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Review Article

Health Issues of Nanoparticles

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ABSTRACT

The rapid development of nanotechnology has opened the doors of innovation of many industrial sectors like food technology, food development, food packaging, agricultural sector and pharmaceuticals, sport goods, electronics, paints, varnishes and cosmetics.Some applications of nanoparticles have already been explored and some are under research. The nanotechnology based sectors mainly includes increased efficacy of drugs, agrochemicals and cosmetics. Such a development has poked the human health and environment due to its specific size related propertie and wide spread use and applications. This paper targets the potential risks and harms to the human healths from this technological boon. In absence of any legislative recommendations for production, handling and disposal of nanomaterials, the life of human beings is more prone to damages beyond imagination.

Keywords: Nanoparticles, Cosmetics, Agriculture, Food packaging, Health

INTRODUCTION

Nanotechnology is the study, exploration and creation process of practical and useful materials and systems through control of matter at the nanometer (nm) scale, generally between 1 to 100 nm in at least one dimension. The word "Nanotechnology" was originated from a Greek world which means "dwarf" i.e. one billionth of a meter (1nm= 10^{-9} m). The nanoscale is unique because nothing solid can be made any smaller. It is also unique because many of the mechanisms of the biological and physical world operate on length scales from 1 to 100 nm. A number of important breakthroughs have already occurred in nanotechnology. These developments are discovered in materials and products used throughout the world. Some examples are devices in computers that read from and write to the hard disk, catalytic converters in automobiles that help remove air pollutants, certain sunscreens, and cosmetics that transparently block harmful radiation from the Sun, and special coatings for sports clothes and gear that help improve the gear and possibly enhance the athlete's performance. Still, many scientists believe that they have only scratched the surface of nanotechnology's potential and it will have a major impact on medicine and health care; energy production and conservation; environmental cleanup and protection; electronics, computers, and sensors; and world security and defense.

Comparison of nanosize with smallest world items

To grasp the size of the nanoscale, consider the diameter of an atom, the basic building block of the matter. The hydrogen atom, one of the smallest naturally occurring atoms, is only 0.1 nm in diameter. In fact, nearly all atoms are roughly 0.1 nm in size, too small to be seen by human eyes. We know that atoms bond together to form molecules, the smallest part of a chemical compound. Molecules that consist of about 30 atoms are only about 1 nm in diameter. Molecules, in turn, compose cells, the basic units of life. Human cells range from 5,000 to 200,000 nm in size, which means that they are larger than the nanoscale. However, the proteins that carry out the internal operations of the cell are just 3 to 20 nm in size and so have nanoscale dimensions. Viruses that attack human cells are about 10 to 200 nm, and the molecules in drugs used to fight viruses are less than 5 nm in size.

Biomineralization of nanoparticles

The synthesis of Nano compounds (NCs) such as metals and metal alloys by biological molecules is known as biomineralization[1]. Over millions of years of evolution, nature has evolved mechanisms to produce such NCs for a wide variety of purposes. Diatoms produce exquisitely intricate porous silica shells with nanoscaled spikes , pores and valleys[2]. and sponges produce spicules[3]. that are utilized for structure and protection. Bacteria synthesize crystalline magnetic NCs for navigation and orientation[4]. Algae, plants and bacteria produce metal NCs as a consequence of detoxification pathways[5]. In many cases, the NCs are produced under genetic control, resulting in specific morphologies, sizes, and crystallinities of the structures[6]. We are getting an awareness of remuneration of nanotechnology but the probable effects of their widespread use in the daily life are just emnerging out[7,8]. Both supporters of nanotechnology[9]. and its opponents[10]. are finding it extremely hard to argue their case as there is limited information available to support one side or the other. It has been shown that nanomaterials can enter the human body through several ports. Accidental or involuntary contact during production or use is most likely to happen via the lungs from where a rapid translocation through the blood stream is possible to other vital organs[11]. On the cellular level an ability to act as a gene vector has

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been demonstrated for nanoparticles[12]. Carbon black nanoparticles have been implicated in interfering with cell signalling[13].

Applications of Nanotechnology

Food technology and food packaging Food nanotechnology has its history from Pasteurization process introduced by Pasteur to kill the spoilage bacteria (1000 nanometers), made the first step of revolution in food processing and improvement in quality of foods. Later, Watson and Crick's model of DNA structure which is about 2.5nm opened the gateway of applications in biotechnology, biomedical, agricultural and production processes. Further, the invention of carbon nanotubes which is 1nm in size served as the cutting edge discovery to the world of innovation and led to the era of nanoscience. Food processing is the conversion of raw ingredients into food and its other forms by making it marketable and with long shelf life. Processing includes toxin removal, prevention from pathogens, preservation, improving the stability of foods for better marketing and distribution. Processed foods are usually less prone to early spoilage than fresh foods and are better suited for long distance transportation from the source to the consumer. All these are made more effective by the incorporation of the nanotechnology nowadays .Nano capsules delivery systems plays an important role in processing sector and the functional property are maintained by encapsulating simple solutions, colloids, emulsions, biopolymers and others into. Foods. Nano sized self assembled structural lipids serves as a liquid carrier of healthy components that are insoluble in water and fats called as nanodrops. They are used to inhibit transportation of cholesterol from the digestive system into the bloodstream. The incorporation of nano materials such as silicate, clay, and titanium dioxide to biopolymers may improve not only the mechanical and obstruction properties but also offer other functions and applications in food packaging. The packaging with nanofillers have properties with antimicrobial activity, biosensor and oxygen scavenger properties[14-16]. The bio nanocomposite can be an active food packaging whereby the food packaging can interact with food in some ways by releasing beneficial compounds such as antimicrobial agent, antioxidant agent or by eliminating some unfavorable elements such as oxygen or water vapor. At nano-scale level, the size of the nano phase or filler is significantly reduced, leading to the dramatic increment in the surface area of the fillers. This is desired because bio-nanocomposites rely on the high surface area of the nano sized fillers which results to a large interfacial or boundary area between the matrix or biopolymer and nanofiller. Hence the nano fillers are greatly enhancing the market of food packaging.

Application in agriculture

Nanotechnology offers new opportunities to agricultural industries and several applications can be found at different stages of agrochemicals delivery. Nanomaterials have been used for the detection of animal and plant pathogens, food additives as color and flavor enhancers, food supplements i.e to increase iron or other trace element bio-availability. In particular, it has emerged that 276 nanomaterials (NMs) are currently available on the market; nano-encapsulated, silver and titanium dioxide have the highest number of records in the Nano Inventory and food additives and food contact materials are the most frequent applications. As far as future developments are concerned, it seems that a potential shift from inorganic materials like silver to organic materials like nano-encapsulates and nanocomposites might occur, suggesting that applications in novel foods, feed additives, biocides and pesticides have been so far only at a R&D stage.

Application in cosmetics

Nano-emulsions are commonly used in certain cosmetic products, such as conditioners or lotions. Nanoemulsions combine traditional cosmetic ingredients, such as water, oils and surfactants, in a two-phase system in which droplets sized 50–100 nm are dispersed in an external (aqueous) phase. The small droplet size renders nano-emulsions transparent and pleasant to the touch, their texture and rheological properties have yet to be obtained by other formulation methods[17]. Liposomes and Niosomes are globular vesicles with diameters between 25 and 5,000 nm and are composed of amphiphilic molecules which associate as a double layer (unilamellar vesicles) or multiple double layers (multilamellar vesicles). Liposomes are mainly composed of phospholipids, whereas niosomes use non ionic surfactants, such as polyoxyethylene alkyl ethers or esters[18]. The ultra structure of these vesicles is quite similar to that of mammalian milk, which contains nano-sized fat droplets surrounded by the milk fat globular membrane[19]. Vesicle formulations are important in cosmetic applications because they may improve the stability and skin tolerance of ingredients, such as unsaturated fatty acids, vitamins or anti-oxidants and thereby contribute to the safety of cosmetics. Sunscreens contain insoluble, mineral-based materials whose performance depends on their particle size. Mineral particles, such as TiO_2, reflect and scatter UV light most efficiently at a size of 60–120 nm. The surface of these particles is frequently treated with inert coating materials, such as aluminium oxide or silicon oils, in order to improve their dispersion in sunscreen formulations. Sunscreen products containing mineral UV filters protect consumers from the harmful effects of UV exposure, including skin ageing, herpes as well as skin and lip cancers[20]. The transparency of man-sized particles of titanium or zinc oxides results in better consumer acceptance/compliance and thus improves the protection of human skin against UV induced damage. Some nanotechnology enabled products are already on the market and enjoying commercial success. For example, self-cleaning windows use a 15 nm thick coating of activated TiO_2 engineered to be highly water-repellent, so that rainwater just flows off the surface, washing away the dirt. Studies so far on TiO_2 nanoparticles suggest that they do not penetrate beyond the epidermis. Nanoparticles of silver are now used in toothpastes, soaps and face creams, food packaging, clothing, household appliances, disinfectants and wound dressings. Silver nanoparticles have a potent ability to kill bacteria[21]. Other examples of nano cosmetic products on the market include body firming lotion, bronzer, exfoliant scrub, eye liner, and styling gel.

Effects on Health

Human skin and intestinal tract are always in direct contact with the environment. The intestinal tract is in close contact with all the materials taken up orally; there all nutrients are exchanged between the body and the environment. The histology of the environmental contact sides of these three organs is significantly different. The intestinal tract is a more complex barrier – exchange side, it is the most important portal for macromolecules to enter the body. From the stomach, only small molecules can diffuse through the epithelium. The epithelium of the small and large intestines is in close contact with ingested material so that nutrients can be utilized. Skin is an important barrier, protecting against insult from the environment. The skin is structured in three layers: the epidermis, the dermis and the subcutaneous layer. The outer layer of the epidermis, the stratum corneum, covers the entire outside of the body and only contains dead cells, which are strongly keratinized. For most chemicals the SC is the rate-limiting barrier to percutaneous absorption The skin of most mammalian species is, on most parts of the body, covered with hair. At the sites, where hair follicles grow, the barrier capacity of the skin differs slightly from the "normal" stratified squamous epidermis. Most studies concerning penetration of materials into the skin have focussed on whether or not drugs penetrate through the skin using different formulations containing chemicals and/or particulate materials as a vehicle. The main types of particulate materials commonly used are: liposomes; solid poorly soluble materials such as TiO_2 and polymer particulates and submicron emulsion particles such as solid lipid nanoparticles. The penetration of these particulate carriers has not been studied in detail. TiO_2 particles are often used in sunscreens to absorb UV light and therefore to protect skin against sunburn or genetic damage. The main characteristic of NM is their size, which falls in the transitional zone between individual atoms or molecules and the corresponding bulk materials. This can modify the physicochemical properties of the material as well as create the opportunity for increased uptake and interaction with biological tissues. This combination of effects can generate adverse biological effects in living cells that would not otherwise be possible with the same material in larger form.

Legislation

The legislation applicable to nanomaterials is complex as well, as described in the following brief overview. As described in the introduction, the first legal definition of nanomaterials was provided in 2011 in the EU in the form of a non binding legal document. After that, the definition of “engineered nanomaterials” has been included in the Reg. 1169/2011 on the provision of food information to consumer, where the labelling of food products containing nanomaterials is mandatory. More detailed rules are laid down in other regulations whose application depends on the intended use of the nanomaterials. If nanomaterials are used as primary ingredients (e.g. nanoemulsions), they fall within the scope of “Novel Food” *Regulation* (258/97) as “foods and food ingredients with a new or intentionally modified primary molecular structure” and they are subjected to a risk assessment procedure before market approval. If they are used as food additives, a different procedure is applied (Reg 1333/2008) and they are expected to be inserted in the EU register before use. In this sector, the definition of nanomaterials appears controversial, since some approved additives, such as Silica (E551), can contain primary particles satisfying the requirements of nanomaterial definition. The main questions in similar cases are whether already approved products discovered to be nanomaterials should be re-evaluated or not, and whether the presence of nanoparticles due to production technology and not to producer willingness should be exempted from further evaluations. Also, in the case of food contact materials, an approval procedure is required before the inclusion in the EU catalogue. Currently there are few materials approved, such as Titanium Nitride nanoparticles used in plastic materials to prevent carbon dioxide leakage from carbonated drinks, that are recognized to generate no concern since migration has not been demonstrated (Scientific Opinion on the safety evaluation of the substance, titanium nitride, nanoparticles, for use in food contact materials, EFSA Journal 2012;10(3):2641 .As far as products to be used in the agri sector are concerned, the environmental impact should be evaluated together with the potential for human exposure.

CONCLUSION

The development of new products and applications involving nanotechnologies holds great promise in different industrial sectors, food not excluded. Several possibilities exist to exploit the benefits of nanotechnologies during different phases of the food chain with the aim to enhance animal nutrition and health, promote the formulation of new food products and improve the microbiological quality of food during production and processing. Despite these promises, however, nanotechnologies should be carefully applied because toxicological data on several nanomaterials already in use are lacking and because the development of analytical methods able to guarantee consumer protection is still ongoing and need to face several challenges before any routine application in food control could be imagined.

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