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THE ROLE OF NANOMATERIALS IN COSMETICS: NATIONAL AND INTERNATIONAL LEGISLATIVE ASPECTS

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Nanotechnology is currently one of the fastest growing scientific fields. The products of this science have become part of our everyday lives. However, to date, regulatory agencies have not yet established a single definition for nanomaterials and nanotechnology. Therefore, each country has its own definitions and legislation to control products containing nanomaterials. Being relatively new materials, there are no long-term studies showing their impact on human health and the environment. Consequently, countries control the amount of nanomaterials present in cosmetics, allowing the end consumer to choose which cosmetic to use, by choosing products with or without nanomaterials. Therefore, the primary objective of this study was to identify the most used nanomaterials in cosmetics and verify whether these formulations are in accordance with the laws in force in the United States, the European Union and Brazil, thereby determining if the cosmetics on the market are in line with the existing laws in these three economic powers. This study is unique and will contribute to furthering the discussion on existing laws pertinent to the use of nanotechnology in cosmetics.

Keywords: nanotechnology; cosmetics; legislation.

INTRODUCTION

What's Nanotechnology?

Nanotechnology is the science of manipulating atoms at the nanometer scale (1 nm = 10^{-9} m), creating a new organizational structure presenting different behaviors and properties of materials currently known.[1]

From a molecular standpoint, many nanomaterials are equal or very similar to bulk materials with higher dimensions and dependent size.[2] Thus, the fluorescence properties, melting point, chemical reactivity, electrical conductivity, magnetic permeability, change according to the particle size used in the formulation of products.[2] Moreover, reduction in particle size results in increased area/volume ratio. Thus, the nanoparticles have area surface/mass unit ratio much greater than the larger particles of the same material, which increases their reactivity,[3] being more used in cosmetic and pharmaceutical formulations, although their cytotoxicity is controversial.

Nanotechnology

Since last decade, the nanotechnology has been acquired prominence in several Science fields. This science is increasingly inserted in our daily life being used as raw in cosmetics and pharmaceutical materials, in the manufacturing of packaging.[4] As vectors for gene manipulation, diagnosis and anticancer treatment.[5] As adjuvants in the formulations of vaccines and antimicrobials, and in the development of tools and analytical instruments.[5] Moreover, because it is a multidisciplinary technology, it is applied and covers several areas such as physics, chemistry, biology and medicine.[6] However the scope of nanotechnology is vast, the great highlights are in the development of nanoelectronics.[1,5,7]

The *National Science Foundation* estimates that nanotechnology reaches an impact on the overall economy of about $ 1 trillion by 2015, requiring approximately two million workers.[8,9] The highest level of development in nanotechnology is found in the United States, Union Europe and Japan, which invested about a billion dollars a year, and represent almost half of the investments in the world. However, countries such as Russia, China, India and Brazil have made significant investments in the sector the last years. The Brazilian government invested R$ 140 million between 2001 and 2006 in research networks and projects in the areas of nanotechnology.[8-10]

Nanotechnology and the cosmetics market

The nanocosmetic aims products intended for application to the skin of the face and body, with anti-aging action and photo protection, capable of penetrating into the deep layers of the skin, potentiating the effects of the active.[9,11]

Fronza and collaborators in 2007 defined nanocosmetic as "a cosmetic formulation that carries actives or other nanostructured ingredients, which has superior properties regarding its performance if compared with conventional products".[9,12]

In the cosmetic industry, the nanoparticles are present in shampoos, conditioners, toothpastes, anti-wrinkle creams, anti-cellulite creams, whitening skin, moisturizing, face powders, aftershave lotions, deodorants, soaps, sunscreens, make up in general, perfumes and nail polishes.[9,11,12] The nanoemulsions, in turn, constitute a class of emulsions with uniform droplets of small size in the range between 20 and 500 nm, which become increasingly popular as vehicles for the controlled release and optimized dispersion of active ingredients.[9,13]

Although widely used in cosmetics, it is necessary to choose carefully the carrier of the active substance. Therefore, products, which intended to remain on the skin without absorption,

such as sunscreens, are formulated to meet this end. When a highest penetration is expected, another active should be used. The first products that promised to combat wrinkles were limited to exfoliate the most superficial epidermis layer - the stratum corneous. In the 70s, there were creams whose formulations contained substances that could penetrate the skin, but only the stratum corneous. In the

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80s, alpha-hydroxyl acids have emerged, with penetration capability slightly higher. In 1990, appeared the liposomes, tiny particles composed of fat and water that reached deeper in the skin, but not on the basal layer.[7]

The advantages of using nanocosmetics come from protecting ingredients from chemical or enzymatic degradation; control their release, especially in the case of irritant at high doses, and the prolongation of residence of cosmetic actives or drugs in the stratum corneous.[9,11,12]

The first company to introduce a nanotechnology-based cosmetic was *Lancôme,* the luxury division of *L'Oréal* in 1995, with the launch of a cream face composed of nanocapsules of pure Vitamin E, to combat skin aging.[7] From this release, other international companies started to invest in researching to develop nanocosmetics.[9,11] Meanwhile, companies such as *Christian Dior, Anna Pegova, Procter & Gamble, Revlon, Dermazone Solution, Chanel, Skinceuticals, Estee Lauder, Shiseido, Garnier, Johnsons & Johnsons* developed products in this line.[9]

In Brazil, the first company to develop and market a nanocosmetic was *O Boticário.* It produced an anti-aging cream for the area of the eyes, forehead and around the mouth, called *Nanoserum*. The nanostructure composition takes active as vitamin A, C and K and a product for whitening.[9] The technology, developed in partnership with the French laboratory *Comucel* had investment of R$ 14 million and is part of the Active line, which began to be sold in 2005.[9] In 2007, launched the *VitActive Nanopeeling* Renovator Microdermabrasion, anti-aging cosmetic with applied nanotechnology. Other items include *Lift serum Anti-aging* and Anti-aging 65+ Advanced System. *Natura*, in turn, launched in 2007 a product to body hydration, called "Brumas de Leite", with particles of approximately 150 nanometers. In the same year it also put on the market the "Refreshing Body Spray" to the male public.[9,11]

Therefore, the cosmetic industry uses nanotechnology due to several advantages of its implementation, especially regarding to higher penetration capacity of actives in skin layers. However, only in a near future, with a larger and more effective development of this technology, it will be more clearly observed its real benefits and the safety of products offered with this appeal. The possible risks in applying nanoparticles include possible toxicity and absence of biocompatibility of the materials used.[9,14]

Thus, regulations become necessary to ensure that this technology is within the current legislations.

Nanotechnology and legislation

Until now, grant and regulatory agencies have not yet established the exact definition of Nanotechnology. So, each country has its own definition and legislation.

International ASTM (American Society for Testing and Materials) recognized worldwide for developing international standards published in 2006 the first formalized definition of Nanotechnology. Thus, any technology that measures, manipulates or incorporates materials and / or resources from 1 to 100 nm is known as Nanotechnology.[15] This concept is very similar to the declared by the *National Nanotechnology Initiative* (NNI),[16] this center is a government initiative of the United States of America (USA), which encompasses 20 departments and federal regulatory agencies of research and development (R&D) involved with the use, creation and manipulation of nanotechnology. According to NNI, nanotechnology is the development, understanding and control of materials at the nanoscale ranging from 1 to 100 nm.[16] Moreover, it also enacts its scientific application in several fields of study such as chemistry, biology, physics, medicine and engineering. Furthermore, the 2015 Federal Budget provides more than $1.5 billion for the National Nanotechnology Initiative (NNI), a continued investment in support of the President's priorities and innovation strategy.[17]

In 2011, the European Commission published a definition of nanomaterial. They defined as a natural material, made accidentally or purposely containing 50% or more of free particles, aggregated or agglomerated with size between 1 and 100nm.[18]

According to the Guidance for Industry, published in 2014, the *U.S. Food and Drug Administration* (FDA) has not established regulatory definitions of "nanotechnology," "nanomaterial," "nanoscale," or other related terms. In June 2014, FDA issued a guidance for industry titled "Considering Whether an FDA-Regulated Product Involves the Application of Nanotechnology".[19,20] As described in that guidance, at this time, when considering whether an FDA-regulated product involves the application of nanotechnology, FDA will ask: (1) whether a material or end product is engineered to have at least one external dimension, or an internal or surface structure, in the nanoscale range (approximately 1 nm to 100 nm); and (2) whether a material or end product is engineered to exhibit properties or phenomena, including physical or chemical properties or biological effects, that are attributable to its dimension(s), even if these dimensions fall outside the nanoscale range, up to one micrometer (1,000 nm).[19,20]

We will apply these considerations broadly to all FDA-regulated products, including cosmetic products. The National Institute for Public Health and the Environment published the Nanomaterial Report of products for human consumption in the European market in 2010.[21] In the past three years, the number of consumer products with a claim to contain nanomaterial on the European market shows a six-fold increase from 143 products in 2007 to 858 products in 2010. Product categories with the largest growth are the 'Personal care products and cosmetics' like sunscreens and various 'Coating products' such as anti-rain products for shoes and textiles.[21]

Nowadays, there is great difficulty in identifying products containing nanomaterials, because depending on the manufacturer, this may choose, or not to declare the presence of nanomaterials. This occurs because there are no scientific evidences of risks that these nanomaterials may offer to health and environment in short and long term. As the advertising and publicity on these nanocosmetics is eager and intense, many manufacturers declare the presence of nanoparticles for commercial purposes, however, not necessarily they are found in the products.

Actually, there is growing concern of national and international regulatory agencies to promote the declaration of nanomaterials in cosmetics by manufacturers and suppliers. The main national and international regulatory agencies began requiring that both manufacturers and suppliers describe, characterize and detail if their product has any nanomaterial, the chemical identity of its nanomaterial, its concentration and form. In this way, every year the laws become more stringent and demanding not only in Brazil, but around the world.

Regulatory laws of nanomaterials

Prioritizing the principal markets and influencers of today, there were identified what are the main regulatory agencies of these countries and what are the laws for exportation and marketing of finished products containing nanomaterials.

European Union

The main legal instruments of the European Union (EU) are the Directives and Regulations. Regulations are applied to all Member States (28 countries). In 2009, the New European Regulation for Cosmetics was released.[22]

Regulation 1223/2009

Nanomaterials are defined as "insoluble or biopersistant and intentionally manufactured material with one or more external dimensions, or an internal structure, on the scale from 1 to 100 nm". However, this definition is not definitive, and to maintain a high level of consumer protection, free movement of goods and a legal support to manufacturers, it is necessary a uniform and international definition of "nanomaterials".[22]

Regulation 1223/2009 requires that the ingredients present, as nanomaterials in the product shall be indicated in the ingredient list with the word "nano" in brackets.

REACH Regulation (Registration, Evaluation, Authorization and Restriction of Chemicals) follows the norms of the Regulation 1223/2009 and it is applied to every substance, which includes the nanomaterial. According to REACH, manufacturers, importers and consumers should ensure that manufacture, market or use substances that do not affect the environment and human health.[23]

So, manufacturers and importers must submit a registration dossier of substances that go to or are manufactured in the EU, above 1 ton/year. When quantities reach or exceed 10, 100 and 1000 tones/year, a safety report (Chemical Safety Report) and a Safety Assessment must be included in the registry.[23] Minimum information required for registration, if not available must be justified:

1. Name or other identifier of the substance
1.1. IUPAC name or other international nomenclature (INCI name)
1.2. Other names (usual name, trade name, abbreviation)
1.3. EINECS/ELINCS number

Article 16 of Regulation 1223/2009 stipulates that all cosmetic products containing nanomaterials must be notified electronically within six months prior to commercialization in the EU.[22,24]

This notification is made in CPNP - Cosmetic Products Notification Portal. Information required for the notification in CPNP:[24]

1.4. CAS number
2. Information about molecular and structural formulas
2.1. Molecular and structural formula
2.2. Optical activity, isomer/stereoisomer ratio
2.3. Molecular weight
3. Composition
3.1. Degree of purity (%)
3.2. Nature of impurities (isomers, by-products)
3.3. Percentage of main impurities
3.4. Nature and order of magnitude (ppm,%) of additives stabilizing
3.5. Ultra-violet, infrared, NMR, mass spectrometry
3.6. HPLC, gas chromatography

1. Identification
1.1. Product Identification
1.1.1. Category
1.1.2. Name of the cosmetic product
1.2. Identification of the nanomaterial
1.2.1. IUPAC name
1.2.2. INCI name, CAS number, EC number
1.3. Contacts (responsible person contact)
2. Specification
2.1. Primary particle size (smaller cut size of particles, the volume weighted average, weighted average quantities, expressed in nm)
2.2. Morphology
2.2.1. Physical form (solid, powder, solution, suspension, dispersion)
2.2.2 Crystalline form (spherical, pyramidal, crystalline, hexagonal, amorphous, irregular)
2.2.3 State agglomerate / aggregate (free particles dispersed agglomerate, aggregate, etc.)
2.3 Characteristics of surface
2.3.1 Surface charge (zeta potential (mV))
2.3.2 Coating (coated particles or not)
2.4. Solubility (mg/L)
2.4.1 Aqueous Medium
2.4.2 N-octanol
2.4.3 Partition coefficient octanol / water
2.5 Surface area (mandatory for powders)
2.5.1 Specific surface area (m^2/G)
2.5.2 Volume of specific surface area (m^2/cm^3)
2.6. Catalytic Activity
2.6.1 Surface chemically reactive (yes / no)
2.6.2 Photo catalytic Activity (yes / no)
3. Quantity of nanomaterial in the cosmetic product
3.1 Amount per year (kg)
3.2 Product is in the market? (Yes / no)
4. Toxicological Profile
5. Safety data
6. Conditions of exposure
6.1 Rinse-off/Leave-on
6.2 Routes of exposure (dermal, oral, inhalation)
6.3 Maximum concentration of the nanomaterial in the product (% g/g)

U.S.

In the U.S., the National Science and Technology Council coordinates the policies on nanotechnology through the Nanoscale Science, Engineering, and Technology Subcommittee (NSET).[25,26] The Subcommittee is responsible for coordinating, planning, implementing and reviewing the National Nanotechnology Initiative (NNI).[17]

The NNI is not a regulatory agency, but it aims to provide recommendations for evaluation and risk administration of nanomaterials, increasing the conscious development of nanotechnology.[27]

The **TSCA (Toxic Substances Control Act)** aims to allow the U.S. EPA (United States Environmental Agency Protection) to control new chemical products before being marketed and existing products when they present excessive health and environmental risk, and to control their use and distribution.[28]

For this approach, the TSCA has four fronts:

1. **Premanufacture Notifications –** requires manufacturers of new chemicals to provide specific information, so that the Agency can do a review before production and/or marketing.
2. **Significant new use rule (SNUR) –** to ensure that new nanomaterials have appropriate regulatory review and to identify the existing uses of these nanomaterials. It requires that the manufacturer or importer submit a Significant New Use Notice (SNUN) to EPA until 90 days before marketing. The Notification should contain basic information about nanomaterials: chemical identity, characteristic of the material, physical/chemical properties, commercial uses, production volume, exposure and toxicological data.
3. **Information Gathering Rule** - Requires manufacturers of nanomaterials to send additional information such as production volume, manufacturing and processing methods, exposure and release information, and available health and safety data.
4. **Test Rule –** Requires testing for certain nanomaterials that are already on the market. The test results would assist EPA in understanding the potential effects to health and environment. Besides, they can establish a correlation among the physic-chemical properties and the effects of nanomaterials.

The **FDCA (Food, Drugs and Cosmetics Act)** is used by FDA to control and understand, the uses and impacts of nanomaterials in foods (additives and contaminants), drugs and cosmetics. The FDA

may request information about the identity and properties of the materials, regardless of particle size. Usually, premarketing safety data are not required for cosmetics.[20,27]

Currently, there are no specific regulations for nanomaterials related to the safety of food and drugs. Medical products that contain nanomaterials undergo traditional regulatory processes and are required clinical and toxicological tests to determine their safety and effectiveness.[27,29]

Brazil

At the present time, in Brazil, there are no laws or regulations governing the nanomaterials and nanotechnologies. On 31/10/2012, ANVISA (National Agency for Sanitary Vigilance) promoted a thematic discussion on nanotechnology and health surveillance, when they discussed the growth of nanotechnology and the need to enhance the Agency's knowledge in this area.[30]

The Ordinance nº 993/ANVISA of 10 July 2013 instituted the Internal Committee of Nanotechnology (**CIN –** *Comitê Interno de Nanotecnologia*).[31] It aims to: verify the current understanding of the Agency about nanotechnology; account products that use and have knowledge in nanotechnology; prepare a document with the actions and regulatory policies on nanotechnology present in other countries; and suggest alternatives guidelines and regulatory policies to the Agency.

In February 2014, CIN published the "*Diagnóstico Institucional de Nanotecnologia*" (Institutional Diagnosis of Nanotechnology). According to it, in Brazil there are 608 industries that uses nanotech, 150 industries develop nanotech and in the major areas (chemical and petrochemical industry and health).

Were identified 637 products that make reference to nanotechnology, which: 599 cosmetics, 20 sanitizing, 10 drugs, 7 health products and 1 food.

By the end of the document, some considerations are made, such as:

- The necessity to regulate nanotechnology, due to its high degree of uncertainty about its safety, and also, the absence of regulation creates legal uncertainty which is detrimental to the development, production and marketing.
- There are several nanoproducts on the market without specific technical analysis.
- It is necessary a qualification in this field of knowledge.
- It is necessary to keep up with the evolution of the international regulatory scenario, which is dynamic.
- There are still conceptual, technical, scientific and structural limitations to have a scientifically referenced regulation.

CIN also made some suggestions:

- Elaboration of a norm that obliges to declare the nature of the nanotechnology used in products and process registered/notified in ANVISA.
- Elaboration of norms and guidelines for the safety evaluation, monitoring and control of the products and process.
- Stimulate the financing of regulatory research to overcome significant gaps for the establishment of more specific regulations for nanotech.
- Create a database of nanoparticles/nanomaterials related to human health and environment safety.

CONCLUSION

Nowadays, nanotechnology is one of science's important topics; it is a promising area for the development of drugs, health products, digital devices and others. However, its effects and impacts in health and environment are still not clear.

In this way, its evaluation and regulation are very important. It was seen that there are several different definitions and positioning regarding nanotechnology and nanomaterials, for each country, each regulatory agency.

The "lack" of a single and international definition may harm consumers (who do not know the actual properties of the products they are buying/using) and also manufacturers/suppliers (who find themselves without legal guidance on how to use and sell this technology and its products).

The next challenge would be a deeper alignment among the main regulatory entities and research centers that have better understanding about this subject, to lead to a single definition of those terms. In addition, they can create a database that would include: the products containing this technology, the tests already carried out, and other information, aiming the products efficacy and mainly the safety of human health and environment.

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