ENGINEERED NANOPARTICLES AND ENVIRONMENT

Tanmay Chattopadhyay [24]

Abstract

Recently, nanotechnology covers a wide range of scientific fields, engineering disciplines, and technological applications. In general, however, nanotechnology is still an emerging field and there is a lack of information about how nanoscale particles might harmfully affect the environment. Therefore, evaluation of the positive and negative impacts of nanotechnology is essential for the safety of society.

Key words:- Nanotechnology, Environment, Positive and negative impacts.

Introduction

Only in the last few years has nanotechnology begun to grow into a valuable science. A nanometer (nm) is extremely small, one billionth of a meter to be particular, i.e., 10^{-9} m. This is eighty thousand times smaller than the width of a human hair. This smaller size of the materials develops new properties which are fundamentally different from larger materials; for example they can be more chemically reactive, have greater strength or conduct electricity more effectively. It is well known that graphite (which is used in the lead of pencils) and diamond both are made up of the same element (carbon), but the way in which the atoms are arranged in each is slightly different, giving the dramatic differences between them. Nanotechnology also offers the opportunity for us to make such differences by design. Nanoparticles have existed naturally for thousands of years. They are produced by volcanoes, algae and in processes such as burning and cooking for instance. Now, we have also been capable to use chemistry and molecular biology to help us to build synthetic nanomaterials out of bulk materials. Nanotechnology influences virtually all industrial and public sectors, including healthcare, agriculture, transport, energy, materials; information and communication technologies. Both the potential benefits and the risks, associated with the application of prepared nanoparticles have been widely debated in recent years. In contrast to the dominating hopeful projections that nanotechnology will bring significant technological development and well-being

[24] Assistant Professor in Chemistry, Panchakot Mahavidyalaya, Sarbari, Neturia, Purulia, W.B.

to society, it is considered that exposure to certain nanoparticles may cause environmental problems and/or do harm to human health. Currently, varieties of methodologies are being internationally discussed and assessed with great retribution with the idea that, in the near future, it will be possible to perform complete and scientifically sound risk assessment of synthetic nanoparticles. This can be very useful for the training and protection of students, as well as scientists, engineers, policymakers, and regulators working in this field. We need to understand more about the impacts of nanotechnology on the environment in order to provide effective safeguards for us all. This article is based on an extensive review of literature published in different scientific publications and books will give some idea about the impacts of nanotechnology on the environment.

Nanoparticles in Environment

Nanoparticles are the materials with at least two dimensions between 1 and 100 nm. Two types of nanoparticles can be distinguished: (a) naturally occurring nanoparticles (e.g., generated naturally in volcanoes, forest fires or as combustion by-products) and (b) synthetic nanoparticles, deliberately developed to be used in application (e.g., carbon black, fumed silica, titanium dioxide, iron oxide, fullerenes, carbon nanotubes (CNTs), dendrimers. In environment, nanoparticles present in different form as depicted in figure 1 below.

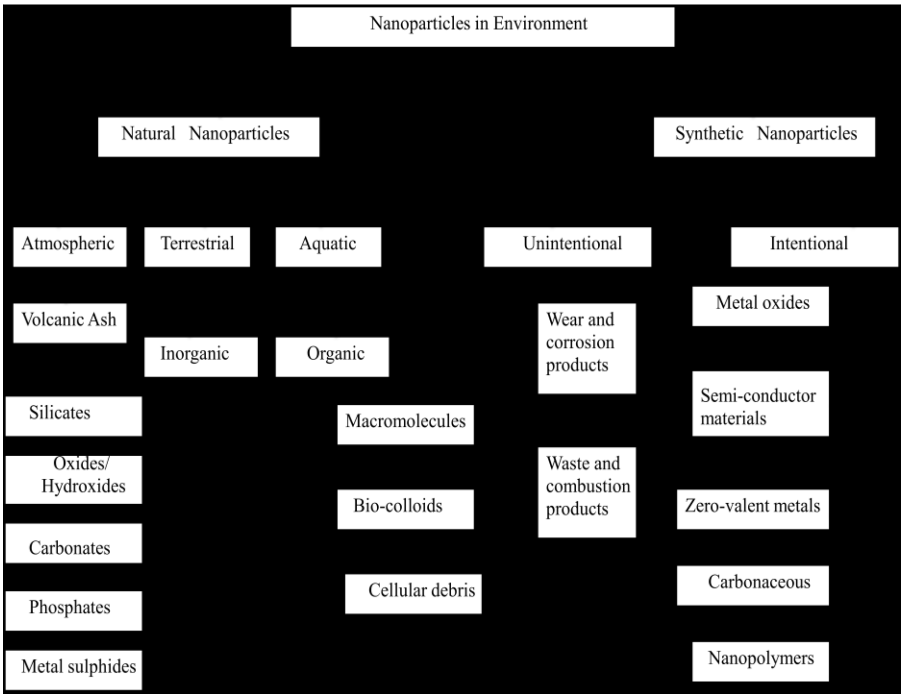

Figure 1. A detailed sorting of nanoparticles existing in the environments.

Impacts

Recent advances in technology allow us to study and manipulate atoms much more precisely and easily, leading to an expansion of the potential uses of an interest in this science. The rapidly developing nanoscience and nanotechnology reveal many exciting features of materials at the nanometer scale, and the possibility of manipulation of such features to create novel materials or products that are previously unthinkable. Many believe that nanoscience and nanotechnology development will become a new industrial revolution. On the other hand, together with the numerous beneficial potentials, scientists also warn against possible adverse health and environmental impacts brought by the vastly unknown physicochemical properties of materials at the nanoscale. Nanomaterials, in particular, nanoparticles probably cause the highest concern because of their potential of rapid uptake by biological system, unknown distribution pathways and potential interactions with various components of the biological system. Nanoparticles are previously known in the air pollution field as ultrafine particles, which are defined as particles less than 100 nm in aerodynamic equivalent diameter. Some ultrafine particles are generated by natural processes such as volcanic activities and wild fires. Others are derived from anthropogenic sources, e.g. engines and incinerators.

Nanoparticles have unique physicochemical properties that are not found in their parent materials. The novel properties of nanomaterials, however, are a two-sided sword. The same properties that allow the wonderful beneficial uses also imply potentially devastating adverse health effects. Rapid uptake through skin and epithelial cells, capability to translocation along neurons, plus the known toxicity of some parent materials warrant careful environment, health and safety evaluation side by side with every nanomaterial application study. Examples are carbon nanomaterials: Fullerenes, which consist of repeating hexagonal and pentagonal rings of carbon atoms. They include buckyballs (C60) and other spherical structures, and single wall and multi-wall carbon nanotubes. Buckyballs are extremely stable. They can trap other atom or molecule inside the carbon structure. Possible applications include superconducting material, drug delivery system, lubricant and catalyst. Carbon nanotubes can be made into mechanically super-strong materials which are 100 times the strength, but one sixth the weight of steel, among many other potential applications. Today, nanotechnology is available on the market for great variety of applications (**Table 1**). Some examples are: cosmetics and sunscreens, water filtrations, glare filters, ink, stain-resistant clothing, dressings for burns or injuries etc.

Table 1. Nanotechnology areas of application.

Carbon has always been considered a non-toxic element, and not very water soluble.

Areas	Applications
Automotive	Lightweight construction; Catalysts; Painting; Tires; Sensors
Construction	Materials; Insulation; Flame retardants; Surface coatings; Mortar
Electronics	Displays; Data memory; Laser diodes; Fiber optics; Optical switches; Filters
Engineering	Protective coatings for tools, machines; Lubricant-free bearings
Food & Drink	Packaging; Storage life sensors; Additives; Juice clarifiers
Medicine	Drug delivery systems; Rapid testing systems; Antimicrobial agents
Textiles	Surface coatings; —Smart clothes (anti-wrinkle, temperature controlled)
Chemical	Fillers for paints; Composite materials; Impregnation of papers; Adhesives
Cosmetics	Sunscreen; Lipsticks; Skin creams; Toothpaste
Energy	Lighting; Fuel cells; Solar cells; Batteries; Capacitors
Environmental	Environmental monitoring; Soil & groundwater remediation; Green chemistry
Household	Ceramic coatings for irons; Odor removers; Cleaners for glass, ceramics
Sports	Ski wax; Tennis rackets; Golf clubs; Tennis balls; goggles
Military	Neutralization materials for chemical weapons, bullet-proof protection

However, recent studies found that buckyballs have considerable water solubility, and can cause lipid peroxidation in fish brain after 48 hours at a concentration of 500 parts per billion (ppb). This kind of oxidative stress is usually a first sign of biological damage. Single-wall nanotube has been found to cause other oxidative stresses such as free radical formation and depletion of antioxidants in cells. Metal impurity in synthesis of nanotube may also add to the toxicity. Besides, physical dimensions of some nanotubes may cause pulmonary fibrosis and cancer similar to the effect of asbestos. Although quantum dots are used in medical imaging, but the current quantum dots are made of a cadmium-selenium (CdSe) core with a zinc sulfide (ZnS) shell, and all three metals are known to be toxic to different extents. The high surface area and rapid distribution of the ultra small particles are expected to further escalate the potential adverse health effects. Several nanoparticles are currently used in cosmetics and sunscreens. We believe the published evidence on toxic hazards from some such particles for skin penetration is incomplete, particularly in individuals using these preparations on skin that has been damaged by sun or by common diseases such as eczema. Further careful studies of skin penetration by nanoparticles being considered for use, and the propensity of such particles to potentiate free radical damage, are desirable. Exposure of fibers in industry, in the form of asbestos, is a well-recognized cause of serious illness, including cancer. The toxic properties of such fibers are dependent upon a diameter narrow enough to allow inhalation deep into the lung, a length that prevents their removal by macrophages, resistance to dissolution in tissue fluid, and a surface able to cause oxidative damage. However, the doses of asbestos associated with disease are substantial, of the order of several hundred per breath at work over months or years. Any new fiber with these properties would be expected to cause similar problems if inhaled in sufficient amounts to lead to similar lung burdens of long fibers. Carbon and other nanotubes have physical characteristics that raise the possibility of similar toxic properties, although preliminary studies suggest that they may not readily be able to escape into the air in fibrous form. Such materials require careful toxicological assessment and should be treated with particular caution in laboratories and industry.

Conclusion

In this new millennium, we are enjoying the comforts and benefits that science has provided us, from composites to computer chips, from drugs to dyes. But we are faced with the task of treating wastes generated during manufacturing processes and the proper disposal of various products and byproducts. Free particles in the nanometer size range do raise health, environmental and safety concerns and their toxicology cannot be inferred from that of particles of the same chemical at larger size. Nevertheless, in recent decades it has been suggested, though not proven, that such exposures may be responsible for the observed relationships between air pollution and several diseases, particularly of the heart and the lung, in vulnerable individuals. Thus we need to understand more about the impacts of nanotechnology both on humans and on the environment and develop better techniques for the detection and regulation in order to provide effective safeguards for us all. Choosing right, less toxic materials (e.g., graphene) will make huge impacts on the environment.

Acknowledgement

TC is thankful to UGC-ERO, Kolkata [UGC-MRP No: F. PSW252 195/13-14 (ERO); Dated: 01.08.2014] for financial support.

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