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NANOTOXICOLOGY

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Abstract

Nanotoxicology is a branch of bionanoscience which deals with the study and application of toxicity of nanomaterials. Nanomaterials, because of quantum size effects and large surface area to volume ratio, have unique properties compared with their larger counterparts, even when made of inert elements like gold, become highly active at nanometer dimensions.

This paper is a review intended to rationalize the information concerning to public health related to the new science of nano, while raising awareness of nanomaterials' toxicity among researches and manufacturers. Nanotoxicological studies are intended to determine whether and to what extent these properties may pose a threat to the environment and to human beings.

We know that humans have always been exposed to tiny particles through dust and other natural processes and that our body has been well adapting to protect us from these potentially harmful intruders. Particles originating from human activities have existed for millennia, e.g. smoke from combustion and lint from garments, but the recent development of industry and combustion-based engine transportation has profoundly increased anthropogenic particulate pollution. Significantly, technological advancement has also changed the character of particulate pollution, increasing the proportion of nanometer-sized particles - "nanoparticles" and expanding the variety of chemical compositions. Recent epidemiological studies have shown a strong correlation between particulate air pollution levels, respiratory and cardiovascular diseases, various cancers, and mortality.

Animal and human studies show that inhaled nanoparticles are less efficiently removed than larger particles by the macrophage clearance mechanisms in the lung, causing lung damage, and that nanoparticles can translocate through the circulatory, lymphatic, and nervous systems to many tissues and organs, including the brain. The key to understanding the toxicity of nanoparticles is that their minute size, smaller than cells and cellular organelles, allows them to penetrate these basic biological structures, disrupting their normal function.

For nanotechnologies with clearly associated health risks, intelligent design of materials and devices is needed to derive the benefits of these new technologies while limiting adverse health impacts. A rational science-based approach is needed to minimize harm caused by these materials, while supporting continued study and appropriate industrial development.

A growing number of recent studies show, however, that nano- and micro-organisms may play a role in many chronic diseases where infections pathogens have not been suspected, diseases that were previously attributed only to genetic factors and lifestyle. It is clear that workers/ researchers in nanotechnology related industries may be potentially exposed to uniquely engineered nanomaterials with new sizes, shapes and physicochemical properties. Exposure monitoring and control strategies are necessary. Indeed, there is a need for a new discipline - nanotoxicology - that would evaluate the health threats posed by nanoparticles, and would enable safe development of the emerging nanotechnology industry . We emphasize that this field of study should include not only newly engineered nanomaterials, but also those generated by nature and pollution.

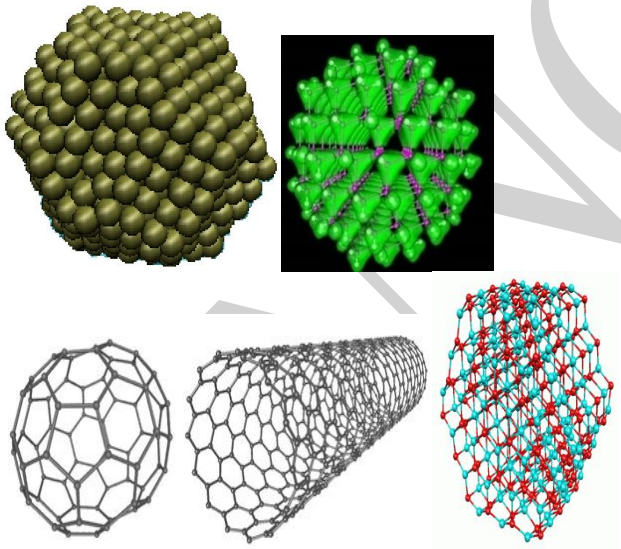
Key words
Nanotoxicology, Nanoparticles, Quantum size, Research, Toxicity, Health impact

Introduction

Nanotechnology can be defined as the design, synthesis, and application of materials and devices whose size and shape have been engineered at the nanoscale. It exploits unique chemical, physical, electrical, and mechanical properties that emerge when matter is structured at the nanoscale.
Nanotoxicology is the study (a new branch of toxicology) to address the adverse health effects caused by engineered nanoparticles

- ❖ Nanotoxicological studies are intended to determine whether and to what extent these properties may pose a threat to the environment and to human beings

The Nanoparticle Spectra
Nanoparticles can be made of any material. However, certain nanoparticles are used with higher frequency



Metal nano particles Quantaum dots Carbon nano tybes Metaloxide nano particles

Aerogel
Nanocrystalline materials synthesized by the sol-gel technique exhibit a foam-like structure called an "aerogel“ . Aerogels are composed of three-dimensional, continuous networks of particles and voids. Aerogels are porous, extremely lightweight, and have low thermal conductivity.
Composites are materials that combine two or more components and are designed to exhibit overall the best properties of each component (mechanical, biological, optical, electric, or magnetic).

Carbon nanotubes CNT
Nanocomposites containing CNT and polymers used to control their conductivity are interesting for a wide range of applications, such as super capacitors, sensors, solar cells, etc

Consumer products using nanoscale materials have an increasingly presence in the market. Deodorants, Soap, Toothpaste, Shampoo, Hair conditioner, Sunscreen, cosmetics (cream, foundation, face powder, lipstick, blush, eye shadow, nail polish, perfume and after-shave lotion).

Properties of Nanoscale Materials
The properties making nanomaterials so interesting can make them potentially harmful are,

- Enhanced reactivity
- Increased surface to volume ratio
- Enhancement permeation
- Relevant quantum effects
- Previously unknown forms of common materials Previously known as a fairly inert material, gold is highly active in its nanoparticle form**.**

Properties & Usages

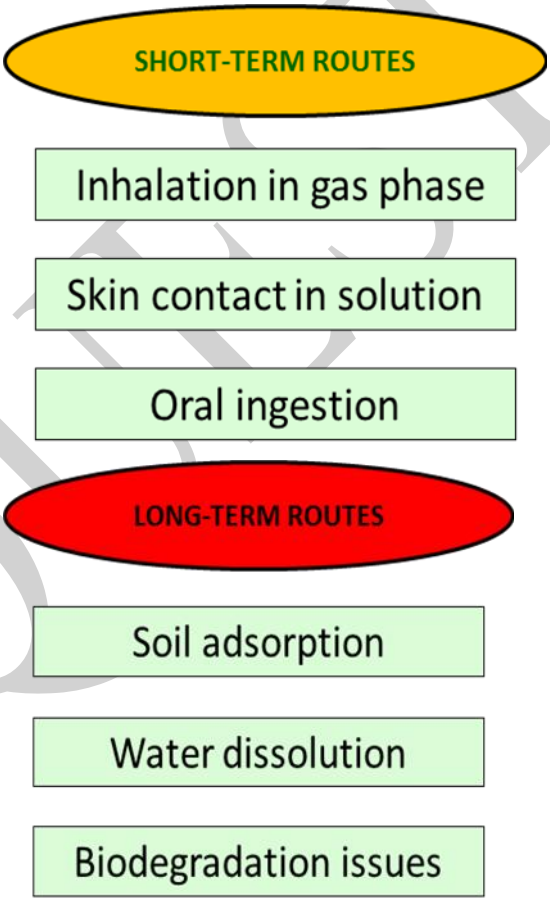
- Ability to penetrate deeper into the protective layers of skin makes them a delivery agents for skin nutrients, & instruct cells to regenerate
- Antioxidant properties helps skin to maintain a youthful appearance
- Specific optical properties and Size combinely used to conceal wrinkles.
- Nanoparticles have already been used in coating textiles such as nylon, to provide antimicrobial characteristics.
- Also the control of porosity at the nanoscale and surface roughness in a variety of polymers and inorganic materials led to ultrahydrophobic - waterproof and stain resistant fabrics.
- Nanoscale intermediate layers between the hard outer layer and the substrate material significantly improve wear and scratch resistant coatings. The intermediate layers are designed to give a good bonding and graded matching of mechanical and thermal properties, leading to improved adhesion.
- Self-cleaning windows have been demonstrated that are coated in highly hydrophobic titanium dioxide. The titanium dioxide nanoparticles speed up, in the presence of water and sunlight, the breakdown of dirt and bacteria that can then be washed off the glass more easily.

Issues & Concern

- All nanoparticles do not produce these adverse health effects - the toxicity of nanoparticles
- It depends on various factors, including: size, aggregation, composition, crystallinity, surface functionalization, etc.
- Due to their small size, nanoparticles can translocate from these entry portals into the circulatory and lymphatic systems, and ultimately to body tissues and organs.
- Some nanoparticles, depending on their composition and size, can produce irreversible damage to cells by oxidative stress or/and organelle injury.

Exposure Scenarios

All substances in the world are toxic to plants, animals and humans at some exposure levels
People working in the nanotechnology industry and consumers of nanotechnology-based products would be the first ones being affected

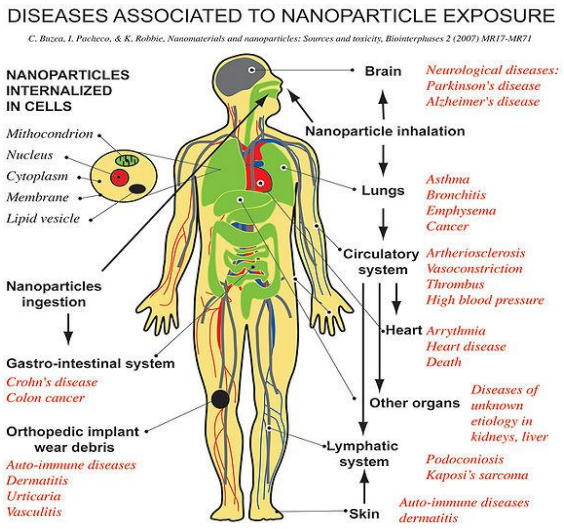


Diseases associated with inhaled nanoparticles

Indoor pollution

According to the Environmental Protection Agency (EPA), Indoor air can be ten times more polluted than outdoor air, due to the generation of nanoparticles through common indoor activities, such as cooking, smoking, cleaning, & combustion (e.g. candles, fireplaces).
Examples of indoor nanoparticles : textile fibers, skin particles, spores, dust mites droppings,

chemicals, smoke from candles, cooking, and cigarettes.



Aluminum

Epidemiological studies researching the connection between aluminum in antiperspirants, antacids, or drinking water and Alzheimer's disease are conflicting, some finding positive associations and others none

Titanium dioxide (TiO2)

Titanium dioxide (TiO2) particles with diameter larger than 100 nm have been widely used in many products, such as food colorant, sunscreens and cosmetic creams .

However, adverse effects of titanium dioxide nanoparticles have recently been uncovered .

Silver nanoparticles

Silver nanoparticles are used as antibacterial/antifungal agents in a diverse range of

applications:

Air sanitizer sprays, Slippers, Face masks, Wet wipes, Detergent, Soap, Shampoo, Toothpaste, Air filters, Coatings of Refrigerators, Vacuum cleaners, Washing machines, Food storage containers, Cellular phones

It was found that the silver nanoparticles were able to trespass the embryo barrier and settle inside, Nuclear deposition is believed to create a cascade of toxic events leading to DNA damage and similar ones

Nanoparticle source	Concentration (nanoparticles/cm3)	Estimated strength (particles/min x 1011)
Cigarette	213,300	3.76
Frying meat	150,900	8.27
Heater	116,800	3.89
Scented	79,600	1.3
Gas stove	69,600	0.88
Vacuum	38,300	0.38
Ironing a	7,200	0.007

Fig: Measured concentrations of nanoparticles resulting from various common indoor household activities

CNT

In a recent study reveals a raising concerns that exposure to carbon nanotubes may lead to pleural abnormalities such as mesothelioma (cancer of the lining of the lungs caused by exposure to asbestos).

Given these risks, effective and rigorous regulation has been called for to determine if, and under what circumstances, carbon nanotubes are manufactured, as well as ensuring their safe handling and disposal.

Control strategies

Questions arise related to the safety of nanoparticles as consumer products**.**

- Are they biocompatible?
- Do the nanoparticles enter the lymphatic and circulatory systems?

- Do they accumulate in the skin and what are the long-term effects of accumulation?
- Do they produce inflammation?
- If they enter the lymphatic and circulatory system, is the amount Significant?

The answers to some of these questions still remain unanswered.

- ❖ Lack of specific regulations on nanotechnology
- ❖ Non-mandatory reports on toxicity of products
- ❖ Old criteria and methods becoming obsolete

International Initiative

Recently, some agencies have taken some actions to establish regulations to

- ❖ International Standards Organization (ISO)
- ❖ US National Nanotechnology Initiative (NNI)
- ❖ British Standards Institute (BSI)
- ❖ Environmental Protection Agency (EPA)
- ❖ Centre for Responsible Nanotechnology-CRN

All these agencies have published reports and guidelines related to the handling of nanomaterials and the research approach to nanotoxicology.(Voluntary)

Governmental agencies worldwide may issue

- ❖ Mandatory guidelines and ground rules for establishing nanotechnology research .
- ❖ New laws that compel companies the exertion of 'responsible' nanotechnology that facilitate the implementation of accurate fate models
- ❖ Establish compromise between testing all the possible scenarios for each nanoparticles & creation of standards to unify tests
- ❖ Determine the exact origin of the toxicity of each nanoparticle to make the pertinent modifications in order to obtain safer products and technologies

Future Nano

As nanotechnology is a double-edge sword, the same novel properties making nanoparticles attractive, makes them potentially toxic.

Care must be taken at Macro level in this field, to

- ➢ Implement Exposure monitoring and control strategies
- ➢ Evaluate the health threats posed by nanoparticles

There is a need to encourage & develop the new discipline "nanotoxicology" that would evaluate enable safe development of the emerging nanotechnology industry

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