UNIT II

NANO CHEMISTRY INTRODUCTION

2.1 WHAT IS NANO CHEMISTRY

Nano chemistry is a branch of nanoscience, deals with the chemical applications of nanomaterials in nanotechnology.

Nano chemistry involves the study of the synthesis and characterisation of materials of nanoscale size.

Nano chemistry is a relatively new branch of chemistry concerned with the unique properties associated with assemblies of atoms or molecules of nanoscale (~1-100 nm), so the size of nanoparticles lies somewhere between individual atoms or molecules (the 'building blocks') and larger assemblies of bulk material which we are more familiar with.

There are physical and chemical techniques in manipulating atoms to form molecules and nanoscale assemblies.

Physical techniques allow atoms to be manipulated and positioned to specific requirements for a prescribed use.

Traditional chemical techniques arrange atoms in molecules using well characterised chemical reactions.

Nano chemistry is the science of tools, technologies, and methodologies for novel chemical synthesis e.g. employing synthetic chemistry to make nanoscale building blocks of desired (prescribed) shape, size, composition and surface structure and possibly the potential to control the actual self-assembly of these building blocks to various desirable size.

At this extremely small scale level, quantum effects can be significant, fascinating and potentially scientifically very rewarding innovative ways of carrying out chemical reactions are possible.

The small size of nanoparticles gives these particles 'unusual' structural and optical properties with applications in catalysis, electro optical devices etc.

As well as the huge numbers of man-made nanoparticles structures being synthesised, there are naturally occurring nanoparticle assemblies e.g. phospholipid vesicles, polypeptide micelle of the iron storage protein, ferritin.

Nanoparticles are very tiny aggregations of atoms but bigger than most molecules.

There is no strict dividing line between nanoparticles and 'ordinary bulk' particles of a material such as baking powder or grains of sand, but particle size matters! ...

Because nanoparticles can display properties significantly different from the bulk material and these properties can be exploited for many different uses. If you compare the size of nanoparticles to that of conventional industrially produced materials, you find they have novel uses such as sunscreens and many present future applications e.g.

Nanoparticles have a high surface to volume ratio which has a dramatic effect on their properties compared to non-nanoscale more bulky forms of the same material.

Nanoparticles have a very high surface to volume ratio and this gives them special properties different from the bulk material e.g.

This difference in surface area / volume ratio for the particles of the material give nanoparticles extra chemical reactivity compared to the bulk material,

less of a material like a catalyst is needed in a chemical process, so catalysts based on nanoparticles are more efficient than those based on bulk material catalysts.

New applications for nanoparticle materials are an important area of research.

Nanoparticles have many applications in medicine for controlled drug delivery via fullerenes - an example of Nano medicine application.

One idea being explored in Nano medicine, is that tiny nanoparticles are more easily absorbed through the skin - an alternative way of delivering a drug directly into the cells where needed.

Nanotechnology is being applied to the production of synthetic skin and implant surgery.

Nanomaterials that conduct electricity are being used in electronics as minute conductors to produce circuits for microchips.

Materials in cosmetics, deodorants and sun creams may be of nanoparticle size and they are used to improve moisturisers without making them too oily.

The tiny nanoparticles don't leave white marks on the skin.

Nanoscale materials are being developed as new catalysts for fuel cells.

Nanoparticle substances are incorporated in fabrics to prevent the growth of bacteria.

What are Nanomaterials?

Nanomaterials are particles that have their size in 1-100 nm range at least in one dimension. There are different sources of these particles. For example, we can get these particles as engineered particles, as incidental components and via natural sources. There are several forms of nanomaterials;

1. Nanomaterials – They have all their dimensions in 1-100 nm scale.
2. One dimensional nanostructure – one dimension has its size outside the nanoscale.
3. Two-dimensional nanostructures – two of the dimensions are not in nanoscale.
4. Bulk nanostructures – none of the dimensions is in the nanoscale (all are above 100 nm).

What are Bulk Materials?

Bulk materials are particles that have their size above 100 nm in all dimensions. Most of the times, we use this term in order to name a substance that is granular or lumpy and exists in free-flowing form. we use the grain size and grain distribution in characterizing these materials. Moreover, we can explain their properties using the bulk density, moisture content, temperature, etc. There are two forms of these materials as follows:

1. Cohesion less, free-flowing bulk materials
2. Cohesive bulk materials

Bulk materials include the material we use in the construction field; plaster, sand, gravel, cement, etc. Moreover, it includes raw materials that we use for various industries such as ore, slag, salts, etc. In addition to that, this includes powdery materials such as pigments, fillers, granules, pellets, etc.

What is the Difference Between Nanomaterials and Bulk Materials?

Nanomaterials are particles that have their size in 1-100 nm range at least in one dimension. We cannot see their particles through the naked eye. Moreover, examples of these materials include nanozymes, titanium dioxide nanoparticles, graphene, etc. Bulk materials are particles that have their

size above 100 nm in all dimensions. We can see their particles through the naked eye. The examples of these materials include plaster, sand, gravel, cement, ore, slag, salts, etc. The below infographic presents the difference between nanomaterials and bulk materials in tabular form.