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Nanotechnology in Mexico: Global trends and national implications for policy and regulatory issues

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ABSTRACT

Nanotechnology, or the capacity to manipulate matter at the atomic (or nanometric) scale, promises such potential that important challenges and impacts are now foreseen, both positive and negative. Examples include possibilities to contribute to the production of clean energy, to water purification, and to important medical advances; specific IP and legal questions posed by the sector; the possibility of risks to health and the environment; as well as societal and ethical aspects linked both, to scientific-technological pursuits per se and to the associated political-business action. In this context, besides more scientific research regarding nanomaterials' potential risks and nanotechnology implications, a broader regulation based on an open, constructive, and permanent dialogue among the diverse actors seems critical. The following paper assesses this diversity of issues for the case of Mexico. It opens with a panoramic introduction to the topic, followed by a general overview on the advancement of nanosciences and nanotechnology (N&N) worldwide. It then offers an evaluation of the current state of Mexico's N&N capabilities and the challenges ahead; a review of IP issues and its implications for Mexico, and finally a discussion on regulatory aspects related to human health and the environment being addressed by national authorities and specialists.

1. Introduction

Nanotechnology refers to the manipulation of material at the nanometric scale, at about a billionth part of a metre. It is a technology that, aside from being characterized by operating at such dimensions (at which other disciplines such as chemistry and biology also work), alludes in particular to the design, characterization, and production of novel nanostructures, nanodevices, and nanosystems based on "controlling" the form, the size, and the properties of matter at said scale with the purpose to use it in specific applications, such as civil, military, or security applications [27,55,59].

Applications may be so varied and have such vast degrees of complexity that some experts prefer to refer to "nanotechnologies" in order to more precisely account for said diversity of uses (this text employs the singular or the plural indistinctly). For example, nanostructured materials are already used in luxury goods such as golf and bowling balls; in the fabrication of high performance tires and stain and wrinkle-resistant fabrics; in cosmetics and new therapeutic treatments; in filters and membranes for water purification and other environmental "solutions;" in the improvement of production processes through the introduction of more resistant or efficient materials, or in the design of new materials for uses that range from electronics

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and practically the entire transportation industry, to inputs used in chemical-biological arms detectors or for the fabrication of more sophisticated weapons.[1]

These applications, among others, have already generated two fronts of attention. On one hand, broad benefits are observed of the possibility of potential restructuration, in principle, of our entire material surroundings. And on the other, warnings have arisen of certain implications that this transformation could generate on the environment, and in turn on health, given the presence of novel human-designed nanostructures (not naturally generated) whose characteristics remain–at least partially–unknown.

The high degree of uncertainty regarding the potential risks of nano-innovations is particularly noteworthy. There is recognition in the sphere of nanotechnologies of the constrictions or obstacles in the internal characterization of nanostructures; in the simultaneous manipulation of various atoms; in the understanding of the collective behaviour of nanosystems, and in the design of assembly mechanisms of new architectural forms of nanocomponents useful for the development of new nanosystems or nanodevices, among other issues [7,29,59]. One may therefore deduce–as is already recognized by the expert and the international regulatory community–that potential risks are probable and, furthermore, in multiple cases are difficult to immediately detect given that what is being manipulated is directly imperceptible to our senses [28,29,53,59]. It is a factor that generates a "disconnection" between the causes and effects of the advance of nanotechnologies, in both time and space, adding further complexity to their handling [13].

Said situation is fuelling the promotion of ecotoxicological research on nanomaterials, the development of portable and reliable devices for the detection of nanostructures, among other aspects and measures [3,7,23,29,41]. Furthermore, some efforts for appropriate nanotechnology governance are been proposed and even carried out [30,60], all in a context in which potential benefits [58], risks and implications are continuously being imagined, discussed and researched, including many approaches with strong ethical-moral overtones [17,39,48,66].

For instance, it is being stated that some nanomaterials may be toxic and therefore result in allergic reactions, intoxication, and possibly even alteration and/or the death of humans and other life forms, with unpredictable consequences; that the benefits of accelerated advancement of nanotechnologies will not necessarily reach the large majority of the population that lacks economic means (for a review of the case of nanomedicine, see Ref. [1]); that the military applications of nanotechnology will potentially affect human rights and international relations by transforming the nature of war [2,13,24,44], or that the current progress of nanotechnology, alongside other novel technologies, may result in the medium to long term in the transformation of human "nature" by altering the human body and mind, supposedly toward something "better," whatever that means [33,46,56]. All the while, the advance of N&N is already an imminent fact.

2. Nanoscience and nanotechnology worldwide: a brief overview

The economic paradigm suggested by the advance of N&N at the global level is already expressed in growing expenditure channelled through diverse governmental and business initiatives and programmes. Total global expenditure by 2010 has been estimated at about 70 billion dollars (USD) of which 18 billion corresponded only to 2010. Less than to thirds of such total expending has been public but it is to notice that since 2008 private funds are now the major source: about 60% by 2010 [58]. Public spending has therefore contracted notoriously. From 2004 to 2008 it grew at a rate of 130% but since then it has dropped to 9.3%.

While countries such as the United States (USA), Japan, Germany, France and United Kingdom are at the forefront of R&D in the matter, others such as China and Russia have begun to take giant steps in this direction [8,13,15,16]. For example, by 2006 China was already in second place on nanoscience publications worldwide, ahead of Japan (although not in the sphere of nanopatents) [13].

While the context is highly competitive, in general terms between the USA, Europe and Japan, the USA remains well positioned in this novel technological niche, mainly in key areas and applications, holding dominant presence in the patent offices of both, its own country and Europe. According to OECD data, since 1978 the USA dominated with 34.6% of nanopatents of the total registered in the European Patents Office (EPO). It was followed by Japan with 29.2% and European Union (EU) countries with a total of 28.4%. In the case of the US Trademarks and Patents Office (USTPO), the USA holds 46% of such patents, while its closest competitor, Japan, held 27%, and the European Union 19% ([13]; OECD Patent Data Base). All together, USA, Japan and the EU hold 90% of worldwide nanopatents. China however figures at the 20th place (Ibid).

Therefore it's not surprising that the USA continues to increase its budget in N&N. For 2013 the Federal request accounts for 1.76 billion USD, mainly for fundamental phenomena & processes (28.2%); nanoscale devices and systems (23.4%) and research and development of nanomaterials (20.8%) (http://nanodashboard.nano.gov). USA strength may be observed in the 5000 active projects it maintains; in the 26 research mega-centres dedicated to N&N and the several dozen research institutes of diverse calibres with some type of nanotech-project(s); in the capacity to train some 10,000 students a year in the field, and in the incomes registered for the sale of inputs for elaboration of products that integrate nanomaterials or nanoprocesses in some stage of their fabrication (Roco, Mihail; personal communication, Mexico: September 11th, 2009). In 2008, Roco states, said income reached 80 billion USD (Ibid).

The real relevance of this last point emerges when one considers the growing market of nanotechnology-enabled products. In 2004 there were some 13 billion USD in sales

[1] For an ample review of nano-products, see: www.nanotechproject.org/inventories/consumer/.