Nanomaterials

Nanomaterial’s are engineered particles made to have extremely small dimensions to take advantage of unique physical and chemical properties that exist at the nanoscale.
Nanomaterials can be defined as materials possessing, at minimum, one external dimension measuring 1-100 nm. The particle size of at least half of the particles in the number size distribution must measure 100 nm or below.
Nanomaterials can occur naturally, be created as the by-products of combustion reactions, or be produced purposefully through engineering to perform a specialised function. These materials can have different physical and chemical properties to their bulk-form counterparts.
Nanomaterials are generally composed of two basic components: a metallic part and organic molecules. In addition, nanoparticles possess unique optical properties that arise because of the nanoscale size of the particle and very large surface-to-volume ratio that differs widely from the macroscopic materials. Thus the final size and structure of nanoparticles are important factors that govern the working efficiency. Green nanomaterials are often used to treat a number of diseases in various traditional systems of medicine.
Nanomaterials are the materials that have the dimensions down to the nanoscale.
Nanomaterials are of two types, namely,
(1)Biodegradable (e.g., liposomes, nanoemulsions, biopolymer-based nanoencapsulates)
(2) Nonbiodegradable (e.g., gold, silver,carbon nano tubes, graphite-based nanomaterials).
Biodegradable nanoparticles-based systems have taken an important place in medical applications, especially for cancer therapy.

Synthesis of Nanomaterials

Scientists are conducting research to develop novel materials with better properties, more functionality and lower cost than the existing one. Several physical, chemical methods have been developed to enhance the performance of nanomaterials displaying improved properties with the aim to have a better control over the particle size, distribution methods to Synthesis of Nanomaterials. In general, top-down and bottom-up are the two main approaches for nanomaterials synthesis.

A. **Top-down:** size reduction from bulk materials.

B. **Bottom-up:** material synthesis from atomic level.

   A. **Top-down** routes are included in the typical solid –state processing of the materials. This route is based with the bulk material and makes it smaller, thus breaking up larger particles by the use of physical processes like crushing, milling or grinding. Usually this route is not suitable for preparing uniformly shaped materials, and it is very difficult to realize very small particles even with high energy consumption. The biggest problem with top-down approach is the imperfection of the surface structure. Such imperfection would have a significant impact on physical properties and surface chemistry of nanostructures and nanomaterials. It is well known that the conventional top-down technique can cause significant crystallographic damage to the processed patterns.

   B. **Bottom –up** approach refers to the build-up of a material from the bottom: atom-by-atom, molecule-by-molecule or cluster-by-cluster. This route is more often used for preparing most of the nano-scale materials with the ability to generate a uniform size, shape and distribution. It effectively covers chemical synthesis and precisely controlled the reaction to inhibit further particle growth. Although the bottom-up approach is nothing new, it plays an important role in the fabrication and processing of nanostructures and nanomaterials.

Applications of Nanomaterials

Due to the ability to generate the materials in a particular way to play a specific role, the use of nanomaterials spans across various industries, from healthcare and cosmetics to environmental preservation and air purification.

Medical or Health care field:

The healthcare field, for example, utilises nanomaterials in a variety of ways, with one major use being drug delivery. One example of this process is whereby nanoparticles are being developed to assist the transportation of chemotherapy drugs directly to cancerous growths, as well as to deliver drugs to areas of arteries that are damaged in order to fight cardiovascular disease. Carbon nanotubes are also being developed in order to be used in processes such as the addition of antibodies to the nanotubes to create bacteria sensors.

In aerospace:

Carbon nanotubes can be used in the morphing of aircraft wings. The nanotubes are used in a composite form to bend in response to the application of an electric voltage.

In the cosmetics industry:

mineral nanoparticles –such as titanium oxide –are used in sunscreen, due to the poor stability that conventional chemical UV protection offers in the long-term. Just as the bulk material would, titanium oxide nanoparticles are able to provide improved UV protection while also having the added advantage of removing the cosmetically unappealing whitening associated with sunscreen in their nano-form.

The sports industry: has been producing baseball bats that have been made with carbon nanotubes, making the bats lighter therefore improving their performance. Further use of nanomaterials in this industry can be identified in the use of antimicrobial nanotechnology in items such as the towels and mats used by sportspeople, in order to prevent illnesses caused by bacteria.

Defence Sector:

Nanomaterials have also been developed for use in the military. One example is the use of mobile pigment nanoparticles being used to produce a better form of camouflage, through injection of the particles into the material of soldiers' uniforms. Additionally, the military have developed sensor systems using nanomaterials, such as titanium dioxide, that can detect biological agents.

Everyday Materials and Processes:

Using nanotechnology, materials can effectively be made stronger, lighter, more durable, more reactive, more sieve-like, or better electrical conductors, among many other traits. Many everyday commercial products are currently on the market and in daily use that rely on nanoscale materials and processes.

- Nanoscale additives to or surface treatments of fabrics can provide lightweight ballistic energy deflection in personal body armor, or can help them resist wrinkling, staining, and bacterial growth.

- Clear nanoscale films on eyeglasses, computer and camera displays, windows, and other surfaces can make them water- and residue-repellent, antireflective, self-cleaning, resistant to ultraviolet or infrared light, antifog, antimicrobial, scratch-resistant, or electrically conductive

  *Nanoscale materials are beginning to enable washable, durable "smart fabrics" equipped with flexible nanoscale sensors and electronics with capabilities for health monitoring, solar energy capture, and energy harvesting through movement.

- Light weighting of cars, trucks, airplanes, boats, and space craft could lead to significant fuel savings. Nanoscale additives in polymer composite materials are being used in baseball bats, tennis rackets, bicycles, motorcycle helmets, automobile parts, luggage, and power tool housings, making them lightweight, stiff, durable, and resilient. Carbon nanotube sheets are now being produced for use in next-generation air vehicles. For example, the combination of light weight and conductivity makes them ideal for applications such as electromagnetic shielding and thermal management.

Advantages of Nanomaterials

The properties of nanomaterials, particularly their size, offer various different advantages compared to the bulk-form of the materials, and their versatility in terms of the ability to tailor them for specific requirements accentuates their usefulness. An additional advantage is their high porosity, which again increases demand for their use in a multitude of industries.

In the energy sector, the use of nanomaterials is advantageous in that they can make the existing methods of **generating energy** - such as solar panels - **more efficient and cost-effective**, as well as opening up new ways in which to both harness and store energy.

Nanomaterials are also set to introduce a number of advantages in the electronics and computing industry. Their use will permit an **increase in the accuracy of the construction of electronic circuits on an atomic level**, assisting in the development of numerous electronic products.

The very large surface-to-volume ratio of nanomaterials is especially useful in their use in the medical field, which permits the bonding of cells and active ingredients. This results in the obvious advantage of an **increase in the likelihood of successfully combatting various diseases**.

Disadvantages of Nanomaterials

Alongside their benefits, there are also a number of disadvantages associated with nanomaterial use. Due to the relative novelty of the widespread use of nanomaterials, there is **not a large amount of information on the health and safety aspects of exposure** to the materials.

Currently, one of the main disadvantages associated with nanomaterials is considered to be **inhalation exposure**. This concern arises from animal studies, the results of which suggested that nanomaterials such as carbon nanotubes and nanofibers may cause detrimental pulmonary effects, such as pulmonary fibrosis. Further possible health risks are ingestion exposure and dust explosion hazards.