Carbonnanotubes (Properties and Uses)

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Abstract:- One of the most important inventions of nanotechnology is carbonnanotubes(CNTs). These have great potential in different fields, hence being studied by many researchers around the world. Along with their light weight and small size their good conducting properties and high tensile strength makes them perfect to be used in variety of fields. CNTs have unique mechanical, electrical and optical properties. Presently they are used as fillers in different materials like in polymers and ceramics. In future, they may find uses in capacitors, transistors, sensors, nanomedicines etc. They may have some toxic effects. In the present paper here is brief discussion of preparation, properties, uses and toxic effects of CNTs.

Nanotechnology:- Word "Nano" is from the Greek, meaning "Dwarf". The word "Nanotechnology" was coined by Norio Taniguchi in 1974 in Japan. The materials are dealt at atomic and molecular levels. It has become a vast field from last three decades.

Carbonnanotubes(CNTs):- CNTs are cylindrical carbon molecules with unique properties which make them useful in different fields. These are called buckytubes. CNTs belong to fullerene family, which were discovered by Kroto et al. Buckyballs are spherical e.g. C_{60} or like rugby ball e.g. C_{70} whereas CNTs are cylindrical with either one or both ends capped by hemisphere with the buckyball structure. In CNTs carbon is sp^2 hybridised. CNTs possess extraordinary strength and hence find applications in nano-electronics, optics and material applications.

Types of CNTs:- On the basis of number of tubes present in CNTs, they are divided into three categories:-

(i) Single walled CNTs, which are made of a single graphene sheet rolled upon itself with a diameter of 1-2 nm.

(ii) Double walled CNTs, which are made up of two concentric carbon nanotubes in which the outer tube encloses the inner tube.

(iii) Multi walled CNTs, which consist of multiple layers of graphene rolled upon itself with diameter ranging from 2-50 nm depending on the number of graphene tubes. These have an approximate interlayer distance of 0.34 nm.

Synthesis of CNTs:- These can be prepared by various methods such as Arc Discharge method, in which carbon needles with diameter ranging from 4-30 nm were grown on cathode of a carbon electrode, by means of Direct Current Arc-Discharge evaporation of carbon in an Argon filled vessel. Second method is Laser Ablation, in which graphite target is bombarded with laser light. The tube grows until too many catalyst atom group on the end of nanotube. This allows the tube to terminate with fullerene like tip. Third method is Chemical Vapour deposition in which a mixture of hydrocarbon gases acetylene, methane, ethene and nitrogen is introduced into the reaction chamber. Reaction takes place at temperatures 700^{o}C-900^{o}C at 1 atmospheric pressure. Nanotubes obtained by this method are of lower quality. Fourth method is Vapour Phase growth. It is the modified form of Chemical Vapour deposition .In this method catalyst is ferrocene. Fifth method is Flame Synthesis method. In this method hydrocarbon flames assists with the initiation and growth of CNTs. Gases like carbon monoxide, methane, acetylene, ethene etc. are present in the post flame area. Exothermic reaction takes place in this presence of catalysts. Recently, a nebulized spray pyrolysis method has been tried for the synthesis of CNTs. Using an ultrasonic nebulizer, ferrocene (catalysts) and ethanol (carbon source and solvent) CNTs are prepared. Ethanol has non-polluting nature.

Properties:- CNTs have extremely high surface area, high aspect ratios and high mechanical strength. Tensile strength of CNTs is hundred times greater than steel and electrical and thermal conductivity is comparable to copper. Hence, they are good fillers and incorporating agents.

Electronic Nature of CNTs:- In CNTs carbon atoms are sp^2 hybridised and bonded to three other carbon atoms to form hexagonal lattice. One electron remains free in each unit. These electrons are delocalised all over the crystal and contribute to the electrical nature of CNTs. Geometric differences such as defects, chirality, different diameters and the degree of crystallinity of the tubular structure greatly influences the electronic properties of CNTs.

Mechanical Properties of CNTs:- CNTs are very strong materials especially in the axial direction with tensile strength of the order of 11-63 GPa. Many recent technologies show that CNTs are rather soft in radial direction, hence used in nanocomposites. These are one of the toughest and stiffest modern materials. Guanghua et al showed theoretically that the mechanical properties of CNTs are dependent on diameter. Increase in diameter enhances the mechanical properties.

Thermal properties of CNTs:- Thermal properties of CNTs are also very important. Factors influencing their thermal properties are number of Phonon active modes, the length of the free path for Phonons and boundary surface scattering. These properties also depend on the atomic arrangement, the diameter and the length of the tubes, morphology, structural defects and presence of impurities in CNTs.

Applications of CNTs: - Nano-technology is the latest and the most developed technologies, which can be used in different applications in various fields including medicine, environment, energy, sensor material. CNTs due to their electrical, mechanical and thermal properties can be used in various fields as described below:-

CNTs as Fillers:- The use of CNTs as fillers in different materials to form nanocomposites in one of the most developed fields in nanotechnology. When CNTs are added to polymers or ceramics, their qualities are improved.

In Electronic Devices:- When a potential is applied between the CNT surface and the anode, electrons are emitted from their tips. Hence CNTs can be used for the fabrication of the multiple electronic devices, including flat panel display, intense light sources, bright lamps and x-ray sources.

In Lithium-ion batteries:- Lithium has lowest standard reduction potential. And is the lightest metal. Hence lithium is best for the fabrication of light weight and efficient batteries. Its high reactivity limits its efficacy. This problem is solved by intercalating lithium ions within CNTs. Such batteries have good storage capacity and enhanced lifetime.

CNTs in Supercapacitors :- Due to their large surface area and high electrical conductivity , CNTs are excellent materials for use in electrochemical devices. CNT embedded supercapacitors can be used to provide fast acceleration. But their efficiency decreases with rise of temperature.

In Sensors :- Sensors are important detecting devices that are now widely used in different fields. The efficiency of biosensors and molecular sensors can be enhanced by attatching CNTs on them. According to scientists, it is possible to construct various types of sensors containing nano composite pellets, which are very sensitive to gases and which can be used to detect leakage of gases in chemical plants. CNTs and its composites can be used as sensitive environmental pressure sensors.

Medial Applications Of CNTs :- The science of nanomedicines has become the most rapidly growing field. CNTs have proven their potential for safer drug delivery method. They can pass through membrane carrying therapeutic drugs, vaccines and nucleic acids deep into the cell to the substrate targets. They serve as ideal non-toxic vehicles, which in some cases increases the solubility of drug, resulting in greater efficiency and safety.

Toxicity OF CNTs :- CNTs have adverse effect on human health, especially on lungs. Overexposure to CNT dust also causes inflammation and oxidative stress.

Conclusion :- The synthesis, structure, properties, applications and toxicity of CNTs have been briefly reviewed in this paper, due to great potential of CNTs , it is clear that novel technologies will emerge in the near future, but the problem associated with these technologies is the quantity and cost of CNTs, larger quantities of nanotubes

are needed if composite materials are to be fabricated. Biological micro filters, virus inhibitors, low cost gas sensors etc., will be produced using CNTs in future.

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