NANOSCIENCE AND NANOTECHNOLOGY IN MEXICO: ORIGINS, EVOLUTION AND PROGRESS

NANOCIENCIA Y NANOTECNOLOGIA EN MEXICO: ORIGENES, EVOLUCION Y PROGRESO

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Abstract

Mexico has a slow development of nanotechnology; however, great efforts have been made to support nanoscience and nanoeducation. The Institute of Scientific and Technological Research of San Luis Potosi created the first specialized graduate program in nanoscience and Nanotechnology in Latin America in 2001, and the first engineering degree in nanotechnology was offered in 2006. Also, the number of researchers, students, networks, clusters and modern equipment for education and researching is growing every year, besides there are 25 degrees of Bachelor of Nanotechnology as well as 87 graduate programs, the country has a great potential for growing in nanoscience and nanotechnology due to its geographic location. Also there are few patents and products based on nanotechnology, despite this, some Mexican researchers have been recognized and honored with awards such as TWAS, and Mexico has created patents as a sanitizer that eliminates the H1N1 virus or anti-graffiti paint. So if the country wants to have a real impact is necessary to make more industry-university links and to promote nanoeducation at all levels focused towards the patents and applications. Research, development and application of standards and regulations for health and environmental protection must not be forgotten.

Keywords: Nanoscience, Nanoeducation, Nanotechnology, Mexico.

Resumen

México tiene un lento desarrollo en nanotecnología; sin embargo, se han hecho grandes esfuerzos para apoyar la nanociencia y la nanoeducación.

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El Instituto de Investigación Científica y Tecnológica de San Luis Potosí creó el primer programa de postgrado especializado en nanociencia y nanotecnología en América Latina en 2001 y la primera carrera de ingeniería en nanotecnología se ofreció en 2006. Además, el número de investigadores, estudiantes, redes, clusters y equipos modernos de nano-educación e investigación ha creciendo año con año, asimismo, existen 25 grados de Licenciatura en Nanotecnología y 87 programas de posgrado. México tiene un gran potencial de crecimiento en la nanociencia y la nanotecnología debido a su ubicación geográfica. También hay pocas patentes y productos basados en la nanotecnología, a pesar de esto, algunos investigadores mexicanos se han reconocido y galardonado con premios como la TWAS y se han creado algunas patentes como la del desinfectante que elimina el virus H1N1 o la pintura anti-grafiti. Sin embargo, si el país quiere trascender en el ramo nanotecnológico, es necesario que tenga más vínculos industria-universidad, promover la nanoeducación en todos los niveles y enfocarse en las patentes y la tecnología, sin olvidar, por ninguna razón, la investigación, el desarrollo y aplicación de las normas y regulaciones para la salud y la protección del medio ambiente aplicables.

Palabras Clave: Nanociencia, Nanoeducación, Nanotecnología, México.

Introduction

1. Public Investment

The Organization for Economic Cooperation and Development (OECD), recommended at least 2.26% of GDP for research and development (R+D) investment and the General Law of Education in Mexico establishes that public spending on R+D cannot be less than 1% of gross domestic product (GDP), nevertheless, in the last decade, the resources for this item have been always at levels less than 0.5% of GDP. Countries with a similar development level invest more of their GDP, for example, Brazil (~1.13% of GDP), India (~0.88%) or Chile (~0.67 %) and there is no specific budget for nanoscience in Mexico, it was not until 2007 when the 2007-2012 National Development Plan of MFG sees nanotechnology as a strategic sector and as a technology pioneer [1,2].
Education in Mexico is based on areas: Synthesis of Materials (such as:gel systems, pyrolisys systems, chemical vapor deposition, sputtering systems, among other systems), Characterization of Materials (such as: electrochemical system, scanning electron microscope, transmission electron microscopes, atomic force microscopes, spectrometers, particle size measurement and area, thermogravimetric analysis, among other instruments characterization), also the development of nanomaterials, nanodevices, nanobiosensors and Project

Management, with solid knowledge and skills developed in the use of tools, instruments and equipment that allow you to innovate professional performance.
In Mexico there have been interesting developments as: water purification, solar cells, new structures, nanofilms, nanostructured polymers, nanoparticles, nanoadditives for polymers, catalytic materials for the oil and glass, new optoelectronic devices, compounds, alloys , ceramics, spintronics, bionanomaterials and energy conversion among others. The increase of events in the last decade is another indicator of the growth of nanoscience and nanotechnology in Mexico.

2. Origins of nanoscience and nanotechnology in Mexico

Pioneering researches in Latin America in transmission electron microscopy were performed at the Institute of Materials Research of the Universidad Nacional Autónoma de México (UNAM) since the early 1960's, while in 1990 the first Carbon Nanotechnology Laboratory in the country was installed in 1999 at UNAM Juriquilla. In 1994 the Research Center in Advanced Materials (CIMAV) was established in Chihuahua, the National Laboratory for Nanoscience and Nanotechnology (LINAN) at Potosi Institute of Scientific and Technological Research (IPICYT) which opened the first specialized graduate program in Nanoscience and Nanotechnology in Latin America in 2001.
The coordinated effort between universities and industries have led to several cases of success, in 2005, Mauricio Terrones Maldonado received The TWAS Prize in Engineering Sciences for outstanding contributions in the synthesis and characterization of novel carbon-based nanomaterials researcher; Tessy Lopez has been widely recognized and has been cited more of 2500 times for her discoveries in some treatments for Parkinson and Tumors, [4-7]; An interdisciplinary group of professors and researchers from different institutions, together with the Mexican company GRESMEX produce a sanitizing capable of removing viruses, bacteria and fungi through the application of nanotechnology [8]. Also, Víctor Castaño and collaborators invented the anti-graffiti paint in 2003, this paint was patented as "Deletum 3000" by the Mexican company COMEX [9].

3. Institutions providing nanoeducation and their infrastructure

The first university in opening Nanotechnology Engineering Bachelor in Mexico, and pioneer in Latin American, was the University of the Americas (UDLA) in 2006. At present there are 25 universities teaching nanotechnology (Table 1). These institutions have modern equipment synthesis and characterization of nanomaterials and there are few private companies that offer characterization.

4. Mobility of students and academics

Other important issue is the collaborations of Mexican researchers with other researching groups of the world, mainly from England, United States and Canada. This relationships have allowed that some students have the opportunity to participate in research stays, internships and academic exchanges abroad [10].

5. Research and development associated

There are 60 institutions in Mexico developing researching and teaching activities, with near 500 researchers in related fields of nanotechnology and nanoscience. There are 160 laboratories and 17 pilot plants, which had produced about 340 lines of researching related to this disciplines. Until February 2013 it was estimated a number of students in programs related to nanotechnology amounted to 257 in doctoral and 216 in master degree and is estimated to number slightly over 500 students in bachelor's degree in Nanotechnology Engineering to the present day. Mexico also has researching groups dedicated to environment, energy, medicine, materials, optics, catalysis and spintronics, among others [11].

6. Nanoscience and nanotechnology events in Mexico

Since 2003 different research groups have organized international congresses, workshops, courses and others events. Table 2 shows a list of the most relevant events realized in Mexico [12].

7. Nanoscience and nanotechnology networks

In an effort to share equipment, make solutions, optimize resources and link industry with researching institutions in Mexico. Some institutions and universities have created some nanotechnology networks and attached to some international ones as show Table 3.

8. Industries and Business related

About 50 companies develop, import or sell products involving nanotechnology, the interest in developing nanotechnology-based products by the private sector has begun to have an increasingly dynamic participation, some companies have their own research, others have approached the cluster of nanotechnology in Nuevo Leon and other most often associated with universities and institutes, both public and private. There was an increase in

patent applications of nanotechnology in Mexico from 2000 to 2015 and articles co-authored with industry have increased [13-20].

9. Standardization and regulation of nanoscience and nanotechnology in Mexico

Mexico has not official standards (called NOM´s in the country) for the care of the environment and health in the production, transport, store or use of nanotechnology [21], Nevertheless, The National Center of Metrology (CENAM) is making efforts to standardize the nanometrology.

In Mexico, research and technological development in nanoscience and nanotechnology are not accompanied by a similar research of their potential social, economic, environmental risks or health, or ethical implications [22,23] and members of the Latin American Nanotechnology and Society (ReLans) and the Center for Analysis and Action on Toxics and Alternatives (CAATA) state that nanoproducts enter the Mexican market without regulations to ensure their safety.

10. Conclusions

Nanoscience origins date back from early 1960's and had a boom at the beginning of this century, nanotechnology has a slow progress because Mexico has no national nanotechnology initiative, coupled with this problems and the public investment in nanoscience has been inadequate. However, Mexico has made significant progresses in nanoeducation, offering bachelor, master and doctoral degrees in nanotechnology, it has also formed several nanotechnology networks and it has begun to invest in equipment and construction of new laboratories.

TABLE 1. *Universities offering a degree in Nanotechnology Engineering and the year since they are offering it. Prepared by the authors.*

Institution	Acronym & Approximate Year of Opening	Institution	Acronym & Approximate Year of Opening
Universidad de las Américas	**UDLA-2006	Univ. Tecnológica de Tulancingo	*Utec-2012
Universidad de la Ciénega	UCMO-2008	Univ. Tecnológica de Torreón	*UTT-2012
Instituto Tecnológico de Tijuana	ITT-2008	Univ. Tecnológica Tula-Tepeji	*UTTT-2012
Univ. Politécnica del Valle de México	UPVM-2010	Univ. Tecnológica de Altamira	*UTA-2012
Universidad Autónoma de Querétaro	UAQ-2010	Univ. Tecnológica de Hermosillo	*UTH-2012

Universidad Autónoma de Baja California	UABC-2010	Univ. Tecnológica de Gral. Mariano Escobedo	*UTE-2012
Universidad Nacional Autónoma de México	UNAM-2011	Univ. Tecnológica del Centro de Veracruz	*UTCV-2012
Universidad Autónoma de San Luis Potosí.	UASLP-2011	Univ. Tecnológica de Querétaro	*UTEQ-2012
Universidad Jesuita de Guadalajara	ITESO-2011	Univ. Jesuita de Guadalajara	ITESO
Universidad Tec. Ciudad Juárez	*UTCJ-2011	Instituto Tec. Estudios Sup. de Monterrey	***ITESM
Universidad de Guadalajara	UDG-2012	Universidad Politécnica de Sinaloa	UPSIN
Universidad Tec. Tecámac	*UTTe-2012	Univ. Politécnica de Chihuahua	UTCh
Universidad Tec. Emiliano Zapata	*UTEZ-2012		

*Higher Technical Degree in Nanotechnology, **Nanotechnology and Molecular Engineering, ***Nanotechnology Engineering and Chemistry Sciences.

TABLE 2. *Congresses and events about nanoscience and nanotechnology in Mexico Prepared by the authors.*

Events
- International Researching Materials Congress, Symposium of Nanotechnology
- Nanotech
- Escuela de Ciencia de Materiales y Nanotecnología
- Mexican Workshop on Nanostructured Materials
- Nanomex
- Week of Nanoscience and Nanotechnology
- International Week of Nanotechnology

TABLE 3. *Nanotechnology and Nanoscience Networks Involved in Mexico: Prepared by the authors.*

Networks
- Latin American Network for Nanotechnology and Society
- Nanoforumeula
- Brazilian-Mexican VirtualCenterfor Nanotechnology
- Pan-American Nanotechnology Network
- Centerfor Nanoscience and Nanotechnology Argentine-Mexican
- Binational Network of Nanoscience and Nanotechnology MEX-USA
- Network Research Group in Nanoscience
- Nanoscience Network of UAM
- Nanosciences and Micro-Nanotechnologies at IPN
- National Network for Nanoscience and Nanotechnology
- Network of Innovation Laboratories in MEMS
- Mexican Physical Society, Division of Nanoscience and Nanotechnology
- University Project Environmental Nanotechnology

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