What is Green Nanotechnology?

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Topics Covered

Introduction

Nanotechnology is a subject which has been popular within the scientific and technology industries for many years. It is now with the ever growing advancement in technology that nanotechnology is picking up the pace and has got a lot of people talking.

Now, engineers are studying ways that it can be made beneficial to the environment. This has been branded as 'green nanotechnology' since it focuses on challenges within the nanoscale that need to be overcome to ensure eco-friendly processes and products. The objectives of nanotechnology are to create eco-friendly designs with nanotechnology and use it to reduce health and environmental hazards by seeking methods to replace present applications with green nanotechnology products.

Green nanotechnology involves the following:

- Use of less energy during manufacture
- Ability to recycle after use
- Using eco-friendly materials.

Nanotechnologies will not just initiate the next industrial revolution, it will also offer technological solutions. It is expected that green nanotechnologies will assist in the following:

- It will help provide clean water to billions through novel filtration techniques and the

capability to decontaminate dirty water
- A large number of efficiency issues stopping the extensive use of renewable energy generation can be solved using nanotechnology
- Nanotechnology can also help in waste management and environmental remediation.

Nanotechnology for Green Manufacture

Nanotechnology can change the manufacturing process in two ways:

- Using nanotechnology for controlled, effective manufacture will reduce waste drastically
- Using nanomaterials as catalysts will ensure better efficiency in present manufacturing processes and will reduce or eliminate the use of toxic materials and generation of undesirable by-products and effluents.

Research has included using nanotechnology to enhance industrial processes and materials, developing new industrial and chemical procedures, developing materials that will act as a replacement for hazardous processes and constituents causing reductions in materials, energy and waste generation.

Listed below are potential examples of nanotechnology research that may cause elimination or reduction of pollutants of concern:

- Atomic level synthesis of novel and improved catalysts for industrial processes
- Addition of information to molecules to build new molecules
- Self-assembly of molecules as the basis of new materials and chemicals
- Building molecules in microscale reactors

Nanomaterials for Water Treatment

The availability of safe, clean drinking water is a challenge being faced worldwide, especially in developing countries. Water purification methods are chemical intensive and are costly as well as harmful to the environment; they cannot be adapted easily to the non-industrialized world. Nanomaterial-based adsorbents, catalysts and technologies can create eco-friendly solutions for water treatment.

Nanomaterials can be used for detecting and sensing pollutants, treating and remediating contaminants and preventing pollution. Nanomaterials are also used to improve membrane separation processes, resulting in better selectivity and lower costs.

Studies indicate that nanotechnology-based water treatment techniques will be more economical, more durable, and more efficient than the present, traditional ones. Technologies that are available commercially or are under development make use of nanomaterials in meshes, filters, clays, ceramics and adsorbents, catalysts and zeolites.

An example of the contaminant filter technology is carbon nanotube (CNT) membranes. They have a high permeability, increased surface area and good thermal and mechanical stability. They can remove water components such as bacteria, stirred up sediments, viruses and organic contaminants. They will require lesser maintenance when compared to osmosis membranes.

Nanotechnology for Renewable Energy

A research area that is being extensively studied is the ability to harness green nanotechnology to design solar cells. Some novel solar cell materials which have been suggested include nanoparticles such as titanium dioxide, cadmium telluride, quantum dots and silver with a polymer that can absorb solar energy. According to the researchers, the cost of production of these solar cells will be much less than those commercially available now. However, the efficiency of these cells are not very high, hence researchers are working to obtain the desired efficiency.

Other techniques include depositing nanocrystals, nanoparticles suspended in quantum dots, nanoparticle ink, silver cells and nanowires and producing highly stable laminate layers for solar cell protection.

A key challenge in renewable energy technology is that power generation is quite inconsistent and has to be on a largescale. Efficient batteries are required to store extra energy produced during windy or sunny periods, so that it can be used during lulls to ensure there is always a steady supply. It is anticipated that the performance of energy storage technologies can be improved using nanotechnology to enable long-life, high capacity energy storage devices for renewable energy applications.

Nanotechnology for Environmental Remediation and Waste Management

There are several proposed remediation techniques that use nanotechnology. For example, solar photocatalysis using titanium dioxide nanoparticles can degrade pollutants like volatile organic compounds and nitrous oxides and consequently has been used in cement and commercial plants. Paints enriched with nano titanium dioxide, replacing

organic biocides, are used to keep the surfaces of buildings clean.

Soil remediation of abandoned and old military and industrial sites has become a great challenge in industrialized nations. Trials have been set-up using nano zero-valent iron and iron oxides and the results have been quite promising. However, there are environmental concerns regarding the impact of nanoparticles on the soil.

Role of Nanotechnology in Chemical Substitution

In the area of coatings and adhesives, nanotechnology products are proposed as potential substitutes for harmful chemicals such as highly toxic chemicals and heavy metals. It is proposed that nanoparticles of silicon dioxide, titanium dioxide, magnesium oxide or zinc oxide could replace chemical flame retardants such as bromine, which is considered to have high toxicity.

Environmental Concerns with Nanotechnology

One major issue with nanotechnology is that it is difficult to keep track of nanoparticles once they are released into the environment. Therefore, the impact of nanoparticles on ecosystems cannot be determined easily. Long-term exposure to low, highly dispersed doses of nanoparticles may cause a considerable impact - however, this kind of exposure is very tough to model in trials. It is essential that consumers are well educated, to make sure nano-waste streams are under control or at least well understood.

More research needs to be done with regards to structure-function relationships and in correlating chemistry and surface area to toxicity and functionality. Risk assessments must be performed on nanomaterials presenting a real exposure risk during use or manufacture. These findings must consider the toxicological hazard, the biological and environmental fate, the probability of being exposed, persistence, transport, transforming into the completed product, and recycling.

References

- Dealing With Nano-Waste: Can Nanoparticles Be Recycled?
- Is Nanotechnology a Green Industry?
- Environmental Effects of Nanotechnology
- Green Nanotechnology Brochure