remediation

Source: Own research (2014)

Table 5.13-3 UNAM´s Researchers and Centers working with nanotechnology applications for water (2014)

Research Center	Description	Researchers	Key words
CICATA LEG	Aplicación de técnicas fototérmicas a la evaluación de la calidad de combustibles y a la detección de contaminantes en líquidos mediante la espectroscopia fotoacústica, universidad de la habana, cuba / facultad de fisica	Helión Vargas Soter , Osvaldo Delgado Vasallo , Marcelo Gomez Da Silva , Luis Carlos De Moura Miranda , Ernesto Marín Moares	Remediation
ESIQIE	Desalación de agua de mar con energías renovables	Gerardo Hiriart Le Bert	Water/ desalinization

ESIQIE	Estudio de alternativas tecnológicas de bajo costo para el tratamiento de la calidad del agua potable del D. F	Sergio Odin Flores, Silvia Patricia Paredes, Martha Leticia Hernández , Martín Daniel Trejo , Miguel Valenzuela Z.	Potabilization
ESIQIE	Diseño Y Evaluación De Alternativas 03/2015 Tecnologicas De Punta, Para La Degradacion Y Remoción De Contaminantes Emergentes En Aguas Residuales	Silvia Patricia Paredes Carrera, Miguel Angel Valenzuela Zapata, Geolar Fetter , Laura Veronica Castro Sotelo , Martha Leticia Hernandez Pichardo , Maria Elena Navarro Clemente	Remediation

Source: Own research (2014)

Table 5.13-4 Researchers of the IPN working with nano-energy (2014)

Research Center	Description	Researcher	Key words
Laboratorio A10. Materiales Naestructurados y Caracterización Electroquímica	Síntesis y obtención de materiales nanoestructurados utilizados como fotocatalizadores para tratamiento de aguas (base TiO_2); así como electrocatalizadores para celdas de combustible tipo PEM.	Juan Francisco Pérez Robles. Luz Ma Reyna Avilés Arellano	Remediation
Unidad Saltillo	Incremento de la cadena productiva de minerales; síntesis de materiales catalíticos y adsorbentes nanoporosos, y tratamiento de efluentes acuosos	Prócoro Gamero Melo	Remediation
Departamento de Biotecnología y Bioingeniería	Biorremediación de suelo y agua. Aplicación de residuos agroindustriales en la biorremediación de suelos, enzimas fúngicas en la degradación de compuestos orgánicos persistentes. y aplicación de la nanotecnología en el tratamiento biológico de efluentes industriales.	Refugio rodríguez Vázquez	Remediation

Source: Own research (2014)

Table 5.13-5 Researchers of CINVESTAV working with nanotechnology applications for water (2014)

Name of the fund	Time period	Total approved	Nanotechnology projects	Nano-water
FORDECyT	2009-2012	71	1	
CIAM*	2004-2012	39	19	
FIC Equipment support	2009-2012	218	16	
FIC –Infrastructure for GMOs	2011	10	0	
FIC. Equip. for Research Groups	-----No data	0	0	
Basic Research SEP-Conacyt	2004-2012	5381	340	
Complementary support for SNI I	2006-2011	1617	61	
CIBIOGEM	2005-2013	40	0	
IDEA	Discontinuated	0	0	
FOMIX	2004-2010	356	45	
SECTORIAL FUNDS				
ASA-CONACYT	2005-2012	37	0	
CONAGUA-CONACYT**	2006-2012	41	2	2
INIFED-CONACYT	2012	1	0	
CONAFOR-CONACYT***	2005-2012	69	2	
CONAVI-CONACYT	2007-2011	43	1	
INMUJERES-CONACYT	2008-2012	38	1	
SAGARPA-CONACYT	2005-2012	80	0	
SSA/IMSS/ISSSTE-CONACYT	2005-2012	1113	8	
SE-CONACYT	2007-2012	586	11	
SEGOB-CONACYT	-------	0	0	
SEMAR-CONACYT	2005-2013	11	0	
SEMARNAT-CONACYT	2006-2008	106	0	
SENER-CONACYT	----	0	0	
SENER-HIDROCARBUROS-CONACYT****	2009-2012	118	1	
RELACIONES EXTERIORES-CONACYT	2006-2012	38	3	
SECTUR-CONACYT	2010-2012	13	0	
INEGI-CONACYT	2011-2012	10	0	
TOTAL		2304	29	

Note: Search terms in titles: nano+ water key terms. Only 1 fund made calls explicitly for nanotechnology: FOMIX (Chihuahua 1; Morelos 1; Querétaro 1; Tamaulipas 3; Nuevo León 6)

Symbols

FORDECyT. Fondo Institucional de Fomento Regional para el Desarrollo Científico, Tecnológico y de Innovación.
CIAM. Fondo Institucional Ciencia. Convocatorias Convenios de Cooperación Proyecto Colaboración Interamericana en Materiales.
FIC-Equipo. Fondo Institucional Ciencia. Apoyo complementario para actualización de equipo científico.

FIC-OGM. Fondo Institucional Ciencia. Apoyos para infraestructura para confinamiento de organismos genéticamente modificados
FIC-CA y GI. Fondo Institucional Ciencia. Apoyos para cuerpos académicos y grupos de investigación.
SEP-Conacyt. Convocatoria de investigación básica SEP-Conacyt
FIC-SNI1. Fondo Institucional Ciencia. Complementario a Investigadores en proceso de consolidación SN1
CIBIOGEM. Fondo para el fomento y apoyo de la investigación científica y tecnológica en bioseguridad y en biotecnología.
IDEA. Incorporación de científicos y tecnólogos mexicanos en el sector social y productivo del país. (Descontinuado)
FOMIX. Fondos Mixtos Conacyt-Gobiernos de Estado
ASA-Conacyt. Investigación para el desarrollo aeroportuario y la navegación Aérea
CONAGUA-Conacyt. Investigación y desarrollo sobre el agua
INIFED-Conacyt. Infraestructura Educativa
CONAFOR-CONACYT. Investigación, desarrollo e innovación tecnológica forestal
CONAVI-CONACYT. Desarrollo Científico y Tecnológico para el Fomento de la Producción y Financiamiento de la Vivienda y el Crecimiento del Sector Habitacional.
INMUJERES-CONACYT. Investigación y Desarrollo
SAGARPA-CONACYT. Investigación en materias agrícola, pecuaria, acuacultura, agrobiotecnología y recursos fitogenéticos
SSA/IMSS/ISSSTE-Conacyt. Investigación en Salud y Seguridad Social
SE-CONACYT. Innovación tecnológica. Secretaría de Economía-Conacyt
SEGOB-CONACYT. Investigación y Desarrollo. Secretaría de Gobernación-Conacyt
SEMAR-CONACYT. Investigación y Desarrollo en Ciencias Navales
SEMARNAT-CONACYT. Investigación ambiental
SENER-CONACYT. Sustentabilidad Energética. Secretaría de Energía.
SENER-HIDROCARBUROS-CONACYT.
SER-CONACYT. Secretaría de Relaciones Exteriores-Conacyt
SECTUR-CONACYT. Secretaría de Turismo. Conacyt.
INEGI-CONACYT. Instituto Nacional de Geografía y Estadística-Conacyt

Table 5.13-6 Main Federal Call for Project sources and approved projects in nanotechnology by sector. México 2004-2012

Researcher	Description	Institution	Key words
Tessy Maria Lopez Goerne	Arquitectura Supramolecular En El Desarrollo De Biomateriales Nanoestructurados Para Remediacion De Aguas Residuales	Universidad Autonoma Metropolitana	Water/ remediation
Alejandro Zepeda Pedreguera	Estudio De La Inmovilización De Bacterias Nitrificantes Con Materiales Cerámicos Porosos Nanoestructurados En La Transformación De Compuestos Fenólicos Presentes En Las Aguas Residuales	Universidad Politecnica De Pachuca	Water/ pollutants
Nina Bogdantchikova	Estudio de Propiedades Físico-Químicas de Nanopartículas De Oro Y Plata Para Aplicarlas en Catálisis, Medicina y Tratamiento De Agua	Universidad Nacional Autonoma de Mexico	Water/ treatment
Sergio Martínez Vargas	Interaccion De Arsénico En Agua Con Nanoparticulas de Ferritas	Universidad de la Sierra Juarez	Water/ pollutants

Alejandro Zepeda Pedreguera	Estudio de la Factibilidad De Compuestos Nano Y Microestructurados, En La Eliminación De Metales Pesados Y Compuestos Fenólicos Presentes En El Agua Y Su Efecto En El Medio Ambiente	Universidad Autonoma de Yucatan	Water/ pollutants

Source: Own research (2014)

Table 5.13-7 Ministry of Education and Basic Science (SEP/CB/ CONACYT) Research Projects

5.14 Annex C. Co-publication study

5.14.1 Definitions

Affiliation: By affiliation we refer to a unique author-institution combination related to **one record**. The same author can be affiliated with several institutions within one

single record. If this is the case, we consequently count several affiliations. Therefore, publications with one author, but two affiliations, one in Mexico and one in France, are included in the analysis and considered a co-publication. The number of affiliations in the EU-LA co-publications therefore shall not be confused with the number of authors.

Categories and main categories: The two scientific literature databases used in this study assign the recorded books or periodicals to one or more thematic key words based on a classification system. In Elsevier's *Scopus* we have around 340 of these thematic keywords (as listed in the following). Only a small percentage of the scientific works is classified independently of the general classification of the periodical.

Co-publication: In the context of this study we refer to international scientific publications, indexed in literature databases, with the participation of at least two institutions/organisations in at least two different countries. For this study the term co-publication therefore is only used for international co-publications, unless explicitly stated otherwise.

Document types:*Scopus* assigns a certain document type to the tracked publications to better describe them. These types reach from articles over abstracts and conference papers to editorials, errata and even music, movie or software reviews.

Institute/Organisation: Because the scientific literature database *Scopus* used in this study relates authors to different organisational entities (i.e.: in one case the university as a whole is named, in another case we have detailed description of the institute or even the research group, etc.), we agreed on the usage of the label "institute" for the more detailed, subordinate level often called "organisational unit" (university institute, department, laboratory, sub entity of a company or international organisation) and the term "organisation" as the bigger entity, for example university, academy or intergovernmental organisation, etc.

5.14.2 Set of Keywords

"nano":scanning probe microscopy, nanoscience, nanoparticle, nanomaterials, nanomanipulation, nanoindentation, nanoimprint lithography, nanofiltration, nanofibers, nanocrystals, nanobiotechnology, molecular electronics microfluidics, microfabrication, mems, gold nanoparticles, electrospinning, electron beam lithography, chitosan; technology, carbon nanotubes, atomic force microscopy, nanotribology, nanorobotics, nanomachining, nanofluidics, nano-integration, nanosensors, nanochips, nanodevices, nanomagnetism, nano-optics, nanoelectronics, nanophysics, nanoscale fullerenes, nanoscale thin films, quantum wells, quantum wires, quantum dots, nanoclusters, nanocrystalline materials, nanocomposites, nanoprobes, nanofabrication, nanolithography, nems, nanoelectromechanical systems, nanotextiles, nanotoxicology, nanostructure, nanomedicine, nanomaterials, nanobiophysics, nanorods, nanoparticles, nanowires, nanotubes, nanotechnology

5.14.3 List of countries

ERA	CELAC
Austria	Antigua Barbuda
Belgium	Argentina
Bulgaria	Bahamas
Croatia	Barbados
Cyprus	Belize
Czech Republic	Bolivia
Denmark	Brazil
Estonia	Chile
Finland	Columbia
France	Costa Rica
Germany	Cuba
Greece	Dominica
Hungary	Dominican Republic
Ireland	Ecuador
Italy	El Salvador
Latvia	Grenada
Lithuania	Guatemala
Luxembourg	Guyana
Malta	Haiti
Netherlands	Honduras
Norway	Jamaica
Poland	Mexico
Portugal	Nicaragua
Romania	Panama
Serbia	Paraguay
Slovakia	Peru
Slovenia	Puerto Rico
Spain	Saint Kitts and Nevis
Sweden	Saint Lucia

Switzerland **Turkey** **United Kingdom**	Saint Vincent and the Grenadines Suriname Trinidad and Tobago Uruguay Venezuela

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