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A Study of Structural & Optical Properties of Nanoparticles

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Introduction:

Nanotechnology has played a crucial part in our everyday lives in recent years. New innovations in science and engineering have been driven by the development of nanomaterials. By enhancing health care, nanotechnology makes our lives safer. Nanotechnology can address the energy issue by maximising energy resources and creating low-cost solar cells, hydrogen generation, and batteries (Richard Booker et al. 2005). In the near future, nanotechnology will transform every sector and many new applications based on nanotechnological advances will be seen. Nanomaterials by their dimensions are divided into four categories.

i) Zero dimension:quantumdots,
ii) one dimension:qunatumwell,
iii) Two dimension: quantum wire,
iv) Three dimension:Bulk materials

The new study is based on quantum dots, which means that nanostructures of zero dimensions are widely used by nanoelectronic devices.

From ancient times, nanomaterials emerge. Nanomaterials are extremely tiny, one billionth of a metre dimensional particles (10-9). In comparison with bulk materials, the nanoscale material has improved physical, chemical, mechanical and magnetic characteristics. Thus, nanoparticles have superior characteristics over traditional materials. Cereals and grain borders consist of nanostructured materials. The granular size reduces, and the flaw density increases as the bulk material is transformed into a nanomaterial. Nanostructure flaws improve the nanomaterials' properties. Nanoparticles are the nanostructured substance of zero dimensions and the tiniest building pieces that form the entire crystal structure. In comparison with bulk materials the physical characteristics of nanostructures are described as per;

The ratio of atoms on the surface to atoms in the inside may be on the order of unity.

- The surface energy-to-total energy ratio might be on the order of unity.
- Because the conduction or valence electrons are limited to a tiny length or volume, the lowest electronic state's quantum wavelength is constrained, and therefore the minimum wavelength is lower than in the bulk solid.
- The optical absorption spectrum is affected by wavelength or boundary condition shifts.
- Because it is difficult to generate and move dislocations in spatially restricted areas, metal nanocluster assemblies may have high hardness and yield strength.

Structural Properties of Nanoparticles

When comparing nanomaterials to bulk solids, the surface area to volume ratio rises as the radius of the atoms decreases [3]. When a large volume is broken down into smaller bits, the particle size shrinks and the number of atoms on the surface rises. Surface effects may also be seen in bigger particle systems, depending on the chemical composition, crystalline structure, and other inherent characteristics of the nanoparticles. The surface effects are caused by the lattice breaking symmetry at the nanoparticles' surface. The material is becoming increasingly chemically reactive, and surface forces are taking over. When a bulk material is reduced to nanoscale, new surfaces are created as the surface area grows.

The surface area of nanoparticles is determined by particle size, porosity, and shape. The surface area to volume ratio of a nanoparticle-based material or substance has a substantial impact on the material's characteristics [4]. When compared to the same amount of material made out of larger particles, nanoparticle-based materials have a greater surface area. Consider the case of a sphere of radius r.

The surface area of the sphere = $4\pi r^2$

The volume of the sphere = $(4/3)\pi r^3$

Therefore, the surface area to the volume ratio will be $4\pi r^2 / (4\pi r^3 /3) = 3/r$

It demonstrates that when the radius of the atom decreases, the surface area to volume ratio rises, and vice versa. When the size of a substance is reduced, the surface area rises, and more atoms are located on the surface than on the interior. The structural characteristics of nanoparticles are investigated using an X-ray diffractometer, a scanning electron microscope, a transmission electron microscope, and a high-resolution transmission electron microscope. Energy Dispersive X-Ray (EDX) Spectroscopy is used to investigate the material's elemental makeup. The atomic proportion of the elements contained in the sample is determined by the EDX spectrum.

Optical Properties of Nanoparticles

Nanoparticles have significantly varied optical properties than bulk materials. The nanoparticle's optical properties rely on the material type. Surface plasmones are electron oscillations on the nanoparticles' surface. The metal may be discovered. When an electromagnetic wave is focused on the surface of a nanoparticle, surface plasmones capture the energy and light emitted by the material. The size and the kind of material of light produced by nanoparticles are governed by their wavelength. The size of the oscillated electron and its dielectric constant affect the frequency of the nanoparticles. The surface plasmon resonance is the cause of Raman dispersion and fluorescence measurements.

The metal sphere's plasmon oscillation and its relative charge electron displacement. The absorbent spectrum varies with regard to the size of nanoparticles in semiconducting nanoparticles. The nanoparticles' band gap value varies with their size. The electron absorbs the photons when an electromagnetic wave falls on the nanoparticle and becomes excited about the conductor band. The coulomb potentials attract Electron and hole and create an exciton termed quasi-paraglium. The generation of exciton relies on the discrete energy set. The spectrum of absorption is turned blue to lower wavelengths. Nanoparticles have a high volume-to-volume surface ratio, which results in corresponding alterations in the emission spectrum.

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