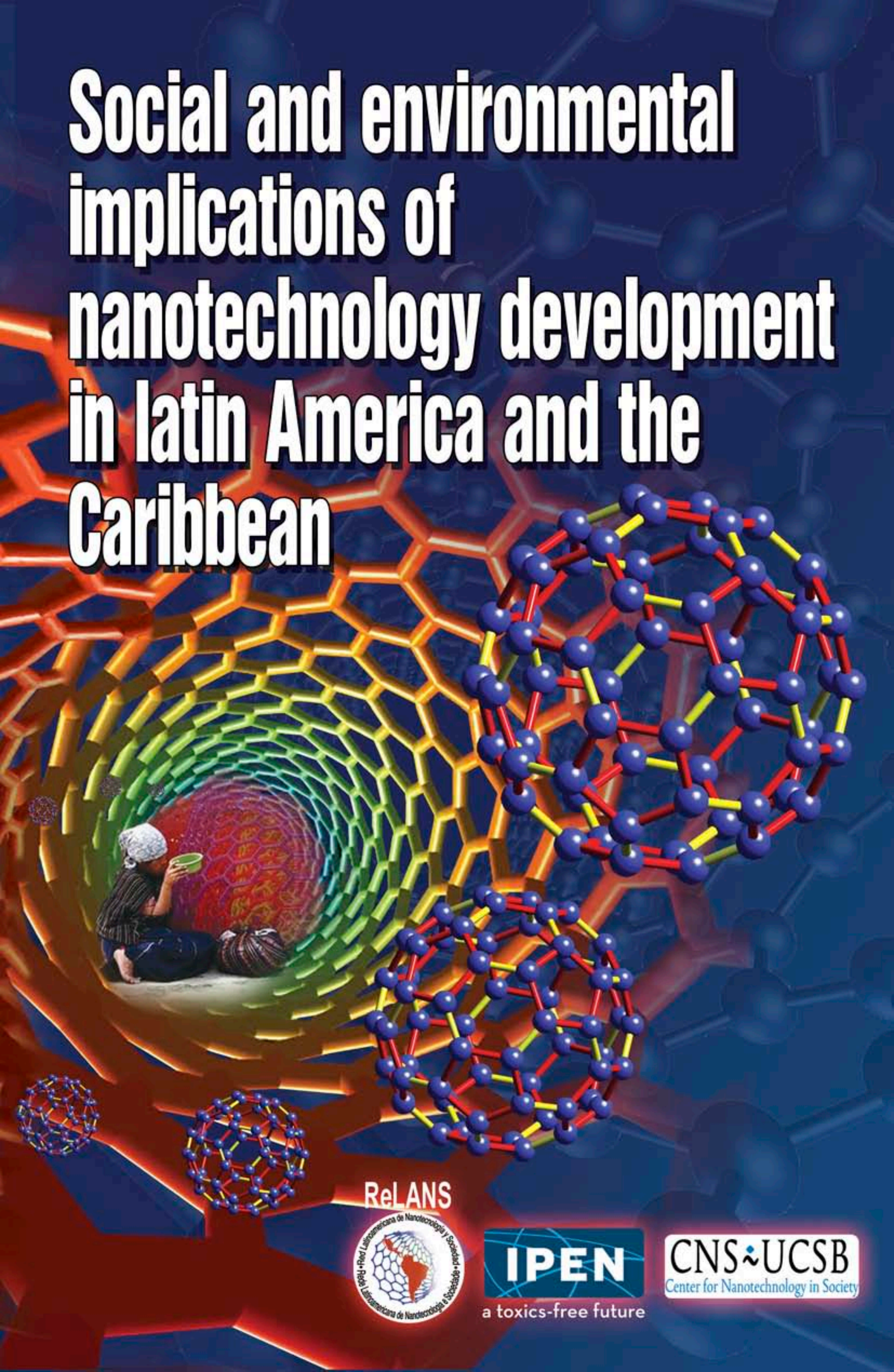
Social and environmental implications of nanotechnology development in latin America and the Caribbean



ReLANS

Red Latinoamericana de Nanotecnología y Sociedad • Rede Latinoamericana de Nanotecnologia e Sociedade

IPEN

a toxics-free future

CNS-UCSB

Center for Nanotechnology in Society

Social and Environmental Implications of Nanotechnology Development in Latin America and the Caribbean

Guillermo Foladori
Noela Invernizzi
(With the collaboration of Fernando Bejarano)

www.relans.org **www.ipen.org** **www.cns.ucsb.edu**

2012
Zacatecas, México / Curitiba, Brazil

This brochure was made possible by ReLANS with the support of the International POPs Elimination Network (IPEN) within the International Project for the Implementation of SAICM (Strategic Approach to International Chemicals Management).
The translation to English was part of the UCMexus-Conacyt Grant CN 10-420 between UC-Santa Barbara and the Autonomous University of Zacatecas. Translation to English by Anna Walsh. English revision by Mark Rushton.

ReLANS (Latin American Nanotechnology and Society Network) is an academic network composed of researchers from diverse disciplines interested in the development of nanotechnologies in Latin America. The network is a pioneer in the analysis of the impact of nanotechnology on the work force, a theme that has been given little consideration in the global discussion despite its significance. The webpage of ReLANS has a section devoted to documents and organizations that focus on this critical theme: www.relans.org

IPEN (International POPs Elimination Network) is a Global network of more than 700 public interest non-governmental organizations working together for a toxic free future. IPEN has a working group on nanotechnology. For more information please contact David Azoulay at dazoulay@ciel.org and www.ipen.org

Foladori, G. & Invernizzi, N. (2012). Social and Environmental Implications of Nanotechnology Development in Latin America and the Caribbean. ReLANS. (Latin American Network of Nanotechnology and Society). Zacatecas, Mexico and Curitiba, Brazil. IPEN

Design by Leonel Reyes Rivera.

Editorial coordinator: Fernando Bejarano

Printed by “Impresos Gama” in Texcoco”, Edo. de México. March 2012.

Contents

Introduction

Research on nanotechnology and commercialization of products with engineered nanomaterial is happening through Latin America and the Caribbean. In Latin America and Caribbean countries nanotechnology has been declared a strategic sector of scientific and technological development. Public funds have been created to encourage nanotechnology development and the majority of countries in the region have research groups and centers on nanotechnology. Graduate courses on nanotechnology are now being offered in Universities in Latin America and the Caribbean. Products with nanotechnology are already on the market, either produced within the region or imported from abroad. Nanotechnology is now used in food, cosmetics, medicine, textiles, cleaning products, computers, cellular phones, sports equipment, construction equipment, and other consumer products.

Nanotechnology is promoted as a technological revolution that will help to solve an array of problems. According to this hype, nanotechnology promises to provide new ways of fighting cancer, making water drinkable, conserving food, and accumulating energy, among other important functions. However, the risks and social implications of nanotechnology are not often discussed, and hence civil society remains uninformed. Even though scientific information exists about potential health and environmental risks of engineered nanotechnology, although there are many uncertainties, the public funds dedicated to evaluating this essential aspect are low. The policy in regards to this technology is far from precautionary: the products enter the market unregulated and unlabeled, neither guaranteeing the safety of the product, nor informing the consumer of potential risks.

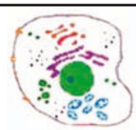
Conscious of the lack of information, regulation and supervision of nanotechnology, governmental delegations, experts and representatives of civil society organization in Latin America and the Caribbean have recommended the necessity of a regulatory framework with a precautionary focus, among other proposals, as they expressed in June 2011 in the regional consultations on the application of SAICM (Strategic Approach to International Chemicals Management).

SAICM is a voluntary treaty that the international community has agreed to be the global framework in which to discuss the methods of cooperation and specific actions that can be taken in relation to nanotechnology and products engineered with nanotechnology. Accordingly, there have been regional reunions and general meetings that have elaborated recommendations and amendments to resolutions that should be adopted by consensus during the Third International Conference on Chemical Management (ICCM3) that will be held in September, 2012 in Nairobi, Kenya, within the organization of the United Nations Environmental Program (UNEP).

In this context, this informational brochure was developed to systemize the principal social, environmental and health implications of nanotechnology for workers and consumers in Latin America and Caribbean, with the objective of strengthening their participation in the public discussion on the actions that national government, industry, and civil society should take in order to comply with a preventative international regulatory framework.

1. What is nanotechnology?

Nanotechnology is the manipulation of matter at a molecular and atomic scale. It means artificially combining atoms and molecules to create particles and structures with functions different from the same material at a larger scale. For convenience, it is said that nanotechnology works on materials with a dimension of 100 nanometers, although new functions often operate at 300 or more nanometers. What is a nanometer? It is a unit of measurement. It is one millionth of a millimeter. The last row of the table illustrates the level at which nanotechnology operates.

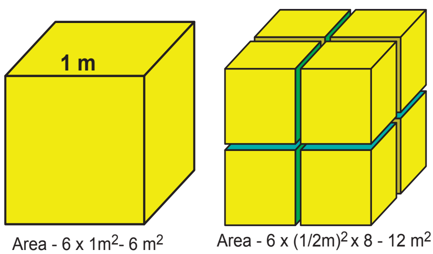
1 meter (m). The macro world		1 person = 1.70 meters
1 milimeter (mm) (1000 milimeters = 1 meter). The small world.		1 ant = 5 milimeters
1 micrometer (µm) (1000 micrometers = 1 milimeter). The celular world.		1 cell = 20 micrometers
1 nanometer (nn) (1000 nanometers = 1 micrometer) The world of nanotechnology.		One virus = 60 nanometers

Source: ReLANS.

Working with matter on such a small scale represents a revolution in technology, because at this scale materials reveal physical, chemical and biological (including toxicological) properties different than they do at a large scale. It is like discovering a world of new materials. This change in the behavior of matter is a result of two different effects.

One, called the *quantum effect*, makes materials of Nano size have different optic, electric, thermic, mechanic (resistance / flexibility) and magnetic properties. Metals, for example, are harder and more resistant at the Nano level. Carbon in the form of graphite (like in a pencil), is soft, but when it is processed at the Nano scale and carbon nanotubes are created, they take up to 100 times harder than at its macro scale. The optic properties of materials change, acquiring other colors and reflecting light differently.

Two: the *surface effect*. The smaller the scale, the larger the exterior surface, and consequently, the more reactive with atoms of neighboring matter. In the figure, the surface of the first cube is 6m2, while the one of the 8 small cubes is 12m2 for the same mass. The atoms that are on the external surface interact more easily with the atoms of other neighboring matter. For this reason, gold, which is not reactive, when manipulated into a Nano scale, becomes reactive and can be used as a base for sensors.



These effects give nanomaterial new properties, which at times, also develop new toxic effects. The increased reactivity and change in chemical and physical property, the increased mobility and capacity for absorption, the tendency to agglutinate, are effects that require new scientific and technological development to understand the toxic impact of engineered nanoparticles.

Nature has always produced nanoparticles. There are nanoparticles in volcanic emissions, clouds, smoke, etc. Also, human beings indirectly produce nanoparticles, like those that surge from combustion motors' emissions; and have produced nanoparticles in artisanal crafts for centuries, for example, when combining of glass with metal powders or dilutions to make stained-glass windows, so common in the Middle

Ages, or in producing the Mayans dye known as "indigo blue." But, if humans have long produced nanoparticles, and nature itself produces it, what is new about nanotechnology?

Lycurgus cup. S. IV D.C. British Museum. Glass with nanoparticles of gold and silver. When reflecting light it becomes green when transmitting from inside, red.

The novelty of nanotechnology is that there exist instruments, technology and scientific knowledge to manipulate with precision and produce nanoparticles, nanostructures, and derived products at industrial capacity.

In many cases nanotechnology is inspired by nature and copies its functions. For example, the leaf of a lotus has a surface of hydrophobic nanoparticles; which could be inspiration for thin film that repels water. And, lizard's feet have Nano-hairs so small that they facilitate that the forces of molecular attraction help stick to vertical surfaces and even defy gravity.

Lotus leaf (hydrophobic)

2. The Market for Nanotechnology Products

There exist many goods on the market that are products of nanotechnology. There are foods, cosmetics, household appliances, computers, cellular phones, medicines, textiles, ceramics, construction materials, sports equipment, weapons, etc.

> The appendix of the book Out of the Laboratory and into the Food Chain: Nanotechnology in Food and Agriculture, Miller & Sejen present 106 foods, nutritional supplements and materials that come into contact with food and agrochemicals that contain nanoparticles and are now on the market. See http://www.foeeurope.org/activities/nanotechnology/Documents/Nano_food_report.pdf

In food, nanotechnology is used in products, packaging, nutritional supplements and agricultural production. There are more than 200 companies that investigate and / or produce goods that utilize nanotechnology in this sector. Nanotechnology is used on the product itself to, for example, homogenize the texture and enhance the flavor of creams or ice creams, or to reduce the fat context, as Kraft, Unilever, Nestle and Blue Pacific Flavors have researched. Or also, to add to the food Nano-encapsulated nutritional supplements, such as Omega3, fortificants, or weight loss supplements. Also, there has been research on incorporating cosmetics into food products, as L'Oreal has done in association with Nestle o BASF. Nanotechnology is used in packaging to give the product a longer shelf-life, like the Nano ceramic bottle by Miller Brewing, or so that the raw material does not spoil, as McDonalds or Mr. Kiplings has experimented. Large seed manufacturing companies, like Syngenta, Monsanto, Bayer and Dow Chemical investigate and produce agrochemicals and seeds that are nano-encapsulated.

The cosmetics industry has the most nanotechnology products on the market. The majority of transnational cosmetic corporations have anti-wrinkle creams, sunscreens and shampoos that use nanotechnology, including Chanel, Clinique, L'Oreal, Revlon, Johnson & Johnson, Proctor & Gamble, and Lancôme. When applied to sunscreen, the Nano scale makes the cream transparent, hence avoiding the dreaded traditional white color. Also, nanotechnology is used to diffuse light and hide wrinkles, among other functions. There are toothbrushes and toothpastes with nanoparticles of sliver that works as a bactericide.

The European Union is legislating on the use of nanotechnology in cosmetics, given the high quantity of evidence of potential health risks.

Various electric domestic products include nanoparticles of silver, which operates as a bactericide; for example, air conditioners, refrigerators, washing machines, and dish washers by Samsung or LG. Thin films engineered with nanotechnology are used to cover floors; nanoparticles are incorporated into paint and also in aerosols sprays to apply on furniture and floors. Glass is processed with nanotechnology to prevent dust and dirt from adhering and to facilitate drying. In the textile industry, the application of nanotechnology can make clothing stain and wrinkle resistant. In some cases, nanoparticles of silver are incorporated to make clothing antibacterial; this is applied not only to nurses or doctors uniforms, but also to towels, sheets and socks. Medicines processed with nanotechnology promise to be more efficient and to have fewer side effects. Nanotechnology is also in sports equipment: in tennis rackets, golf clubs, sports shoes, and weather-resistant clothing. The major computer, cell phone, and video game brands store information in lithium batteries with nanotechnology coated anode, and use Nano electro mechanic devices. Luxury automobiles now come with more than 30 parts that contain Nano devices or combine nanoparticles.

The weapons industry is the one that most benefits from and also most drives nanotechnology development. From precision missiles to super-explosives, from sensors to bullet-proof vests, the military interest is tied to the advancement of nanotechnology.

Practically all branches of industry have nanotechnology products on the market. According to the ultimate study of the Woodrow Wilson International Center for Scholar's, conducted in March 2011, there were more than 1,317 nanotechnology products on the market.

David Haw xhuist, PEN

The majority of products on the market are luxury goods.

3. Nanotechnology in Latin American and the Caribbean

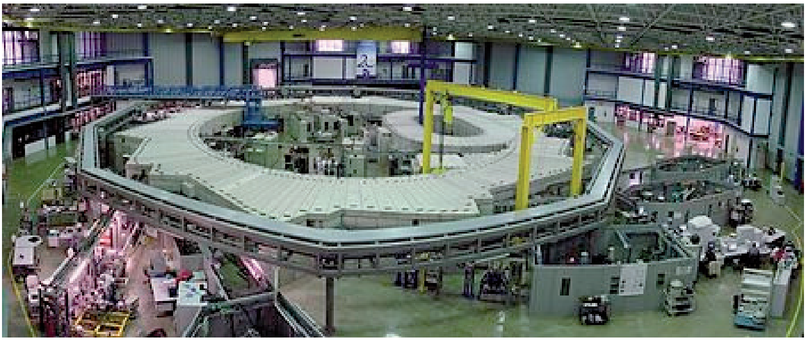
Research into nanotechnology began, at a global level, in the 80s and 90s, even though at this time the term “ultrafine particles” was used instead of “nanomaterial”. Now the vanguard of research and production is in the United States, Germany, the United Kingdom, and China, but all developed countries, and many developing countries, are also investigating and beginning to produce nanotechnology.

When the United States launched its National Nanotechnology Initiative in 2000, it encouraged the development of these related sciences and technologies throughout the rest of the world. International institutions, such as the World Bank, the Organization for Economic Cooperation and Development and the Organization of

American States exercised their influence to stimulate the development of nanotechnology in Latin America. This influence went not only to the largest countries, like Brazil, Argentina and Mexico, but also to the smaller countries, such as Uruguay, the Dominican Republic, Costa Rica or Cuba, and to mid-sized countries, like Peru, Colombia, Venezuela and Chile.

There exist various multilateral and bilateral agreements between countries that facilitates the dissemination of knowledge and the transference of technology in the region. The first was the Brazilian – Argentine Center of Nanotechnology, created in 2005. Various others were created later, like the Brazilian-Mexican Virtual Center of Nanotechnology, the Chilean-Brazilian schools of Nanotechnology, and the Mexican-Argentine Virtual Center of Nanotechnology.

Brazil has the only laboratory of synchrotron light in Latin America, located in Campinas, Sao Paulo, operating since 1997. The synchrotron light, produced by the conversion of artificially accelerated particles into light, permits exploration of the structure of matter. The Ministry of Science and Technology (MCT) and its agencies began to stimulate the development of nanotechnology at the end of 2000. The first action was the financing of four cooperative research networks. In 2004, a program for the development of nanotechnology was incorporated into the *Science and Technology Multi-year Plan 2004-2007*, which was amplified a year later with the launch of the *National Program for Nanotechnology.* This program financed activities of research and development, with particular attention to the associations between universities and companies, the construction and renovation of laboratories, business incubators for nanotechnology businesses and the qualification of human resources. Ten new cooperative networks were financed between 2005 and 2009, and another 17 in 2010. Currently, there are around 50 University and research centers with more than 1200 researchers and 2000 university students working on diverse aspects of nanotechnology in Brazil. Of the 120 National Institutes of Science and Technology created by the Ministry of Science and Technology by the end of 2008, at least 21 do research on nanotechnology. The country has 150 companies that develop nanotechnology or apply it to final products.



National Synchrotron Light Lab. San Paulo, Brazil.

In Argentina, the Secretary of Science and Technology in 2003 considered nanotechnology as a priority area for financing research. In 2005, the Argentina Foundation of Nanotechnology was created with a budget of 10 million dollars for the 5 following years. 4 research networks with broad themes of nanotechnology research were created. Close to 200 researchers work on nanotechnology in Argentina. In 2010, a new line of financing through Secretarial Funds was opened to finance nanotechnology, although these funds stipulated that the projects include business participation.

In Mexico the *Special Program of Science and Technology 2001-2006*, which is part of the *National Development Plan*, mentioned, for the first time in official documents, that nanotechnology is a strategic area in the chapter on advanced materials. In 2009 the Nanosciences and Nanotechnology Network was created. More than 50 Universities and research centers and nearly 500 researchers worked on the topic. Beginning in 2002, the majority of the research funds required the participation of the business sector; and the reform of the *Law of Science and Technology* in 2009 promoted that the public research centers create private companies as spin-offs, and also allowed researchers, even those from public centers, to keep up to 70% of

Center for Nanosciences, Micro and Nanotechnology. National Polytechnic Institute, Qro. Mexico the eventual royalties for inventions that they create, incentivizing the researchers to become businessmen.

Colombia placed nanotechnology within the eight strategic areas in Science and Technology; and in 2005 the National Counsil of Nanoscience and Nanotechnology was established, assigned to the Colombian section of the Institute of Electronic and Electric Engineering. The country has 19 groups of researchers at 10 Universities and a network of research in Nanotechnology.

Chile has various research groups in its principal universities. The Ministry of Education, through the agency of science and technology CONICYT, and the Ministry of Economics, financed nanotechnology research in at least four centers.

In Venezuela, the *National Plan of Science, Technology and Innovation 2005-2030* highlighted the importance of developing vanguard technology, including nanotechnology. In 2010, the Venezuelan Network of Nanotechnology was created, which brought together researchers from the principal universities and research centers, as well as representatives from the productive sector and government agencies.

In Peru, the *National Strategic Plan for Science, Technology and Innovation for Human Competitiveness and Development* placed nanotechnology as a strategic area for the development of the country; and more than four universities have groups researching nanotechnology.

Nanotechnology research and development has also been present in the smaller countries of the region. In Uruguay, nanotechnology was included as a cross-cutting priority area in the *Strategic National Plan of Science, Technology and Innovation* in 2010. In the Dominican Republic, the *Strategic Plan of Science, Technology and Innovation 2008-2018* includes nanotechnology as a priority area within the physical sciences. Costa Rica has had a nanotechnology laboratory (*Lanotec*) since 2004. In Cuba, the Center of Advanced Studies dedicated to nanotechnologies and converging technologies was launched in 2010. The area of greatest development in Cuba is connected with medical and biotech materials and applications. Also, there are research on nanotechnology conducted in Guatemala, El Salvador and Equator. As a whole, the region is incorporating itself, bit by bit, into this cutting-edge knowledge. The following table demonstrates which year nanotechnology came to be considered a strategic sector in the Science and Technology plans of these countries.

Initial official promotion of nanotechnology in Latin American and Caribbean Countries

Year	Country	Institution Promoted
2000	Brazil	Ministry of Science and Technology
2001	Mexico	National Council of Science and Technology
2003	Argentina	Secretary of Science and Technology
2004	Colombia	Administrative Department of Science, Technology and Innovation
2005	Costa Rica	National Council for Scientific and Technological Research
2005	Guatemala	National Council of Science and Technology
2005	Venezuela	Ministry of Science and Technology
2006	El Salvador	National Council of Science and Technology
2006	Peru	National Council of Scientific Technology and Technological Innovation
2008	Dominican Republic	Secretary of State of Higher Education, Science and Technology
2009	Uruguay	Ministerial Cabinet of Innovation
2010	Panama	National Secretary of Science, Technology and Innovation

Not an exhaustive chronology of the first official documents of scientific and technological policy that explicitly included nanotechnology as a strategic area in counties of Latin America and the Caribbean.

Evaluating the amount of nanotechnology products on the market in Latin America is not a simple task. But research in Brazil reported more than 150 companies that research produce or commercialize with nanotechnology. In Mexico, the list surpassed 90; and in Argentina at least 25. In addition, there are products with nanotechnology that freely enter the countries from external commerce. Given the lack of international regulation, there is no obligation to label, nor classify raw nanotechnology materials for international commerce; hence there is no way of knowing what truly exists on the markets.

Even through the development of nanotechnology research and production is not even across Latin America and the Caribbean, these three critical questions are still pertinent to the region as whole: for whom is nanotechnology being researched and produced? And why is the general workforce not prepared or trained to work in nanotechnology? And why is there no transparency in the information about nanotechnology?

The science and technology policy of the majority of countries in Latin America explicitly affirms that the priority function of nanotechnology is to promote international competiveness. The search for market niches and the orientation towards the global market are clear and explicit objectives in the national policies of the region. Although there are research groups that work on aspects of nanotechnology that have a direct impact on society and the environment, such as research groups on nanotechnology on health, on environmental protection, on alternatives for potable water, and alternative energies, the fact that the political orientation has been towards competiveness, in addition to the strong pressure that public research is conducted with the participation of private companies, raises doubts that if the potential impact will not end with simply increasing the profits of the companies involved. In addition, the only way that the science and technology policy responds to interests more directed towards society is if unions, consumers groups, environmental organizations, and other social organizations participate in the decision making, something which is absent in these countries.

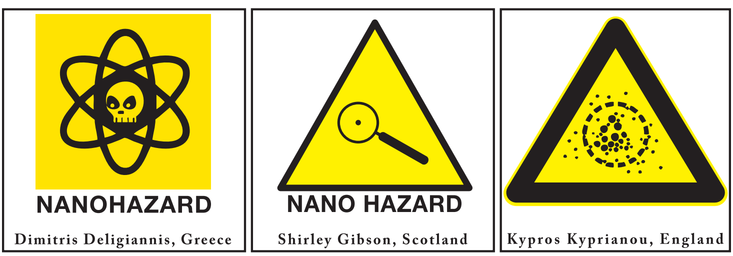
The second issue of concern is the absence of training programs for the work force, and also at the different educational levels. Nanotechnology policy is oriented towards the idea of "centers of excellence" staffed by highly skilled and educated employees. It is presumed that these centers of excellence will provide increased opportunities for innovation. But no country develops without supporting laborers with all levels of educational background, and without preparing and qualifying its workforce. There exists a strong contradiction between the processes of privatization and deterioration of elementary, secondary, and university education, and the idea of developing centers of excellence / specialization. The United States, Japan and the European Union stated the necessity of educating about nanotechnology in the curriculum of elementary and secondary schools. There have been no similar plans made for any Latin America or the Caribbean countries' educational system; hence, the manner in which nanotechnology comes solely from the centers of excellence only can orient it towards the foreign market and competitiveness, thereby losing the vision of the role that this technology could have to relieve basic problems of the population in general.

The third issue is consumer confidence. In order for a new product to enter the market successfully, the consumer must know what it is, its advantages, and importantly, its risks. In Latin America there have been very few researches on the potential health and environmental risks of nanotechnology. And the financing for this type of research is insignificant or nonexistent. Nonetheless, there are hundreds of books and scientific articles, a worldwide database, which discuss the risk of these new technologies. The policy has been, until the present, to hide this type of information in order to not hinder commerce. But hiding this critical information does not stop the problem, nor win the support of the consumer. A policy of transparency is necessary. It is essential to finance independent research on the risks (without the participation of private companies!). Private corporations, and some governments, have issued so-called Voluntary Codes of Conduct to gain the confidence of the consumer. But the public needs to consume based on certainty and official regulation, not based on declarations of those who produce the nanotechnology products themselves. A policy of more public diffusion and participation is necessary, especially within organized groups such as unions and non-governmental organizations.

In summary, nanotechnology policies have neither considered the participation of civil society organizations and unions in the elaboration of national policies and priorities, nor the necessity of qualifying the work force as critical aspects of this technological change. This stymies the working class from being a potential force of support. The potential health and environmental risks of nanotechnologies have also been denied, which ignores the consumer's fundamental role in development. Latin American and Caribbean countries are slowly taking on these questions, but as a result of the international pressure and drop by drop.

4. Risks of nanotechnology for health and the environment

All new forms of technology pose risks. Nanotechnology is no exception. The size of nanoparticles raises suspicion of the possible risks posed to human health considering that particles of a similar size that are sub products of productive processes, such as the smoke of motor combustion or asbestos, are known to cause cancer. Ten years ago, whenever non-governmental organizations or other social sectors questioned politicians or scientists about the risks of nanotechnology, the response was that they were unknown – that it was too soon to evaluate the risks, or simply that there were no risks. This was the general response throughout the first decade of the 21st century. The scientific consensus that the risks were unknown did not impede the introduction of nanotechnology products into the market; on the contrary, all policies were oriented towards accelerating its penetration into the market, in stark contradiction to the precautionary plans recommended by social organizations.



Winners of the symbol for Nanohazard, called by the ETC Group during the Global Social Forum in Nairobi, 2007

More than ten years after the National Initiative of Nanotechnology in the United States, and other initiatives in many other countries of the developed world, it can no longer be claimed that the risks are unknown, or it is too soon to evaluate, or that there are no risks. There exist various databases that classify scientific articles about the health and environmental risks of nanoparticles commonly used in nano technological processes. Admittedly, the majority of these researches were not conducted on human beings, but in vitro and on animals. However, the results still indicate that the precautionary principle needs to be implemented into regulatory measures. The precautionary principle states, "when an activity threatens human health or the environment, methods of precaution ought to be taken, even if the cause-effect relationship is not completely established scientifically."

What actually happens nowadays is in direct contradiction of this principle. The general trend is that products go on the market, and later, if risks are identified, perhaps removed from the market. The precautionary principle demands in this case that scientific studies be conducted first, since there is sufficient evidence to presume that various nano technological products imply health and environmental risks. The precautionary principle implies major expenses. But, wouldn't it be even more costly to repeat the experience of asbestos, with a market presence of more than one hundred years, despite knowledge since the mid-1930s that linked it to cancer? In Latin America and the Caribbean only a half a dozen countries have prohibited asbestos. According to the World Health Organization, nearly 90,000 workers died from cancer due to asbestos exposure each year. One also must consider the cancer cases due to passive exposure, such those afflicting inhabitants of homes with asbestos roofs. Carbon nanotubes are actually similar to particles of asbestos and behave in a very similar manner in the lungs. There are various researches on the risks of carbon nanotubes, one of the most versatile and most used products of nanotechnology. Another problematic question of nanotechnology, one recognized by scientific experts, is whether the safety methods used for the production of chemical substances are also valid for nanomaterial.

The International Council on Nanotechnology, an institution from Rice University, researches on the risks of nanomaterial, and has a database on the topic. From 2000 to 2010 this database registered a sustained increase in published articles in scientific journals dedicated to analyzing the potential risk nanomaterial could have on human health and the environment. In 2010 there were 563[1] scientific articles

[1] Elaborated from the ICON database (http://icon.rice.edu/) combining the following nanomaterials: [Carbon or Metal or Organic/Polymers or Semiconductor or Oxide or Multiple or Other/Unspecified] + Hazard for the following groups [Industrial/Research Worker or Consumers or General Population or Ecosystem or Other/Unspecified] + Peer Reviewed Journal Article + Engineered

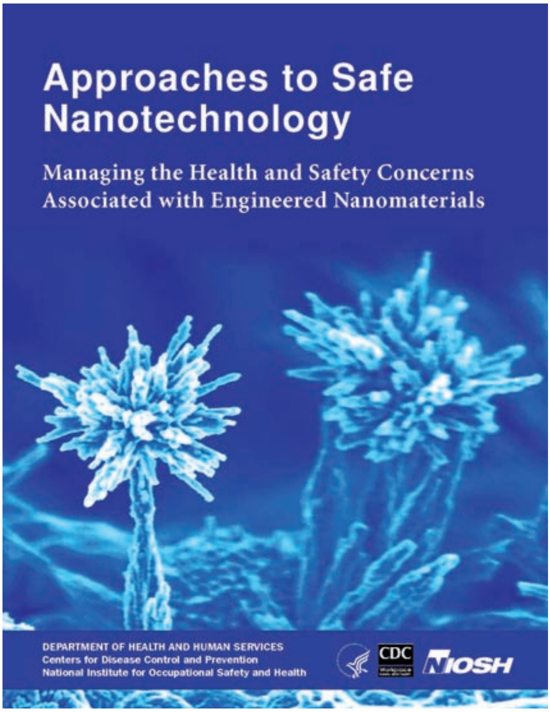
published on the topic. The Nanotechnology Citizen Engagement Organization (NanoCeo) elaborated a database that classifies scientific articles on the risks of nanomaterial according to the type of nano-engineered material. Between the year 2000 and the end 2010 there were 176 articles on the risks of carbon nanotubes, 190 on the risks of silver nanoparticles, and 70 on the risks of nanoparticles of titanium dioxide, among other materials.[2] This accumulation of scientific knowledge no longer permits ignoring the reasonable suspicion that various nanoparticles are toxic to health and the environment.

The overall picture turns out to be very complicated, as there are nanoparticles of very different materials, combined in distinctive forms that expose themselves to living beings in a multiplicity of ways.

The discussion about nanotechnology in the media is basically optimistic. It touts of the possibility of attaching carbon nanotubes or buckyballs to cancinogenic cells in order to kill them off without side effects, transforming cancer into a treatable illness. However, Polland and collaborators, in 2008, discovered that in the abdominal cavity of mice carbon nanotubes are recognized as if they were fibers of asbestos, hence carcinogenic. In addition, Takagi and collaborators (2008) demonstrated that carbon nanotubes produce mesothelioma in mice. Even single wall carbon nanotubes, which are much more perfect, homogenous and pure than multi wall, have demonstrated their toxicity, and Chou and collaborators showed that they produced granulomas in the lungs of the mice investigated. Even protozoa that ingested carbon nanotubes died, became paralyzed, or at least more limited in their mobility, as Ghanfari and collaborators wrote in 2008. In 2009, Nygaard and collaborators published an article which demonstrated that as the size of carbon nanotubes, nanoparticles of black carbon and other materials decrease, allergic responses increase.

To these criticisms scientists respond that nanotubes are embedded in a matrix and are tied together, not isolated particles as they are in the toxicology studies, and the fact that they are tied together radically reduces the possibility that the particles could, for example, be inhaled. Although this is true, the reality is that nanotubes are used in many different industries. Cellular batteries can contain carbon nanotubes,

[2] Database of NanoCeo (Nanotechnology Citizen Engagement Organization – www.nanoceo.net/nanorisks).



as does some sports clothing. In such cases, one never knows when the life cycle of these products will end, and what will happen when they are turned into waste. Trash burning of textiles, batteries and other nanotechnology products can separate carbon nanotubes from their matrix - nanotubes do not break down below 850 degrees, so they survive any regular burning – and then can be inhaled or introduced into the food chain. In addition, carbon nanotubes can also wear off of clothing when the garment in which they are embedded is worn down, and this can imply direct contact with human skin and hence penetration. These possibilities were analyzed by Kohler and collaborators in 2008. According to Roberts and colleagues in 2007, water fleas that consumed carbon nanotubes encompassed in lipid had blocked digestive tracts and died. Lerouеil and collaborators demonstrated, in 2008, that various organic and inorganic nanoparticles produced imbalances. Titanium dioxide, key ingredient for the cosmetics industry next to zinc oxide, has damaged algae and even caused fish to become completely disoriented, according to the research reported by Federici and collaborators in 2007. Also, Takeda and collaborators demonstrated, in 2009, that titanium dioxide can even produce hereditary damage: the nanoparticles that the mother rat receives freely transfer across the maternal-fetal barrier, enter into the embryos and causes a reduction in sperm production in the male embryos. Also, in terms of genetic effects, Yang and collaborators, in 2009, asserted that nanoparticles of silver can interact with genetic material, modifying it and affecting its replication. In addition, Tinkle and collaborators, in 2003, wrote of how particles of 1000 nanometers of zinc and titanium dioxide, sizes much greater than the nanoparticles that appear in cosmetics today, directly penetrate human skin. Also in 2009, Sharma and collaborators reported that nanoparticles of zinc oxide, commonly used as a sunblock in cosmetics, produce, in lower concentrations than is typically used in cosmetics, damage to the DNA of human epidemic cells that were tested and also generation of stress oxidizers that are responsible for the production of free radicals responsible for causing skin cancer. Furthermore, Deng and collaborators affirmed that nanoparticles of zinc oxide have damaged and killed brain stem cells of lab mice. It is known that nanoparticles can cross cell barriers, traveling by the blood or lymphatic system, and even enter into the brain by olfactory nerves, as Oberdorster and colleagues demonstrated in 2005.

FOOD INGREDIENTS | NUTRACEUTICAL INGREDIENTS

NutraLease™

www.nutralease.com

PLT is the exclusive agent for the exciting NutraLease™ nano-encapsulation technology for the functional food marketplace, NutraLease™ is a delivery system for food and beverage applications.

www.pithomas.com/PLTbrando/NutraLease2.htm Visited January 2007

The problem of toxicity is not limited to human health, but also affects the environment, where the accumulation of nanoparticles can create havoc in ecosystems and in the food chain, which obligates an analysis of the life cycle of nanoparticles.

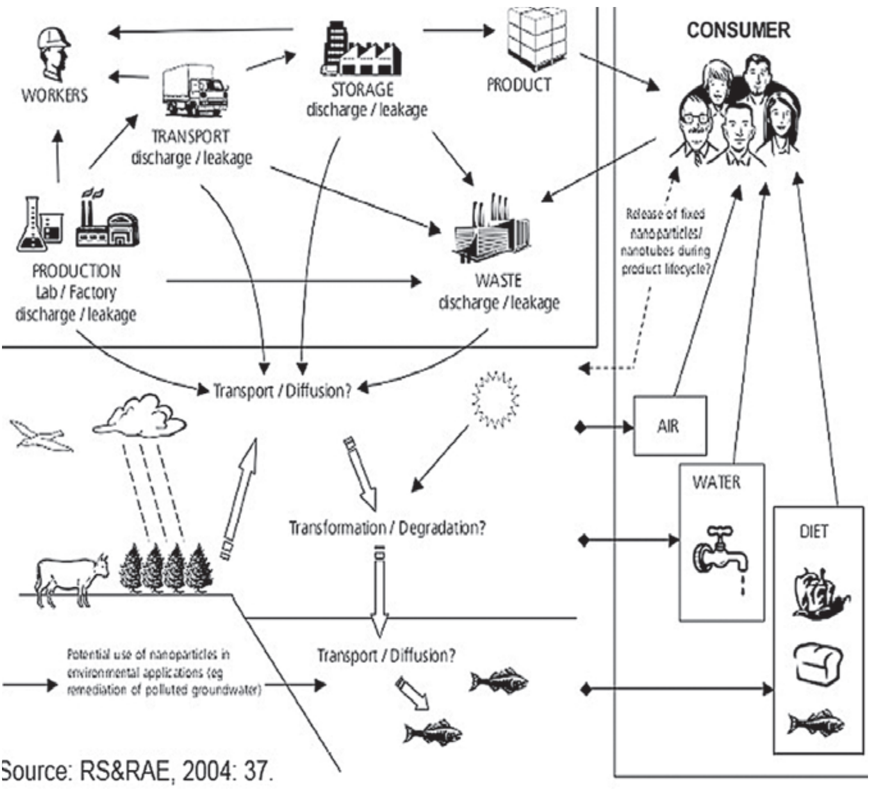
Some argue that the toxicity demonstrated in vitro does not occur once the same nanoparticles are incorporated into final products for consumption. For this reason, it is important to distinguish nanoparticles that are dissolved in liquids, solids, and those which are integrated into their original matrix. The National Institute for Occupational Safety and Health of the United States (NIOSH) recognizes that the worst risk of nanoparticles are in powders of solid states, dispersed or condensed into powders, for example, as they are used in cosmetics. The second level of risk is nanoparticles suspended in liquids, like nanotubes in water. The third riskiest are those integrated into networks, such as thin films. Those that pose the least risk are those incorporated into nanostructures, like in metal alloys.

The scale of risk is also tied to the different manners in which nanoparticles can enter the organism and interact with it. In general terms, the principal methods of ingestion of nanoparticles are inhalation, ingestion, and penetration through the skin. They also can be ingested by injection or by the dissolution of nanoparticles used in implants when considering medical products with nanotechnology. It is important to consider the possibility of accidents, like fires or explosions, which can also expose unprotected individuals to the risk of nanoparticles.

5. Exposure of workers and consumers to engineered nanoparticles

The 2004 report of the Royal Society on Nanosciences and Nanotechnologies voiced concern for the potential health and environmental risks of engineered nanoparticles, and included the following design which illustrates human and environmental potential paths of exposure to nanoparticles:

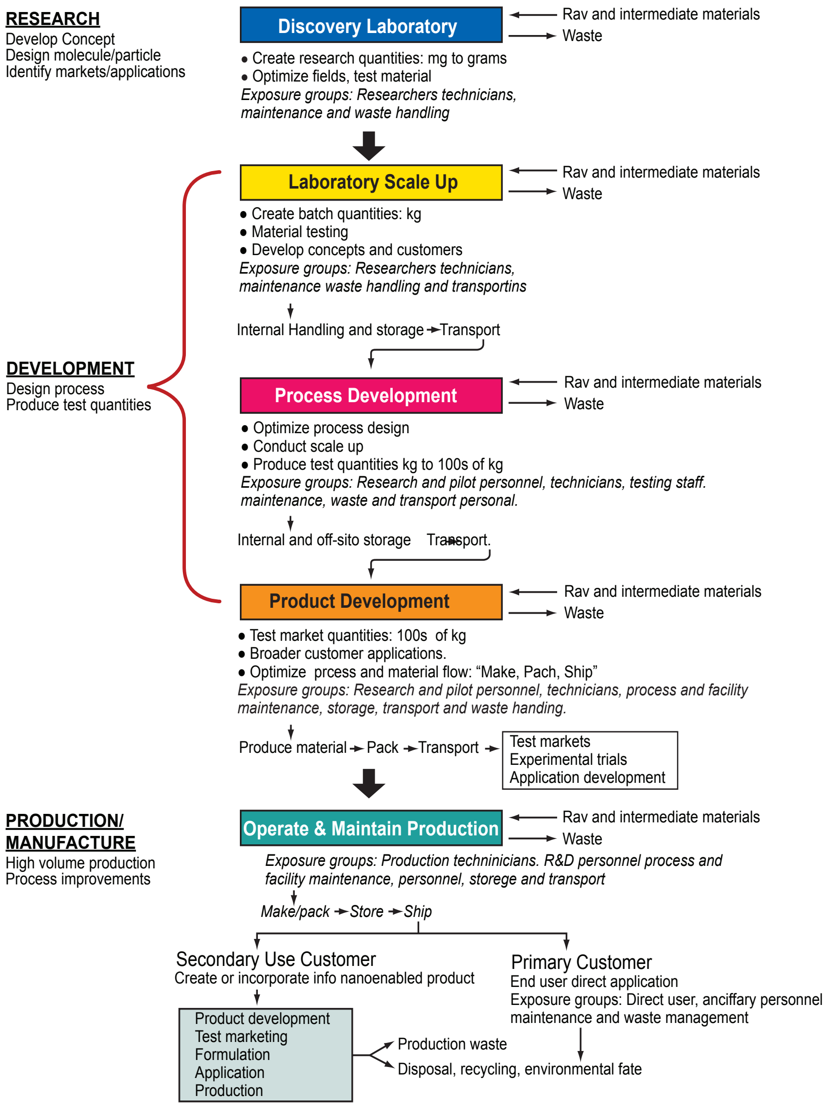
Main routes of exposure to nanoparticles



Some possible exposure routes for nanoparticles and nanotubes based on current and potential future applications. Very little is known about exposure routes for nanoparticles and nanotubes and thes figure should be considered with this in mind (Adapted from National Institute for Resources and Environment, Japan http://www.nire.go.jp/eco_tec_e/hyouka_e.htm).

Schulte, researcher from NIOSH and collaborators, elaborated the following diagram of the risks of exposure to nanoparticles in the workplace.

Workplaces with potential for occupational exposure to engineered nanoparticles.



Workplaces with potential for occupational exposure to engineered nanomaterials. The figure illustrates the life cycle of nanomaterials from laboratory research development through product development, use, and disposal. Each step of the life cycle represents opportunities for potential worker exposure to nanomaterials.

The diagram focuses on the risk of exposure for laborers. For this reason, the environmental and consumer risks do not appear, but following through on each state logically leads to supposing those risks. For example, all the stages demonstrate that residues exist, as shown on the far right of the diagram, and these can affect the environment if the mechanisms to prevent them are inadequate.

The diagram also shows that within every stage people are subjected to various stages of exposure and risk depending on their occupation. In the stage of research, for example, not only are the researchers and technicians themselves exposed to risk, but also the maintenance and waste handling and transporters of the laboratories.

The second stage that the diagram illustrates is the large-scale development or production of raw nanomaterials. Here the subjects directly involved are the researchers, technicians, pilot personnel, testing staff, facility maintenance and those responsible for storing and transporting the nanomaterial to the industries that require it, as well as waste handling workers.

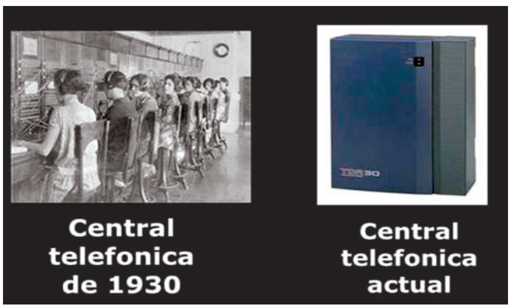
Next follows the production stage and manufacturing of the intermediate and final product. Here the nanoparticles are incorporated into various industrial processes, with the final objective of endowing the product a commercial or utilitarian advantage. In addition to the subjects of risk previously listed are the R&D personnel involved.
The final consumer is subjected to a different degree of risk depending of the type of product and the form of exposure.

It must remain clear that the connection between exposure to nanoparticles and health risks is intervene by multiple factors, not just the risks intrinsic to the nanomaterial itself and the degree of exposure but also, importantly, the conditions of infrastructure, the monitoring equipment, protective instruments and clothing and other preventive methods.

Workers are first exposed to the potential risks of nanoparticles. Workers who manufacture nanoparticles or labor in the textile industry or other industrial sectors that incorporate nanoparticles into their fabrics or final products are exposed to free nanoparticles that are not linked in a physical or chemical way to the final product, and hence are at a greater degree of exposure than the final consumer. However, there are cases where the final consumer can be directly exposed as well; for example, with cosmetics usage when the nanoparticles can easily be absorbed by the human body. Another example is agricultural workers who handle pesticides and other agrochemicals, where the least carelessness can imply direct contact with nanoparticles via skin absorption or inhalation of vapors.

6. Implications of nanotechnologies for employment

We must mention that the theme of employment has not yet entered into the research agendas on the social implications of nanotechnology. Even though currently there are relatively few products, industries and workers related to nanotechnology, it is clear that this is high tech and sophisticated, which deepens the trend to minimize and automate the processes of production and services, a trend which began with the microelectronic revolution and which resulted in a dramatic reduction of employment in many sectors of the economy.



Nanotechnology products that are already on the market allow us to identify three common characteristics: the products have multiple functions that previously required more than one product (multifunctional); the products remain useful longer; and, the products use fewer raw materials. Some products combine two or three of these characteristics. Taken together, this signifies that manufacturing these products will lead to decreased demand for workers. In addition, these innovations reduce the demand for traditional products that compete with them.

The food industry illustrates the multifunctional aspect of nanotechnology well. Food corporations add vitamins, collagen, photo extracts and other nano-encapsulated substances to food and drinks. George Weston Foods adds the fatty acid Omega-3 to one of the most popular brands of white bread in Australia; the Qinhuangdao Ialji

Ring Nano-Product Co. Ltd., enriches its nano-tea with selenium. These are examples of nutracetical products that simultaneously have aesthetic, nutritional and medicinal functions; functions that were previously delivered with different products. CHT Brazil Chemical (Brasil Quimica) produces Nouwell E, a textile fiber that has cosmetic functions, transferring vitamin E to the skin and releasing perfume. The shirt Life Shirt, for example, monitors the respiratory, cardiac activity, and changes in posture and transfers this information to a portable computer.

These multifunctional products demonstrate a trend of merging of productive branches, and signify a reconfiguration of current industrial sectors and workforce distribution. It is likely that there will be fewer jobs available and a demand for less specialized employees. The aggregating of functions also brings the centralization of transportation, distribution, marketing and commercialization, which possibly results in fewer employees in these fields as well.

Many nanotechnology products are used to make goods more durable on the market. EMBRAPA developed digestible films with nanoparticles to cover macadamia nuts to block the entrance of oxygen and water vapor, making the nut last longer. Miller Brewing uses bottles from a plastic that incorporates nanoparticles of ceramics to establish a barrier blocking molecules of carbon dioxide from escaping and molecules of oxygen from entering the bottle, keeping the beer fresh and giving it a shelf-life of up to 6 months. Scientists from companies like Kraft, Bayer and Kodak are developing a variety of packaging materials that absorb oxygen, detect pathogens in foods, and alerts the consumer when the food is spoiled.

By using nanotechnology, companies can produce products that have a longer storage life in supermarkets. This will help companies because it will reduce the amount of products wasted. However, the economic activities revolving around transportation, storage, quality assurance, shelf maintenance and other functions will be reduced. With this increase efficiency, fewer workers will be required. What sort of public policy are governments considering to remedy this loss in employment? None thus far.

Other products exploit the advantages of new materials produced by nanotechnology to substitute for other raw materials. Adidas uses carbon nanotubes to produce running shoes with lighter weight traction systems. Easton Sport uses carbon nanotubes to produce bicycle frames. Elko's Invisicion uses the conductive properties of carbon nanotubes in the manufacturing of transparent covers for flat screen (TVs) with OLED light and for solar cellular phones. Nanotubes also could replace the copper wires that transmit electricity, modifying all global commerce. Braskem produces a resin of polypropylene with added nanoparticles of ceramic that replaces metals and other plastics in the automobile and domestic appliances industries.

These changes in the materials used alter the distribution of the workforce between different sectors. Given that the exploitation of raw materials is tied to geographic characteristics, on a national and international level, the changes in demand will bring about a new regional and international distribution of employment opportunities.

7. SAICM and the recommendation for countries of Latin America and the Caribbean

SAICM is a voluntary agreement, approved in Dubai, in the United Arab Emirates in February 2006 at the International Conference on Chemicals Management. This strategic approach is composed of a High Political Declaration, a Global Political Strategy and a World Plan of Action, which all together constitute a regulatory framework that pursues the following overall objective: to *achieve the sound management of chemicals throughout their life-cycle so that, by 2020, chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment.* SAICM is administered by the United Nations Environmental Program and with the World Health Organization, run the Secretary of this agreement.

SAICM is the only multilateral international space where the development of chemical products over their entire life cycle, including the impact on occupational health, public and environmental health, is discussed. SAICM includes most industrialized countries, countries in economic transition, and developing countries, as well civil society groups with public and industrial interests and reaches agreements via voluntary consensus. Although it is not a legally binding instrument, each member country has the responsibility to develop a national plan to apply the specific activities based in the Global Plan of Action.

The Second International Conference on Chemical Management (ICCM) was held in Geneva in 2009, where governments and NGOs recognized and decided (Resolution 11-4-E) that nanotechnology and engineered nanomaterial are a new emerging policy issue that should be regulated in the framework of SAICM. Highlighted in the resolution is the call to grant assistance to developing countries and transition economies so that they can increase their capacity for nanotechnology and engineered nanomaterials and maximize its benefits while minimizing its risks. In addition, it asks that government and industry maintain a dialogue with the workers and their representatives during the creation and implementation of regulations to protect human health and the environment, and maintain a more general public dialogue with all interested sectors.

Within this framework, regional conferences on nanotechnology and nanomaterial in Africa, Latin America, and Asia were organized by the United Nations Institute for Training and Research and the Organization for Economic Co-operation and Development (OECD). In Latin America and the Caribbean, such workshops were given in coordination with the regional consultation meetings on the progression on the application of SAICM held in Kingston, Jamaica, from March 8-12th 2010 and in Panama City from June 2nd to 3rd 2011. In these regional meetings series of recommendations regarding the policy towards nanotechnologies and engineered nanomaterial were approved, and at the Panama meeting possible measures of cooperation and specific actions that need to be incorporated within the Plan of Global Action of SAICM were discussed, using the proposal of the Swiss government as a foundation.

In what follows is a general summary of the overarching themes and key proposals that were included in the resolutions of regional meetings held in Latin America and the Caribbean (GRULAC in Spanish) along with some additional commentaries.

- To apply the **precautionary approach** during the complete life cycle of engineered nanomaterial. The GRULAC resolution, adopted in Panama, recommended the *"development of a regulatory framework based on a focus of precaution in relation to public health, occupational health and the environment, throughout the life cycle of engineered nanomaterials"*. One must remember that applying a precautionary approach forms a part of Article 15 of the Declaration of the United Nations Conference on Environment and Development in Rio de Janeiro 1992 signed by all countries. The application of the **precautionary principle** as the *general principle in risk management* was also a recommendation unanimously approved by governments, industry and other non-governmental groups in the declaration on nanomaterial and nanotechnology from the International Forum on Chemical Safety (IFCS) held in Darkar, Senegal in September 2008; unfortunately, in the last conference ICCM2, held in Geneva in 2009, the pressure of developed countries and industry succeeded in preventing this principle from being invoked. Regardless, this principle should be included in the design of national policies on nanotechnology.

- **Transparency and the right of consumers and workers to information.** Demand that producers provide adequate information on the contents of engineered nanomaterial, so that authorities and consumers know the potential risks through the registration and labeling of products (GRULAC Kingston resolution "b"; GRULAC Panamá). The mandatory labeling of products with nanomaterials allows consumers to freely choose what do or not consume, in the same way that the information producers provide to unions is a right established in Collective Bargaining Convention 154 by the International Labor Organization, signed by many Latin American and Caribbean countries and included in the labor codes of many countries. Another recommendation was the necessity of a national public registry of engineered nanomaterials produced and imported, with its characteristics and volumes produced. The countries of GRULAC supported the proposal of the Swiss Government to develop criteria to incorporate safety of nanomaterials into the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) as a new activity of the Global Plan of SAICM.
- The application of the **extended producer responsibility** throughout the entire life cycle of engineered nanomaterials. This implies that the producer is responsible not only during the production phase but also during transportation and even when the engineered nanomaterials are converted into waste, and does not transfer the responsibility to the consumer and the government, as it does currently. This proposal is included in the draft of the Global Plan of Action of the Swiss Government and was supported by GRULAC in Panama.
- Strengthen the capacity to effectively evaluate the potential risks of engineered nanomaterials, especially for vulnerable groups, such as children, pregnant women, and elderly individuals (GRULAC recommendation, Panama). It must be added that these evaluations must be done within the **establishment of national and regional institutions so that they are evaluated independently** from industry.
- Incorporate **multisectorial participation, particularly of workers and of the health** sector in the elaboration of policies, programs and

training materials on occupational health and environmental safety of nanotechnologies and engineered nanomaterials (GRULAC resolutions "e" and "g" of Kingston and resolution of Panama). Although it is not mentioned in GRULAC's resolutions, it should be added that the participation of workers, consumers and other groups of public interest is essential to elaborating policies of science and technology to assure that nanotechnology policy is oriented towards satisfying social needs, training the workforce, and providing remedial measures for resulting technological unemployment.

- Establish **regulations of foreign trade**. The development of customs codes specific to engineered nanomaterial. Demand that residual waste that contains engineered nanomaterial should not be transferred to counties who do not have the capacity to appropriately dispose of them, and propose that it be recognized that countries have the right to accept or reject the importation and use of engineered nanomaterial and products that contain it, with the purpose of minimizing risk. Proposes the necessity to regulate the transportation of engineered nanomaterials on the basis of safety criteria (recommendations of GRULAC in Panama).

The chemical industry and some industrialized countries, principally the United States, Canada, Japan and Australia opposed the majority of these proposals during the working group of the ICCM that meet from the 15th to 18th of November 2011 in Belgrade, Serbia. For this reason, it is important that civil society organizations demand that governments in Latin America and the Caribbean consult and represent general interests above commercial interests in the final negotiations on nanotechnology and related actions to include in the Global Plan of Action of SAICM, which should be approved in the third conference of the ICCM, to be held from the 17th to 21st of September 2012 in the headquarters of PNUMA in Nairobi, Kenya. In this way, the countries of Latin America and the Caribbean can renew these demands together with other affiliated regional groups, such as the African Group, to accomplish the general strategic objective of SAICM to significantly reduce the risks in the production and use of engineered nanomaterials and increase the response to the real social necessities of Latin American and Caribbean countries.

Bibliography

Adidas (2008). Olympic hopeful Jeremy Wariner to compete in revolutionary track spike at U.S. Olympic trials. Press Release, June 28. http://www.press.adidas.com/en/DesktopDefault.aspx/tabid-11/16_read-9399/

Assis, Odilio B.G. & Forato, Lucimara A. (2009). Embrapa Desenvolve Coberturas Comestíveis para Minimizar Rancificação de Nozes Macadamia, *Toda Fruta*, Aug. 13. http://www.todafruta.com.br/todafruta/mostra_conteudo.asp?conteudo=19733

Basson, Astrid (2003). *Ready to Wear –Innovative Textiles with Medical Applications*, *Frost & Sullivan Newsletter,* July 25. http://www.frost.com/prod/servlet/market-insight-top.pag?docid=4950390.

Behr Process Corp., (s/f). Our Products. http://www.behr.com/Behr/home#

BMC Trading AG (s/f). Bikes: Frame Design. http://www.bmc-racing.com/en/us/bikes/technology/frame-design/

Choi, JY ; Ramachandran, G ; Kandlikar, M. (2009). The impact of toxicity testing costs on nanomaterial regulations. *Environmental Science and Technology* 20 Feb.

Chou, Cheng-Chung , Hsiang-Yun Hsiao, Qi-Sheng Hong, Chun-Houh Chen, Ya-Wen Peng, Huei-Wen Chen, and Pan-Chyr Yang (2008). Single-Walled Carbon Nanotubes Can Induce Pulmonary Injury in Mouse Model. *Nano Lett.,* 8(2), 437-445.

CONACYT (Consejo Nacional De Ciencia Y Tecnología) (México). *Programa especial de ciencia y tecnología 2001-2006.* [See also Vol. II]. México D.F: Conacyt, 2002.

Deng, Xiaoyong, Luan, Oixia; Chen, Wenting; Wang, Yanli; Wu, Minghong; Zhang, Haijiao; y Zheng Jiao (2009). Nanosized zinc oxide particles induce neural stem cell apoptosis. *Nanotechnology,* 20, 115101**.**

DHHS (Department Of Health And Human Services). Centers for Disease Control and Prevention. National Institute for Occupational Safety and Health. (2009). *Approaches to Safe Nanotechnology.* DHHS (NIOSH).

Elko's (s/f). Why Choose Invisicon® Transparent Conductive Films for your Display System? http://www.eikos.com/advantages.html

ETC Group (2003). Size Matters! The Case for a Global Moratorium. *Occasional Paper Series*, 7(1), April.

ETC group (2003). *The Big Down: Atomtech – Technologies Converging at the Nano-Scale.* http://www.etcgroup.org/upload/publication/171/01/thebigdown.pdf

ETC Group (2005). *Report Prepared for the South Centre - The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries.* http://www.etcgroup.org/en/node/45

ETUC (2008). ETUC resolution on nanotechnology and nanomateriales. http://www.etuc.org/IMG/pdf_ETUC_resolution_on_nano_-_EN_-_25_June_08.pdf

EurActive (2009). 'No data, no market' for nanotechnologies, MEPs say. News. Abril 02, 2009. http://www.euractiv.com/en/science/data-market-nanotechnologies-meps/article-180893

European Parliament (2009). Novel foods, MEPs set new rules. http://www.europarl.europa.eu/news/expert/infopress_page/067-52498-082-03-13-911-20090324IPR52497-23-03-2009-2009-false/default_en.htm

Federici, Gillian; Shaw, Benjamin J.; & Handy, Richard D. (2007). Toxicity of titanium dioxide nanoparticles to rainbow trout (*Oncorhynchus mykiss*): Gill injury, oxidative stress, and other physiological effects. *Aquatic Toxicology*, 84, 4, 415-430.

FoE – A. (Friends of Earth – Australia). (2006). *Nanomaterials, sunscreens and cosmetics: small ingredients big risks*. FoE. http://nano.foe.org.au/node/125.

Foladori, Guillermo; Záyago, Edgar; Invernizzi, Noela. (2012). *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina.* México D.F.: Miguel Angel Porrúa.

Garber, Cathy (2006). Nanotechnology Food Coming to a Fridge Near You. *NanoWerk*, Dec. 28. http://www.nanowerk.com/spotlight/spotid=1360.php.

Gatchair, S. (2010). Potential Implications for Equity in the Nanotechnology Workforce in the US. En: Cozzens, S. and Wetmore, J. *Yearbook of Nanotechnology and Society,* Vol. III: Nanotechnology, Equity and Equality. New York: Springer.

Ghafari, P; Christine H. St-Denis, Mary E. Power, Xu Jin, Veronica Tsou, Himadri S. Mandal, Niels C. Bols and Xiaowu (Shirley) Tang (2008). Impact of carbon nanotubes on the ingestion and digestion of bacteria by ciliated protozoa. *Nature Nanotechnology* advance online publication 11 May 2008.

Herbold, Frits V. (2005). *Nanotecnologia na Industria Têxtil: Onde Estamos e para Onde Vamos*. Presentação em *Nanotec 2005*. http://www.abtt.org.br/artigos/confrits.pdf

Howard, Vyvyan (2004). [Conference] *Nanotex 2004*, Daresbury Laboratories. Warrington, England. En: *SmallTimes* (2004 January 14). British scientist: Nanoparticles might move from mom to fetus http://www.smalltimes.com/Articles/Article_Display.cfm?ARTICLE_ID=269201&p=109.

Incrementha PD&I (2007). Incrementha Lança Primeiro Fármaco Brasileiro Desenvolvido com Nanotecnologia. Press Release, April, 25, 2007. http://www.tramaweb.com.br/cliente_ver.aspx?ClienteID=75&NoticiaID=4029

Invernizzi, N. ; Foladori, G. (2010). Nanotechnology implications for labor. Nanotechnology Law & Business Journal, 7, 1: 68-78

IPEN (Red Internacional de Eliminación de Contaminantes Orgánicos Persistentes). Breves Antecedentes sobre nanotecnología y nanomateriales. 2011. http://www.ipen.org/ipenweb/work/nano.html

Kaluza, Simon; Kleine Balderhaar, Judith; Orthen, Bruno; Honnert, Bertrand; Jankowska, Pietrowski, Piotr; Elzbieta; Rosell, María Gracia; Tanarro, Celia, Tejedor, José & Zugasti, Agurtzane. (2009). *Workplace exposure to nanoparticles*. European Risk Observatory Report. Literature Review. The European Agency for Safety and Health at Work.

Köhler, A., Som, C., Helland, A., Gottschalk, F. (2008). Studying the potential release of carbon nanotubes throughout the application life cycle. *Journal of Cleaner Production.* 16 (8-9):927-937.

Kulinowski, Kristen. (2009). Temptation, Temptation, Temptation: Why Easy Answers About Nanomaterial Risk are Probably Wrong. *AzoNanotechnology*.

Leroueil, Pascale R.; Berry, Stephanie A.; Duthie, Kristen; Han, Gang; Rotello, Vincent M.; McNerny, Daniel Q.; Baker, James R. Jr.; Orr, Bradford G.; & Banaszak Holl, Mark M. (2008). Wide Varieties of Cationic Nanoparticles Induce Defects in Supported Lipid Bilayers. *Nano Lett.,* January.

Lyons, Kristen (2006). Nanotech Food Futures? *Chain Reaction*, 97, 38-39. http://www.foeeurope.org/publications/2006/Size_matters_foe_australia.pdf

Maynard, Andrew D. (2006). Nanotechnology: Assessing the risks. *NanoToday*, May. 22-33.

Maynard, Andrew D.; Aitken, Robert J.; Butz, Tilman; Colvin, Vicki; Donaldson, Ken; Oberdörster, Günter; Philbert, Martin A.; Ryan, John; Seaton, Anthony; Stone, Vicki; Tinkle, Sally S.; Tran, Lang; Walker Nigel J. & Warheit, David B. (2006 nov). Safe handling of nanotechnology. *Nature*, 444, 16.

Meridian Institute. (2007). *Nanotechnology, Commodities and Development.* Background Paper for the International Workshop on Nanotechnology, Commodities and Development, Rio de Janeiro, May 29-31. http://www.merid.org/nano/commoditiesworkshop/files/Comm_Dev_and_Nano_FINAL.pdf

Miller, Georgia & Rye, Senjen (2007). Del laboratorio a la cadena alimenticia. La nanotecnología en los alimentos y la agricultura. En: Foladori, G & Invernizzi, N. *Nanotecnologías en la Alimentación y Agricultura*. UdeLAR-Extensión, UITA, ReLANS. Montevideo.

Miller, Georgia (2008). Mounting evidence that carbon nanotubes may be the new asbestos. Friends of the Earth Australia. http://nano.foe.org.au/sites/default/files/Mounting%20evidence%20that%20carbon%20nanotubes%20may%20be%20the%20new%20asbestos%20-%20August%202008_0.pdf

Nanoaction (2007). Principios para la supervision de las nanotecnologías y nanomateriales. NanoAction. A Project of the International Center for Technology Assessment. 2007. www.nanoaction.org/nanoaction/page.cfm?id=223

Nanoceo (Nanotechnology Citizen Engagement Organization). Database. http://www.nanoceo.net/nanorisks

Nygaard, Unni; Hansen, Jitka S; Samuelsen, Mari; Alberg, Torunn; Marioara, Calin D.; y Martinus Løvik (2009). Single-Walled and Multi-Walled Carbon Nanotubes Promote Allergic Immune Responses in Mice. *Toxicological Sciences,* 109(1):113-123.

Oberdorster, G; Oberdorster, E; and, Oberdorster, J. (2005). Nanotoxicology: An emerging discipline evolving from studies of ultrafine particles. *Environ Health Perspect,* 113 (7): 823-839.

OICTI (Observatorio Iberoamericano De Ciencia Tecnología E Innovación). (2009). *La Nanotecnología en Iberoamérica. Situación Actual y Tendencias.* Observatorio Iberoamericano de Ciencia, Tecnología e Innovación Del Centro de Altos Estudios Universitarios de la Organización de Estados Iberoamericanos. http://www.oei.es/observatoriocts/index.php?option=com_content&view=article&id=12&Itemid=3

Oliveira, Marcos de (2007 Feb.). Unbreakable: The Company Braskem is Producing Resins Using Nanotechnology that Result in Plastics that are More Resistant, *Pesquisa Fapesp Online.* http://www.revistapesquisa.fapesp.br/?art=1899&bd=1&pg=1&lg=en

Poland, C.A.; Duffin, R.; Kinloch, I; Mayonard, A.; Wallace, W.A.H.; Seaton, A.; Stone, V.; Brown, S.; MacNee, W.; Donaldson, K. (2008). Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study. *Nature Nanotechnology* advance online publication May 18, 2008.

Qinghuangdao Ialji Ring Nano-Product Co. Ltd. (s/f). About Nanotea. http://web.archive.org/web/20071217224829/http://www.369.com.cn/En/nanotea.htm

Roberts, Aarón P; Andrew S. Mount, Brandon Seda, Justin Souther, Rui Qiao, Sijie Lin, Pu Chun Ke, Apparao M. Rao, and Stephen J. Klaine (2007). In vivo Biomodification of Lipid-Coated Carbon Nanotubes by *Daphnia magna*, *Environ. Sci. Technol*, *41* (8), 3025–3029.

Royal Commission on Environmental Pollution (2008 noviembre). *Novel Materials in the Environment: The case of nanotechnology.* London: TSO (The Stationery Office). http://www.rcep.org.uk/novel%20materials/Novel%20Materials%20report.pdf

RS&RAE (Royal Society & Royal Academy of Engineers). (2004). *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*. http://www.nanotec.org.uk/finalReport.htm

SAICM/ICCM 2-15 (2009). *Informe de la Conferencia Internacional sobre Gestión de los Productos Químicos sobre la labor realizada en su segundo período de sesiones. Conferencia Internacional sobre Gestión de los Productos Químicos*. Segundo período de sesiones. Ginebra, 11 a 15 de mayo de 2009. http://www.saicm.org/documents/iccm/ICCM2/ICCM2%20Report/ICCM2%2015%20FINAL%20REPORT%20S.pdf

Sarma, Shilpanjali Deshpande & Chaudhury, Saswata (2009). SocioEconomic Implications of Nanotechnology Applications. *Nanotechnology Law & Business Journal***,** 6, 2: 278-310.
Schulte, Paul; et al. (2008). Occupational Risk Management of Engineered Nanoparticles. *Journal of Occupational and Environmental Hygiene,* 5, 4: 239-249.
ScienceDaily (2008 Oct. 23). Nanomaterials May Have Large Environmental Footprint. ScienceDaily. http://www.sciencedaily.com/releases/2008/10/081022135805.htm.
Sharma, V., Shukla, R.K., Saxena, N. *et al.* (2009). DNA damaging potential of zinc oxide nanoparticles in human epidermal cells. *Toxicology Letters,* 185, 3: 211-218.
Spatuzza, Alexandre (2006). *Braskem launches nanotechnology compound resin – Brazil*, *Bus. News Americas*, Nov. 7. http://www.bnamericas.com/news/oilandgas/Braskem_launches_nanotechnology_compound_resin
Takagi, A.; Hirose, A.; Nishimura, T.; Fukumori, N.; Ogata, A.; Ohashi, N.; Kitajima, S.; Kanno, J. (2008) Induction of mesothelioma in p53+/- mouse by intraperitoneal application of multi-wall carbon nanotube. *The Journal of Toxicological Sciences*, 33, 105-116.
Takeda, K; Suzuki, K; Ishihara, A; Kubo Irie, M; Fujimoto, R; Tabata, M; Oshio, S; Nihai, Y; Ihara, T; Sugamata, M. (2009). Nanoparticles transferred from pregnant mice to their offspring can damage the genital and cranial nerve systems. *Journal of Health Sciences*, 55(1), 95-102.
Tinkle SS, Antonini JM, Rich BA, Robert JR, Salmen R, DePree K, Adkins EJ (2003). Skin as a route of exposure and sensitization in chronic beryllium disease. *Environ Health Perspect* 111(9):1202–1208.
UITA (2007). The IUF Resolution. http://www.rel-uita.org/nanotecnologia/resolucion_uita_nano_eng.htm.
Visser, Rob (with co-op: G. Karlaganis, V. Murashov & S. Seo). (2011). Nanomaterials: applications, implications and safety manafement in the SAICM context. En: Report on nanotechnologies and manufactured nanomaterials. SAICM/OEWG.1/INF/8 30 sept., 2011. http://www.saicm.org/documents/OEWG/Meeting%20documents/OEWG1%20INF8_Nano%20report.pdf
Von Vroekhuizen, Pieter & Reijnders, Lucas (2011). Building Blocks for a Precautionary Approach to the Use of Nanomaterials: Positions Taken by Trade Unions and Environmental NGOs in the European Nanotechnologies Debate. *Risk Analysis*, 31, 10:1646-1657.
Wilhelm, F.H., Roth, W.T. & Sackner, M.A. (2003). The LifeShirt. An Advanced System for Ambulatory Measurement of Respiratory and Cardiac Function. *Behavior Modification* 5: 671-691.
Wong-Ekkabut, Jirasak; Svetlana Baoukina, Wannapong Triampo, I-Ming Tang, D. Peter Tieleman and Luca Monticelli (2008). Computer simulation study of fullerene translocation through lipid membranes. *Nature Nanotechnology*. Advanced on line online publication May 18, 2008.
Woodrow Wilson Internacional Center for Scholars (2009). Inventory of Consumer Products. Project on Emerging Nanotechnologies. Washington D.C.: Woodrow Wilson International Center for Scholars. http://www.nanotechproject.org/inventories/consumer/
Yang, Wenjuan; Cenchao Shen; Qiaoli Ji; Hongjie An;JinjuWang; Qingdai Liu; and Zhizhou Zhang (2009). Food storage material silver nanoparticles interfere with DNA replication fidelity and bind with DNA, *Nanotechnology*, 20.
Zhu L, Chang DW, Dai L, Hong Y. (2007). DNA damage induced by multiwalled carbon nanotubes in mouse embryonic stem cells. *Nano Lett.*, 7(12):3592-3597.