2.3TYPES OF NANO MATERIALS:

The classification of nanomaterials is based on the number of dimensions. According to Siegel, nanostructured materials are classified as: zero-dimensional (0D), one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) nanomaterials.

(i) Zero-dimensional nanomaterials: Here, all dimensions (*x*, *y*, *z*) are at nanoscale, i.e., no dimensions are greater than 100 nm. It includes Nano spheres andnanoclusters.

(ii) One-dimensional nanomaterials: Here, two dimensions (*x*, *y*) are at nanoscaleand the other is outside the nanoscale. This leads to needle shaped nanomaterials. Itincludes nanofibers, nanotubes, Nano rods, and nanowires.

(iii) Two-dimensional nanomaterials: Here, one dimension (*x*) is at nanoscale and the other two are outside the nanoscale. The 2D nanomaterials exhibit plate- like shapes. It includes nanofilms, nanolayers and nanocoatings with nanometre thickness.

(iv) Three-dimensional nanomaterials: These are the nanomaterials that are not confined to the nanoscale in any dimension. These materials have three arbitrary dimensions above 100 nm. The bulk (3D) nanomaterials are composed of a multiple arrangement of Nano size crystals in different orientations. It includesdispersions of nanoparticles, bundles of nanowires and nanotubes as well as multi- Nano layers (polycrystals) in which the 0D, 1D and 2D structural elements are in close contact with each other and form interfaces.

For the better understanding, nanomaterials are again organized into four typesas follows.

(i)Carbon based materials

(ii)Metal based materials

(iii)Dendrimers

(iv)Composites

(i)Carbon based materials: These are composed of carbon, taking the form of hollow spheres, ellipsoids or tubes. The spherical and ellipsoidal forms are referredas fullerenes, while cylindrical forms are called nanotubes.

(ii)Metal based materials: These include quantum dots, Nano gold, Nano silver andmetal oxides like TiO2. A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, whose size is on the order of a few nanometers to a few hundred nanometers.

(iii)Dendrimers: Dendrimers are repetitively branched molecules. The name comes from the Greek word ‘dendron’ (tree). These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can perform specific chemical functions. Dendrimers are used inmolecular recognition, nanosensing, light harvesting, and opto-electrochemical devices. They may be useful for drug delivery.

(iv)Composites: Composites are combination of nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles like nanosized clays are added to products (auto parts, packaging materials, etc.) to enhance mechanical, thermal, and flame-retardant properties.

PROPERTIES AND USES OF NANOPARTICLES:

Definition:

A nanoparticle is a small particle that ranges between 1 to 100 nanometres in size. Undetectable by the human eye, nanoparticles can exhibit significantly different physical and chemical properties to their larger material counterparts.

Properties

The material properties change as their size approaches the atomic scale. This is due to the surface area to volume ratio increasing, resulting in the material's surface atoms dominating the material performance. Owing to their very small size, nanoparticles have a very large surface area to volume ratio when compared to bulk material, such as powders, plate and sheet. This feature enables nanoparticles to possess unexpected optical, physical and chemical properties, as they are small enough to confine their electrons and produce quantum effects.

For example, copper is considered a soft material, with bulk copper bending when its atoms cluster at the 50nm scale. Consequently, copper nanoparticles smaller then 50nm are considered a very hard material, with drastically different malleability and ductility performance when compared to bulk copper. The change in size can also affect the melting characteristics; gold nanoparticles melt at much lower temperatures (300 °C for 2.5 nm size) than bulk gold (1064 °C). Moreover, absorption of solar radiation is much higher in materials composed of nanoparticles than in thin films of continuous sheets of material.

Uses of Nanoparticles:

Nanomaterials can occur naturally, be created as the by-products of combustion reactions, or be produced purposefully through engineering to perform a specialized function.

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

The healthcare field, for example, utilizes 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.

Elsewhere, environmental preservation processes make use of nanomaterials too - in this case, nanowires. Applications are being developed to use the nanowires - zinc oxide nanowires - in flexible solar cells as well as to play a role in the treatment of polluted water.

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 and 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.

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.

The use of Nano-titanium dioxide also extends to use in coatings to form self-cleaning surfaces, such as those of plastic garden chairs. A sealed film of water is created on the coating, and any dirt dissolves in the film, after which the next shower will remove the dirt and essentially clean the chairs.

Controlling the size, shape and material of the nanoparticle enables engineers to design photovoltaics (PV) and solar thermal products with tailored solar absorption rates. Absorption of solar radiation is much higher in materials composed of nanoparticles than in thin films of continuous sheets of material.

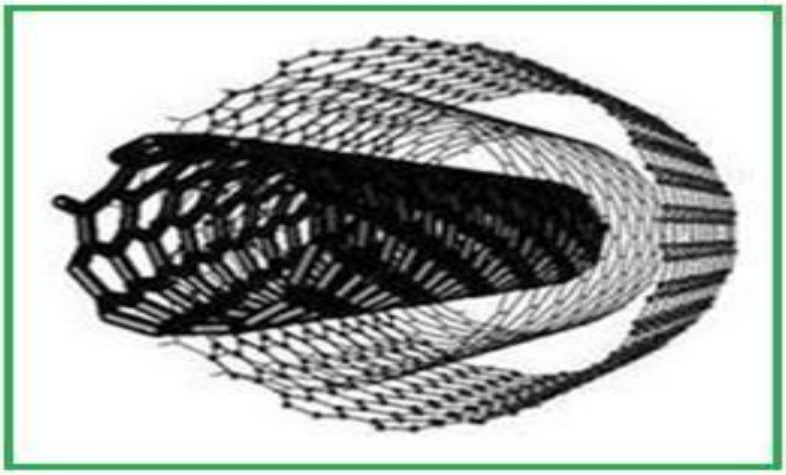
The Sol-Gel process is a method for producing solid material from nanoparticles. Whilst it is generally viewed as a relatively new industrial technology, it is used extensively in a number of industries, such as abrasive powder manufacture, coatings production and optical fibres.

PROPERTIES AND USES OF NANOTUBES:

The carbon nanotubes (elongated form of fullerenes) were identified in 1991 by Iijima Sumio of Japan. A carbon nanotube is a tube-shaped material, made up of carbon, having a diameter ranging from < 1 nm to 50 nm. Simply we can say, carbon nanotubes (CNTs) are cylinders of one or more layers of graphene (lattice). Carbon nanotubes show a unique combination of stiffness, strength, and tenacity compared to other fibre materials. Thermal and electrical conductivity are also very high as comparable to other conductive materials. Carbon nanotubes may be categorized as follows:

Single-wall nanotubes (SWNT): These may be zigzag, armchair and chiral depending on the manner in which the grapheme sheets are rolled.

Multi-wall nanotubes (MWNT): It consists of several single walled nanotubes with different diameters.



Multi-walled nanotube

Applications

Carbon nanotube technology can be used for a wide range of new and existingapplications, which are as follows:

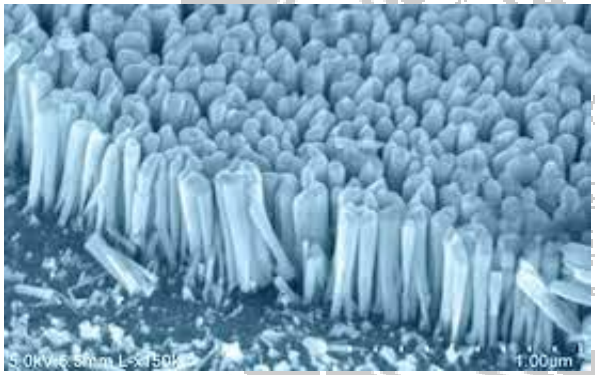
- Nanotubes can potentially replace indium tin oxide in solar cells to generatephotocurrent.
- SWNTs are used in transistors and solar panels.
- MWNTs are used in lithium ion batteries to enhance cycle life.
- Parallel CNTs have been used to create loudspeakers.
- CNTs can serve as a multifunctional coating material.
- CNTs can be used to produce nanowires.

CNTs are also used for applications in energy storage, automotive parts, boathulls, water filters, thin-film electronics coatings, ultra-capacitors, biosensors for harmful gases, extra strong fibers, etc.

NANOWIRES:

properties

These are defined as the structures which have the diameters of the order of a nanometre and an unconstrained length. i.e., nanowires are much longer than their diameters. These are also called *quantum wires* because at this scale they have different quantum mechanical effects. There are different types of nanowires. For example: carbon nanowires, molecular nanowires, metallic nanowires, etc.



Nanowire

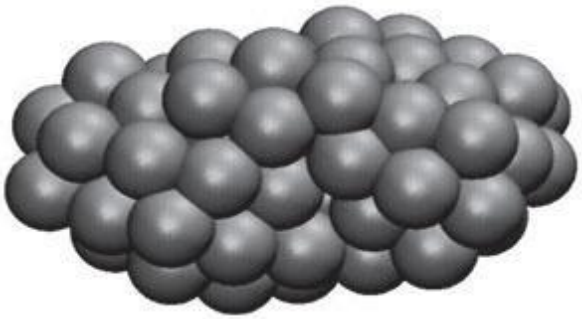
Applications

- They are useful in digital computing.
- These are used for the preparation of active electronic components like p-njunction, logic gates, etc.
- They have potential applications in high-density data storage.
- Silver chloride nanowires are used as photocatalysts to decompose organicmolecules in polluted water.

NANOCLUSTURE:

properties

It is the grouping of a number of nanoparticles in a narrow size distribution having at least one-dimension between 1 and 10 nm. Simply, they are fine aggregates of atoms or molecules. Nanoclustures contain a couple of hundred atoms but the larger aggregates may have more than 1000 atoms (called *nanoparticles*). The number of atoms in the clusters of critical size with higher stability is called *magic number*. The nanoclustures are bridge between bulk materials and atomic or molecular structures.



Nanoclusture

Applications

A bulk material has constant physical properties but at the nanoscale, it has many properties.

- It is used in biotechnology and pharmacology.

- It has potential applications in microelectronics, telecommunications,sensors, transducers, electroluminescent displays, catalysis, etc.

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