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Prospective Study

Pharmaceutical Nanotechnology: A Therapeutic Revolution

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Introduction

The definition of nanotechnology is not yet a consensus in the scientific community. Among the most widespread concepts, it can be defined as the science that studies nanoscale materials (1 to 1000 nm) involving areas such as materials engineering, energy, biotechnology, physics and pharmacy, among others [1]. It is based on the development of nanostructures, providing revolutionary applications in various sciences [2]. Among the applications of nanotechnology is the pharmaceutical nanotechnology, a developed expertise mainly by pharmacists, engineers and biotechnologists. Regarding to pharmaceutical nanotechnology, it is based on the life sciences, which allows the development of nanostructures capable of promoting innovative drug delivery systems as therapeutic alternatives to various pathologies, as well as biosensors of nanomaterials to perform advanced diagnostics.

Nanotechnology and pharmaceutical industry

Faced with so many positive aspects offered by this technology, the pharmaceutical industry has been increasingly inserting nanotechnology in its products, based on the concept that innovation moves the world. In addition, nanotechnology has been decisive in the production and optimization of drugs based on potentially promising active principles, but which have limitations that compromise their application. The table 1 exemplifies some success of nanoformulations transferred to the industry.

Among the biggest problems can be mentioned, high toxicity, degradation of the active ingredient, quick release, non-specificity, reduced bioavailability and low solubility [3].

To mention, one of the great challenges of the

pharmaceutical industry has been the use of pharmaceutical products with low solubility in water and their bioavailability in the therapeutic window. It is known that, of the pool of molecules of pharmaceutical interest under development, 90% have low water solubility, configured by the biopharmaceutical classification as class II molecules (low water solubility and high permeability) and class IV (low solubility) water and low permeability) [4,5]. This limitation can be overcome by nanocarriers, opening the door to the development of many new treatments.

Nanocarriers in focus

Nanocarriers are transporters of active ingredients in the nanoscale that have the function of directing substances, increasing bioavailability, reducing toxicity, in addition to modulating the kinetics profile of the active principle. As an example of nanocarriers, we can mention nanoemulsions, microemulsions and nanoparticles. Nanoemulsions are nanotechnological systems composed of an oily phase and an aqueous phase that is emulsified in the presence of surfactants, which will reduce the surface tension of the phases and, therefore, will allow obtaining nanometric drops in the range of 50 to 500 nm. These systems are thermodynamically unstable and kinetically stable, that is, it is necessary to supply energy to obtain this "stable" system for a time, also called, metastable [6,7].

Regarding the microemulsions, they are translucent systems composed of water, oil and surfactants (usually in a higher concentration than in a nanoemulsion), where we have droplets in the range of 10 to 100 nm. Unlike nanoemulsions, microemulsions are thermodynamically stable systems, with spontaneous formation, that is, it does not require energy to

**Table 1:** Nanoformulation approved by FDA available in pharmaceutical industry. Source: Adapted from US-FDA and EMA.

Commercial nanoformulations	Nanocarrier	Active pharmaceutical ingredient	Application
Nanocurc™	Polymeric nanoparticles	Curcumin	Pancreatic cancer
Lipocurc™	Liposome	Curcumin	Inflammatory diseases
Doxil®	Liposome	Doxorubicin	AIDS-related KS, multiple myeloma, ovarian cancer
Abraxam®	Protein Nanoparticles	Paclitaxel	Breast cancer, Non-small cell lung cancer, Pancreatic cancer
Inflexal® V	Liposomes	Influenza virus antigens	Influenza vaccine
Copaxone®	Polymer-based nanoformulations	Polypeptide	Multiple sclerosis
Genexol®	Micelles	Paclitaxel	Metastatic breast cancer, pancreatic cancer
Fungizone®	Colloidal micellar dispersion	AmB	Systemic fungal infections
AmBisome®	Liposome	AmB	Systemic fungal infections
Feridex®	Inorganic nanoparticles	Iron oxide	Liver/spleen lesion MRI
NanoTherm®	Inorganic nanoparticles	Iron oxide	Iron deficiency anemia, glioblastoma, prostate, and pancreatic cancer
Adagen®	Polymeric nanoparticles	Pegademase bovine	Severe combined immunodeficiency disease
Estrasorb™	Micelles	Estradiol	Menopausal therapy
Avinza®	Nanocrystal	Morphine sulphate	Psychostimulant
Emend®	Nanocrystal	Aprepitant	Antiemetic
Visudyne®	Liposomes	Verteporfin	Ocular histoplasmosis, myopia, decreased vision
Taxotere®	Micelles	Docetaxel	Antineoplastic

obtain a microemulsion, since the most comfortable energy state is not the separation of phases, but the microemulsified conformation [6,8].

In the universe of nanocarriers, there are also nanoparticles. These systems, unlike nanoemulsions and microemulsions that have droplets, presented particles (solid-state). Nanoparticles are colloidal systems at the nanoscale that have been developed as an important strategy for carrying conventional drugs, recombinant proteins, vaccines and, more recently, nucleotides. Nanoparticles modify the kinetics, body distribution and drug release. Furthermore, they may have specific targeting for cells or tissues, optimize pharmacological activity and reduce unwanted side effects [9].

There are a variety of nanoparticles, these can be lipid nature, like solid lipid nanoparticles, where we have solid and liquid lipids that will allow the formation of this system, they can be polymeric, where there is a mandatory polymer coating, there are also magnetic nanoparticles that are mostly intended as disease diagnosis systems [10–12], among many others. All of these systems mentioned can improve the characteristics of the active ingredients, whether physicochemical, pharmacodynamics and/or pharmacokinetics. It is necessary to understand the needs for choosing the ideal system.

Perspectives

It is clear that nanotechnology represents a key research area to face the pharmaceutical industry's R&D challenges. Nanotechnology-based medicines have already found success in the industrial scenario. This worldwide trend, had increased in the coming years. However, it is necessary to evaluate the

ethical aspects of the impacts of this new technology in the long term with great responsibility.

Nanotechnology represents a real *therapeutic revolution*, as it will make it possible to multiply the number of active ingredients that are candidates for composing medicines and, therefore, in the long term, the number of therapeutic solutions available for the treatment of diseases.

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