

Current Status of Nanotechnology in México

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Abstract: -As a result of the absence of nanotechnology in Mexico scientific- academic organizations with politic business interests encourage the country to create associations in this topic. One of the first associations is he United States –Mexico Foundation for Sciences (FUMEC). FUMEC has been active on promoting partnerships between Mexican and US-based nanotechnology research institutes. It has also been an important agent in the creation of high-tech parks where nanocomponents play a mayor role in the productive process. One of the first incursions of nanotechnology was born in Mexico around the year 2000 with Terrones brothers in the carbon nanostructures research and the design of the coating antigrafiti at the UNAM invented a couple of years later. Mexico lacks a National Nanotechnology Initiative and the Mexican government spends just 0.4% of Gross Domestic Product for scientific research. However, progress has been made significantly in research and development of nanotechnology. Mexico is using now nanotechnology as a tool to encourage competitiveness. Without a National Plan on Nanotechnology Research, the growing U.S. influence might not correspond with Mexican national interests. This work describes the state of nanotechnology in Mexico, its progress and proposes measures for the development of nanotechnology in the short term.

Key-Words: - Current, Status, Nanotechnology, Mexico, Progress, Needs, Potential

1 Introduction

Mexico lacks a National Initiative of Nanotechnology although efforts have been made to establish networks of nanotechnology research since the last decade. The National Program for Nanoscience and Nanotechnology was created by September 2002nd, by seven prominent public institutions and four foreign expert Advisors. Since 2002, Nanotechnology has been considered a strategic sector in Mexico, according to the Special Program of Science and Technology 2002-2006, and the support of the United States-Mexico Foundation for Science (WSCF). By the way, nanotechnology has been developed in various research centers and companies whose achievements have been recognized internationally. Although nanotechnology in the country has walked slowly but firmly, Mexico has great a potential for nanotechnology as shown by recent trends [1]. Several companies have developed patents and products applying nanotechnology and several cities are funding nanotechnology research and developments as well as hosting nanotechnology companies in advanced technology industrial parks. Nevertheless these advanced technology centers are being created at the richest economic zones leading to a concentration of resources that leaves behind those poorest states. A Mexican National Initiative could address this kind of segregation

induced by advanced technology, creating research institutes in poor zones of the country, attaining a better distribution of wealth in our country. Another important issue is the incorporation of women to nanotechnology which demands the creation of scholarships for women in advanced technology. Mexico City Institute of Science and Technology has recently created for women in Science and Technology which could enhance women participation in nanotechnology. Special funds for women faculty in nanotechnology need to be considered to improve the statistics of faculty women in nanotechnology. In a country where National University concentrate most of the efforts on research and development, many things need to be done yet to attain a better involvement of the Mexican States in nanotechnology. In past years several technological universities have been created and science and technology budget needs to be allocated to strengthen this new system of technological universities. Local companies can be benefited of the cooperation between these technological universities and the local companies which are already using nanotechnology in their products. Certification needs to be done of these nanotechnology products and there is already an initiative in the Mexican Standard Institute in order to regulate the certification of these nanotechnology products

which will require the instruction of new workers trained in nanotechnology. UAM is currently involved in developing patents, products and helping nanotechnology companies which will help to improve graduates with experience on nanotechnology. Seven universities offer Bachelor in Nanotechnology Engineering until today as shown in figure 1 [2-13].

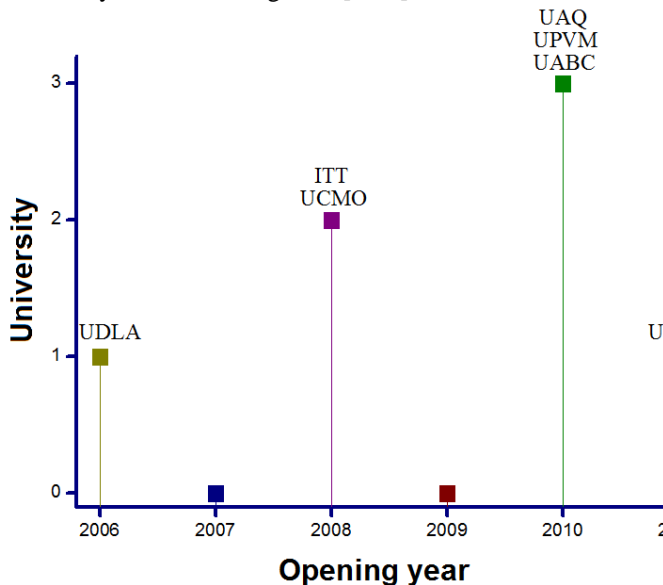


Fig.1. Universities that offer the Bachelor in Engineering in Nanotechnology in Mexico and its opening year.

In the following we enlist some activities related to nanotechnology in Mexico, although by the limitations of time and space we apologize for those activities unlisted.

2 Nanotechnology Industries and Commerce in Mexico

In Mexico there are a number of industries involved in nanotechnology. Among them, the most notable for their economic impact along the country: PEMEX, VITRO, GIRSA. Industries are already in contact with the Centre for Research and Technological Development owned by RESISTOL, with the aim of studying composite materials and plastic carbon nanostructures [14,15]. There is also collaboration between companies and the CIQA Applied Chemistry Research Center. International companies such as Hitachi, IBM and Philips have established contact with IPICYT scientists to develop nanostructures. On the other hand, companies like LAMOSA, SIGMA and CEMEX are developing nanotechnology research and development in nanotechnology cluster located in Monterrey, Nuevo León.

2.1 Successful nanotechnology in Mexico

2.1.1 Nanosoluciones

This Mexican company evaluates and develops innovative

solutions to meet the requirements for polymer industry, improving the properties of their products and materials used in various manufacturing processes, using a basic tool of nanotechnology which focuses on the introduction of nanomaterials into another material in order to improve mechanical, thermal, electrical and optical properties.

2.1.2 Gresmex

This Mexican company designed, patented and sells a sanitizer that destroys H1N1 virus, the cause of the epidemic of 2009 in Mexican Republic.

2.1.3 Sanki

Sanki is the first company to sell a food supplement made with nano-biotechnology. Sanki is based in Mexico and will soon have a global network of independent distributors. This company has a unique product which was designed with nano-biotechnology and has two patents registered worldwide. This product is endorsed by international scientific societies such as the International Society of Antioxidants in Nutrition and Health (ISANH).

2.1.4 Distribuidora Nano de America S.a. de C.V.

This is a Mexican company dedicated to the importation and distribution of nanotechnology coverings, in order to produce and manufacture decks modified with nanotechnology coatings. This should be done in the City of Knowledge at the state of Nuevo Leon in collaboration with ITESM and UANL. New patents are developed in Mexico for domestic use and export to NAFTA, Latin America and Asia.

2.1.5 Nanosoluciones

Nano Soluciones is a Mexican firm that sells water-repellent coatings allowing transpiration of materials, preventing mold and moisture where small amounts can cover large areas and claim to be friendly to environment.

2.1.6 Vago de Mexico

This firm in April 2008 launched a mechanical seal with carbon face reinforced with nanotubes, becoming the first and only global company in their industry using nanotechnology

2.1.7 Sigma Alimentos

This Mexican company has developed a new packaging for food based on new plastics in combination with nanomaterials that is lighter, stronger and has a better thermal efficiency

2.1.8 UNAM

On 2001, the Department of Physics and Technology from UNAM at Querétaro Campus developed an Anti-Graffiti coating currently on the market under the brand name Deletum 3000 (registered trademark of UNAM).

In the same way, Mexico has the potential to develop

nanotechnology industrial applications for health and beauty since at least seven leading companies are doing industrial production or extensive trade in Mexican territory (figure 2).

Rank	Top 20 Institutions	Patents
1	L'Oreal	109
2	Elan Pharma	38
3	Nanosystems (ISRA)	31
4	Henkel	28
5	Cognis	15
6	Sanofi-Aventis	15
7	Amorepacific	14
8	Vesifact	13
9	Japan Science and Technology Agency	11
10	GlaxoSmithKline	11
11	Rohm and Haas	10
12	Centre National De La Recherche Scientifique	9
13	Eastman Kodak Company	9
14	Ciba Specialty Chemical Holdings	8
15	The Regents of The University of California	8
16	Diagnostikforschung Institute	7
17	University of Texas	7
18	Alfatec Pharma	6
19	Max Planck Gesellschaft	6
20	Novartis	6

Fig.2. Top 20 companies with patent activity related to nanotechnology in health and beauty, seven of them develop industrial and commercial activities in Mexico.

In August 19 of 2009, Group KUO, who has three product lines: additives for polymers, plastic compounds based on nanomaterials and materials with special properties, such as controlled release, announced the opening of a plant operated by its subsidiary Macro-M, in Lerma, State of Mexico. Other companies that have research projects in an industrial scale are shown in figure 3.

Name	Project 1	Project 2	Project 3
Sigma Alimentos Plásticos Rev. S.A.	Improved packaging resistance Application in PVC pipe	Functional packaging	Extending shelf life of food
Policyd S.A de CV	Development of PVC pipe and floor nanoclays		
Magnekon S.A.	Development of enamel Salic polyamide hybrid by Sol-Gel process		
Vitro Corporativo S.A.	Functional coatings using nanotechnology		
Viakable	Development of a 1350 type aluminum alloy reinforced		
3M México	Development of enamel Salic polyamide hybrid by Sol-Gel process	Bactericidal consumption for industry	
MABE S.A.	Carbon Nanotubes Development	Using charges of nanoclay	Nanostructured coating Additives for temperature control
KALTEX FIBERS S.A.	Photocatalytic Acrylic Fiber	Dyed in the mass	
Dynasol Elastomeros S.A.	Confidential		
Indelpro S.A.	Cap-screw dimensional microstructure of PP	Dispersion of additives in injection moldings of PP	
CEMEX CENTRAL S.A.	Nanocem European Consortium of Construction Industry		
Nemak	Aluminum alloys high temperature		
Owens Corning	Development of composites		
Prolec GE	Development of plastics		

Fig.3. Other firms developing nanotechnology projects in Mexico.

3 Applied Research

Mexico begins to develop applications that impact society, some of them are:

3.1 Restoration and conservation of paintings

Restoration of paintings using nanoparticles has been done in Cholula, Puebla, the Wall of the Temple of the Niches at Mayapán, Yucatan, and a Mural Painting at Tlatelolco.

3.2 Solar panels

Scientists at the National School of Biological Sciences use nanoclay to remove the bitter taste of the juice.

3.3 Nanoclay

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3.4 Cancer Research

Mexican scientists battling cancer, led by Tessa Lopez fell to 96 percent the size of tumors in the brain of animals, thanks to an innovative start chemotherapy tested in the coming months in people with terminal cancer. After four years of work in teams, researchers from the Autonomous Metropolitan University (UAM) and the National Institute of Neurology and Neurosurgery (INNN) built, atom by atom, titanium-platinum molecules so small that they are able to cross the membrane cancer cells, enter the nucleus and then destroy the double helix of genetic material, all without affecting healthy cells. An additional advantage of this proposal is that drugs are injected directly into tumors and are 100 times less toxic than chemotherapy. Other developments which may be made based on this program are: catalytic materials to be used by industries oil and glass, prototype sensors increasingly efficient and miniaturized, new optoelectronic devices, markers of samples very small, composites of ultra high strength, paintings conductive electron emitter displays efficient and ultra-thin devices for atomic force microscopy, new materials to avoid rejection in medical implants, new storage devices, high-capacity magnetic storage materials that mimic nature, new polymers and magnetic drivers, adsorbents for decontaminants. On the other hand, more research in catalysis needs to be done in Mexico because the annual local market of catalysts is close to 100 Million USD [16-20].

Also, Mexico begins to participate in international affairs on nanotechnology and its economic impacts. Mexico joined in 2004 the first intergovernmental dialogue on Responsible Research and Development of Nanotechnology (IDRDN). Figure 4 shows the breakdown of country representation in the International Dialogue on Responsible Research and Development of Nanotechnology (IDRDN).

COUNTRY	IDRDN
United States	7
Italy	1
Japan	5
United Kingdom	1
Taiwan	3
Canada	3
Australia	1
France	2
Belgium	1
Germany	1
Switzerland	1
Austria	1
Ireland	1
The Netherlands	1
New Zealand	1
South Africa	2
Argentina	1
India	1
Mexico	2
South Korea	2
Brazil	1
Czech Republic	1
Israel	1
Romania	1
Russia	1

Fig.4. Breakdown of country representation in the International Dialogue on Responsible Research and Development of Nanotechnology (IDRDN).

4 National and International Agreements

4.1 The Silicon Border Science Park Development

It is promoted as the first high technology park specialized in Latin American nanocomposites. Located in Mexicali, Baja California Norte, covers an area of 400 hectares (Presidency of the Republic, 2006). The purpose is to create a science park that caters for the whole industry chain of semiconductors and other high technology. The project started in 2006 and is expected to be finished in ten years.

4.2 High tech Park

The Puebla state government intends to create a high-tech park at Huejotzingo. This cluster is expected to offer products for medical and automotive industry. At that place is based INAOE, which is building a National Laboratory of Nanoelectronics with a clean room of the highest class donated by Motorola in 2004 and a line of integrated circuit manufacturing.

4.3 Research Park and Technology Innovation

The State of Nuevo Leon is building since 2005 this park as part of the Knowledge City Project, which aims to attract major educational centers and research from

Mexico to the city of Monterrey. The UANL is part of this project with the Centre for Innovation, Research and Development in Engineering and Technology, where a Nanotechnology and Nanosciences Laboratory is located. CONACYT will create an Engineering and Development Centre for Industry. ITESM will bring the Centre for Research and Strategic Product Design (CIDEP) and UAEM will open Advanced Packaging Technology Center.

4.4 Industrial Park Project of High Technology “cabeza de Juarez”

Mexico City Government has planned to build this park for companies whose activities are based on innovation processes and productive applications, which do not harm environment, contributing to ecological conservation and promoting by employment generation. Hosting at least five large enterprises engaged in advanced technology as well as small and medium enterprises engaged in subsidiary processes.

5 Other types of cooperation and agreements

5.1 program for Bilateral International Cooperation Mexico-EU Nanotechnology (2009).

5.2 Inter-American Collaboration in Advanced Materials-CIAM (2002).

5.3 Bilateral Science and Technology Project-PROBYCYT (2004).

6 Conferences and Symposia of Nanotechnology

Mexico has organized several Meetings on Nanotechnology as:

6.1 The Foundation for Education and Commercialization of Micro and Nanotechnology (MANCEF)

This meeting is considered by specialists in the top 10 worldwide.

6.2 Nanomex

It is an international meeting held annually by the UNAM in response to the urgent need to promote a high quality interdisciplinary dialogue on nanotechnology.

6.3 Nanotech-Isamn

This is an International Topical Meeting on Nanostructures Materials and Nanotechnology and 5th International Symposium on Advanced Materials and Nanostructures

Brazil-Chile-Mexico.

6.4 Annual International Congress on Materials Research

The Mexican Academy of Materials Science organizes the annual International Congress on Materials Research at Cancún, Quintana Roo.

6.5 In 2011 will be held Nanomaterials Conference in Puerto Morelos, Mexico.

Also, an international Meeting was held in Monterrey Nanosciences in May of 2009 at the Centre for Research, Innovation and Development in Engineering and Technology (CIIDIT) of the Autonomous University of Nuevo León.

7 Schools and Workshops

7.1 Nanotechnology and Nanoscience Winter School, 1st Workshop on Characterization Techniques and Calculations in Nanostructures Ab initio organized by the Mexican Society of Physics.

7.2 School of materials science and nanotechnology, which will be organized for the sixth time on October 2010 involving experts from various parts of the world

8 Associations

8.1 Nano Network UAM

Metropolitan Independent University (UAM) has a nanoscience network of five campus and has specialists in different fields related to nanotechnology.

8.2 Latin American Network on Nanotechnology and Society (ReLANS)

Latin American Network on Nanotechnology and Society (ReLANS)

This network based in Zacatecas, Mexico

8.3 National Network of Science and Technology

This network is formed by ININ CNYN-UNAM, CIMAV, IPICYT, INAOE and CINVESTAV-Irapuato.

8.4 UNAM Nanoscience Network

At the National Autonomous University of Mexico, there are currently several research groups in the areas of Nanoscience and Nanotechnology. These research groups have organized to set the UNAM nanoscience network

8.5 Mexican Physical Society

Mexican Physical Society Division (SMF) has a Nanoscience and Nanotechnology Division (Dinano).

8.6 Environmental Nanotechnology University

Project (TIP).

9 Reviews

9.1 Mundo Nano

9.2 Ciencia y Desarrollo

9.3 Tip

9.4 Nanoscience et Moletrónica

11 Public Support

Mexican Congress has joined efforts to promote nanotechnology, asking CONACYT, UNAM and National Polytechnic Institute (IPN), as well as all other universities, public and private research centers, business sector, to implement a national emergency program to improve funding of research and to enhance education and research, in order to strengthen Mexican scientific community, particularly in the area of nanotechnology [21]. The emergence of nanosciences and nanotechnologies (NCT) brings with it promises of scientific and technological advances that will have significant economic impacts (Lux Research, 2006), as well as their social disputes as stated Foladori and Invernizzi in 2005. Although the development of these new sciences and technologies requires considerable investment in infrastructure, developing countries have also turned their attention to the nanosciences and nanotechnology. This is reflected in the initiatives undertaken in countries such as the National Nanotechnology Programs of Brazil and Argentina.

Figure 4 shows the scientific production in nanosciences for six emerging countries and Mexico during two periods: 2000-2003 and 2004-2007. China, South Korea and India are the three countries leading with 49 780, 15 535 and 9430 articles published between 2000 and 2007 respectively. Brazil is the fourth country with 5133 publications and Mexico is the fifth position with 2383 publications. You can easily see that China is the most advanced country with a growth of 186.8% over a period of four years.

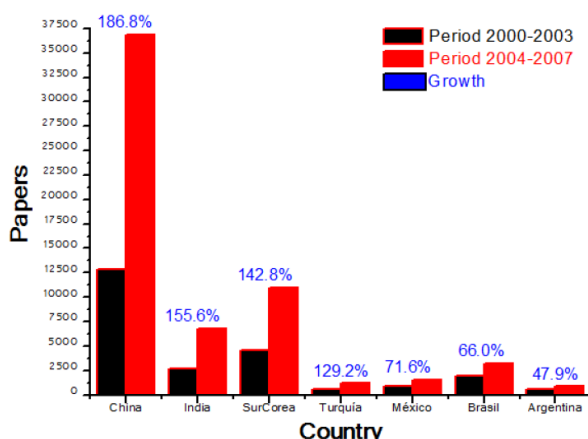


Fig.5. Scientific production in nanosciences six emerging countries and Mexico during two periods: 2000-2003 and 2004-2007.

12 Potential applications of Nanotechnology in Mexico

According to the Mexican economy, the potential benefits of applying nanotechnology are:

1. Storage and Energy Production.
2. Increased agricultural productivity.
3. Water remediation.
4. Disease diagnosis.
5. Drug delivery systems.

Conclusion

Mexico needs to enter the field of nanotechnology in the medium term [22-24] and for this to happen it is necessary to undertake the following actions:

1. Establish a State science policy considering the nanoscience and nanotechnology as two of its strategic areas.
2. Create a National Nanotechnology Initiative including as many partners as possible: Universities, Public and private institutes, CONACYT, PROMEP, and private initiative. Private investment should be supported by the government through tax incentives.
3. Offer more bachelor degrees in Nanoscience and Nanotechnology.
4. Offer more Masters and PhD degrees in Nanoscience and Nanotechnology.
5. Promote and disseminate Nanotechnology to the nation's children from elementary education.
6. Increase of 0.4% of GDP to reach 1% or more in research, that is recommended by the OECD.
7. Promote transfer of technologies related to nanotechnology.
8. Identify and tackle the main problems of Mexico that can be addressed by nanotechnology.
9. Create a legal framework to protect environment and people.

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