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An Overview on Nanoparticles

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ABSTRACT

Nanoparticles are of great interest for a wide variety of applications in the field of information, energy, environmental and medical technologies due to their unique properties determined primarily by size, composition and structure along with their self-organized film structures. For the past few years, there has been a considerable research on the basis of Novel drug delivery system, using particulate vesicle systems as such drug carriers for small and large molecules. Nanoparticles have been modifying the therapeutic effect of drugs and minimize the side effects. Basically, Nanoparticles have been prepared by using various techniques as such Gas Condensation, Vacuum Deposition and Vaporization, Chemical Vapor Deposition (CVD) and Chemical Vapor Condensation (CVC) along with evaluations of nanoparticles.

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INTRODUCTION:

Nanotechnology is a field of science that includes synthesis as well as development of various nanomaterials. Nanoparticles are defined as objects ranging in size from 1-100 nm that due to their size may differ from the bulk material. Various metallic nanomaterials are being produced using copper, zinc, titanium, magnesium, gold, alginate and silver. Nanoparticles are used for purposes from various branches of industry production such as solar and oxide fuel batteries for energy storage, to wide incorporation into diverse materials of everyday use such as cosmetics or clothes, medical treatment. A nanoparticle is the important component in the fabrication of a nanostructure, and is far smaller than the world of everyday objects that are described by Newton ' s laws of motion, but bigger than an atom or a simple molecule that are governed by quantum mechanics.[1]

Nanoparticles (from Greek nanos – dwarf) are organic or inorganic solid particles. The dimension of nanoparticles is not defined in a uniform manner.

a) Particles in the sub micron range (< 1 μm) ,

b) Materials science: < 100 nm (nano scaled particles)

c) Pharmaceutics: < 500 nm, < 1000 nm = 1μm

Usually nanoparticles are dispersed in a continuous phase .

Table No.1 Historical overview – Nanotechnology and nanoparticles

Year	Scientist	Work
1857	Faraday	Synthesis of colloidal gold nanoparticles, colour effects
1915	Ostwald, Wolfgang	Colloids - world of neglected dimensions
1931	Ruska, Knoll	development of an electron microscope TEM, 1938 built commercially by Siemens
1942	Knöpfer	Aerosil process (Degussa) – pyrogenic silica, 1953 aluminium oxide, 1954 titanium dioxide
1959	Feynman	lecture on the prospects of miniaturisation, "There's plenty of room at the bottom"
1968	Stöber, Fink, Bohn	Synthesis of monodisperse silica, described before in 1956 by Kolbe in PhD thesis
1974	Taniguchi, Norio	"Nanotechnology" for processing of separation, consolidation, and deformation of materials by one atom or one molecule
1985	Smalley, Curl, Kroto	Buckminster fullerenes, e.g. C60 carbon
1986	Binnig, Quate, Gerber	construction of an atomic force microscope AFM, 1981 Binnig, Rohrer construction of a scanning tunnelling microscope
1989	Eigler, Schweizer	IBM logo written with 35 Xe-atoms on Ni
1991	Iijima	Carbon nanotubes

SYNTHESIS OF NANOMATERIAL

1. Gas Condensation

Gas condensation was the first method used to synthesize nanocrystalline metals and alloys. In this method, a metallic or inorganic material is vaporized using thermal evaporation sources such as a Joule heated refractory crucibles, electron beam evaporation devices, in an atmosphere of 1-50 m bar. In this method a high residual gas pressure causes the formation of ultra fine particles (100 nm) by gas phase collision. The ultrafine particles are formed by collision of evaporated atoms with residual gas molecules. In this gas pressures greater than 3 mPa (10 torr) are required. Vaporization sources used may be resistive heating, high energy electron beams, low energy electron beam and inducting heating. Clusters form in the vicinity of the source by homogenous nucleation in the gas phase grew by incorporation by atoms in the gas phase. It comprises of a ultra high vacuum (UHV) system fitted evaporation source, a cluster collection device of liquid nitrogen filled cold finger scrapper assembly and compaction device. During heating, atoms condense in the supersaturation zone close to Joule heating device. The nanoparticles are removed by scrapper in the form of a metallic plate. Evaporation is to be done from W, Ta or Mo refractory metal crucibles.[2] If the metals react with crucibles, electron beam evaporation technique is to be used. The method suffers from limitations such as a source-precursor incompatibility, temperature ranges and dissimilar evaporation rates in an alloy. For instance, Fe is evaporated into an inert gas atmosphere (He). Through collision with the atoms the evaporated Fe atoms loose kinetic energy and condense in the form of small crystallite crystals, which accumulate as a loose powder. Sputtering or laser evaporation may be used instead of thermal evaporation .[3]

2. Vacuum Deposition and Vaporization

In vacuum deposition process, elements, alloys or compounds are vaporized and deposited in a vacuum . The vaporization source is the only one that vaporizes materials by thermal processes. The process is carried out at pressure of less than 0.1 Pa (1 m Torr) and in vacuum levels of 10 to 0.1 MPa. The substrate temperature ranges from ambient to 500°C. The saturation or equilibrium vapor pressure of a material is known as the vapor pressure of the material in equilibrium with the solid or liquid surface. For vacuum deposition, a reasonable deposition rate can be obtained if the vaporization rate is fairly high. Vapor phase nucleation can occur in dense vapor cloud by multibody collisions, the atoms are passed through a gas to provide necessary collision and cooling for nucleation. These particles are in the range of 1 to 100 nm and are called ultra fine particles or clusters. [4-6]

3. Chemical Vapor Deposition (CVD) and Chemical Vapor Condensation (CVC)

CVD is a process in which a solid is deposited on a heated surface via a chemical reaction from the vapor or gas phase. CVC reaction requires activation energy to proceed. This energy can be provided by several methods. In thermal CVD the reaction is done by a high temperature above 900°C. A typical apparatus consist of gas supply system, deposition chamber and an exhaust system. In plasma CVD, the reaction is activated by plasma at temperatures between 300 and 700°C. In laser CVD, pyrolysis occurs when laser thermal energy heats an absorbing substrate. In photo-laser CVD, the chemical reaction is induced by ultra violet radiation which has sufficient photon energy, to break the chemical bond in the reactant molecules. In this process, the reaction is photon activated and deposition occurs at room temperature. Nano composite powders have been prepared by CVD. SiC/Si3N composite powder was prepared using SiH4, CH4, WF6 and H2 as a source of gas at 1400°C. Another process known as chemical vapor condensation (CVC) was developed in Germany in 1994. It involves pyrolysis of vapors of metal organic precursors at a reduced pressure atmosphere. [7]

4. Chemical Precipitation

In this technique the size is control by arrested precipitation technique. The basic thing has been to synthesis and studies the nanomaterial in situ i.e. in the same liquid medium avoiding the physical changes and aggregation of tiny crystallites. Thermal coagulation and Oswald ripening were controlled by double layer repulsion of crystallites using non-aqueous solvents at lower temperatures for synthesis. The synthesis involved reaction between constituent

material in suitable solvent . Surfactant is used to maintain separation between the particles. Thus formed nanocrystal are separated by centrifugation, washed and vacuum dried. The dried material was further subjected to UV curing for possible polymerization of surfactant capping film on the surface of nano cluster for imparting true quantum confinement. [8,9]

5. Sol-Gel Techniques

Colloidal particles are very larger than normal molecules or nanoparticles. However, upon mixing with a liquid colloids appear bulky whereas the nanosized molecules always look clear. This technique involves the evolution of networks through the formation of colloidal suspension (sol) and gelatin to form a network in continuous liquid phase (gel). The precursor for synthesizing these colloids consists of ions of metal alkoxides and aloxysilanes. The most widely used are tetramethoxysilane (TMOS), and tetraethoxysilanes (TEOS) which form silica gels. Alkoxides are immiscible in water. They are organo metallic precursors for silica, aluminum, titanium, zirconium and many others. Mutual solvent alcohol is used.[10-13]

EVALUATION OF NANOPARTICLES

Zeta potential [14]

The Zeta potential of a nanoparticle is commonly used to characterized the surface charge property of nanoparticles. It reflects the electrical potential of particles and is influenced by the composition of the particle and the medium in which it is dispersed. Nanoparticles with a zeta potential above (±) 30 mV have been shown to be stable in suspension, as the surface charge prevents aggregation of the particles.

Particle Shape [15]

SEM characterizes the nanosuspension before going for evaluation; the nanosuspension is lyophilized to form solid particles. The solid particles are coated with platinum alloy using a sputter coater.

Particle size [16]

Particle size and size distribution are the most important characteristics of nanoparticle systems. They determine the in vivo distribution, biological fate, and toxicity and targeting ability of nanoparticle system. In addition, they can also influence the drug loading, drug release and stability of nanoparticles. Currently, the faster and most routine method of determining particle size is by photon-correlation spectroscopy or dynamic light scattering. The results obtained by photon-correlation spectroscopy are usually verified by scanning or transmission electron microscopy (SEM or TEM).

Drug Entrapment Efficiency [17]

The nanoparticles were separated from the aqueous medium by ultracentrifugation at 10,000 rpm for 30 min at 50C. Then the resulting supernatant solution was decanted and dispersed into phosphate buffer saline pH 7.4. Thus the procedure was repeated twice to remove the unentrapped drug molecules completely. The amount of drug entrapped in the nanoparticles was determined as the difference between the total amount of drug used to prepare the nanoparticles and the amount of drug present in the aqueous medium.

Drug Entrapment efficiency (%) = Amount of released from the lysed nanoparticle X 100 Amount of drug initially taken to prepare the Nanoparticles.

APPLICATIONS

1. Targeted Drug delivery

A key area in drug delivery is the accurately targeting of the drug to cells or tissue of choice. Drug targeting systems should be able to control the fate of a drug entering the body. Today's delivery technologies are far away from the design of the so called "magic bullet", proposed by Paul Ehrlich at the beginning of the 20th century, in which the drug is precisely targeted to the exact side of action. Nanotechnology offers here another challenge to come to this goal a bit closer, to deliver the drug in the right place at the right time .[18] Nanotechnology is expected to bring a fundamental change in manufacturing in the next few years and will have an enormous impact on Life Sciences, including drug delivery, diagnostics, nutriceuticals and the production of biomaterials.

2. Applications of nanotechnology

The main application involved in use of nanoparticles for biomedical applications, such as drug and gene delivery, cancer treatment and diagnostic tools, food etc and also nanoparticle created a huge interest due to their very small size and large surface-to-volume ratio, and they display absolutely novel uniqueness contrast to the large particles of bulk material.

3. Applications of nanoparticles in food

Nanofood is a term used to describe foods that use nanotechnology techniques, tools or manufactured nanomaterials that have been added during cultivation, production, processing or packaging. There are several purposes for the development of nanofood. These include improvement of food safety, enhancement of nutrition and flavor, and cutting production and consumer costs. In addition, nanofood provides various benefits by which include health promoting additives, longer shelf lives and new flavor varieties The application of nanotechnology in food is rapidly emerging and is involving all areas of the food chain from agricultural applications to food processing and enhancing bioavailability of nutrients.

4. Application of nanoparticle in gene delivery

Gene delivery is a technique which plays a vital role that can efficiently introduce a gene of interest in order to express its encoded protein in a suitable host or host cell. Now a day, there are different types of primary gene delivery systems that mainly employ viral vectors like retroviruses and adenoviruses, nucleic acid electroporation, and nucleic acid transfection .

5. Application of nanoparticle in cancer treatment

There are a variety of nanoparticle systems currently under investigation to be applied in biomedical with the emphasis on cancer treatment. There are a various nanoparticle systems currently investigated and explored for biomedical applications with some particular emphasis for cancer therapeutics; hence some precious metals (mainly gold and silver systems) and some magnetic oxides (in particular magnetite Fe_3O_4) received much interest including quantum dots and some of what is called natural nanoparticles.

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