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Functionalisation of Nanomaterials: Synthesis and Application

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Abstract
The recent past in the technological development evidenced that evolution in Nanotechnology and nanoscience is the key factor. Nanotechnology is multidisciplinary science which deals with physics, chemistry, materials science and other engineering sciences. The applications of Nanotechnology are spreading in almost all the branches of science and technology. The present article highlighted the types of nanoparticles and their synthesis and application techniques. There are many techniques and applications are reported in the last seven years but here we strictly focused on the general synthetic approaches and applications of the nanomaterials which provide a general idea to the young researchers.

Key Words : Nanotechnology, multidisciplinary, synthetic approaches

Introduction
Over the last century nanotechnology branch is flourishing to a great extent. And today many types of research are directly or indirectly related to the nanotechnology. Nanotechnology can be stated as the developing, synthesizing, characterizing and application of materials and devices by modifying their size and shape in nanoscale" In each and every stream the prefix "nano" is using as a keyword even in advertising the products also. Actually the word "nano" is derived from the Greek word *nanos* or Latin word *nanus* means which "dwarf". It is the combination of physics, chemistry, material science, solid state, and biosciences. So profound knowledge in one field will not be sufficient, the combined knowledge of physics, chemistry, material science, solid state, and biosciences is required. The applications of Nanotechnology are spreading in almost all the branches of science and technology. The difference between the nanoscience and nanotechnology is the nanoscience gives the knowledge about the arrangement of atoms and their basic properties at nanoscale whereas the nanotechnology is the technology used in governing the matter at the atomic level for the synthesis of the novel nanomaterials with different characteristics. The nanotechnology getting attention in almost all engineering branches but the common people didn't get the knowledge about its existence in daily life but its vast usage in the medicine, engineering, environment, electronics, defense, and security is still increasing. Even though so much work was done using this technology but still have space for developing the new novel nanomaterials in various fields for the progress of mankind. The researchers are fascinated and working for the progress of knowledge in terms of their size, capability, and expenditure. So special interest on the miniaturization of the device with economical is focusing mainly in the field of medicine, electronics. In upcoming days the nanotechnology controls mankind in living, working and communicating fields. So this gives interest in this subject and leads to the discussion of the basic and major topics of nanotechnology.
The basic and the key elements of nanotechnology are the "nanomaterials". The nanomaterials are the materials with less than 100 nm size ones at least in one dimension. That means they have very less size than that of microscale. The nanomaterials are usually 10^{-9} m in size that means it is one billionth of a meter. The nanomaterials show different physicochemical properties than the bulk material which inherently depends on their size and shape.

Surprisingly the nanomaterials produce a unique character with new characteristics and capabilities by modifying the shape and size at the nanoscale level. Nanomaterials may be of different shapes like nanorods, nanoparticles, nanosheets which can be characterized based on their dimensionality. Nanomaterials with zero-dimensional are nanoparticles, one dimensional is nanorods or nanotubes and two dimensional are generally films and layers type one. These are categorized mainly for the single isolated nanomaterials. By the interaction of two or more particles, their physical properties will alter. These particles of different constituents are called bulk or three-dimensional nanomaterials.

SYNTHESIS OF NANO MATERIALS

Many significant historical occurrences, including the industrial revolution and the discovery of antibiotics, have been compared to nanotechnology. Working with materials and technologies that are only a nanometer in size—one billionth of a meter—requires the application of science. Nanomaterials typically have diameters between one to 100 nanometers. Nanoscience and nanotechnology, which study and use very small objects, are applicable to all other scientific disciplines, including chemistry, biology, physics, materials science, and engineering.

It's difficult to grasp how tiny nanotechnology is. One nanometer, or 10-9 of a meter, is one billionth of a meter. Here are some concrete examples:

One inch has 25,400,000 nanometers. In comparison, a sheet of paper is around 100,000 nanometers thick; if a marble were a nanometer, the size of the Earth would be one meter.

The visibility and manipulation of specific atoms and molecules are key components of nanoscience and nanotechnology. Atoms make up every single item on Earth, including the food we consume, the clothing we wear, the homes and structures we live in, and our own bodies.

However, an atom is too small to be seen with the human eye. With the standard high school science microscopes, it is actually difficult to see. About 30 years ago, the microscopes that are required to see objects at the nanoscale were developed.

The era of nanotechnology began when researchers got the appropriate equipment, such as the scanning tunneling microscope (STM) and the atomic force microscope (AFM). Nanoscale materials have been utilized for centuries, despite the fact that current nanoscience and nanotechnology are relatively new. The hues in the medieval cathedrals' stained glass windows were produced by different-sized gold and silver particles hundreds of years ago. Simply put, the artists of that time were unaware that the techniques they employed to produce these exquisite works of art actually caused modifications to the chemical makeup of the materials they were using. In order to benefit from the enhanced properties of materials at the nanoscale, such as higher strength, lighter weight, increased control of the light spectrum, and greater chemical reactivity than their larger-scale counterparts, scientists and engineers today are developing a wide range of deliberate manufacturing techniques.

MEMS (Micro- Electro-Mechanical-Systems) Manufacturing eventually replaces conventional manufacturing, advancing nanotechnology in the process. The distinction between "top-down" and "bottom-up" production techniques is highlighted by a comparison of conventional, MEMS, and nanotechnological manufacturing, underscoring the revolutionary nature of nanotechnology.

Some of the concepts used in the research of nanotechnology are misunderstood, and frequently, terms like "nanoparicles," "nanomaterials," and "nanotechnology" are used interchangeably. As a result, it's critical to comprehend what some of the key phrases in this field of study signify.

The study of events and substances at the atomic, molecular, and macromolecular scales, where attributes change noticeably from those at the larger scale, is known as nanoscience.

Having at least one dimension that influences functional behavior at this scale, or having one or more dimensions on the order of 100 nm or less.

Top-down and bottom-up strategies are the two main ways used to synthesis nanomaterials. Top-down approach is used when bulk molecules are broken down into nanosized pieces of the same molecules. It can be merely defined as the idea of sculpting from bulk. The materials used in the bottom-up approach are assembled by themselves. The self-assembly of molecules and atoms holds the process by which molecules and atoms are transformed into clusters and subsequently referred to as nanoparticles. Physical forces are used at the nanoscale during self-assembling to transform small, unstable units into big, stable structures. Examples of a bottom-up strategy include the development of a quantum dot during epitaxial growth and the formation of nanoparticles through colloidal dispersion. Figure provides a schematic illustration of top-down and bottom-up strategies.

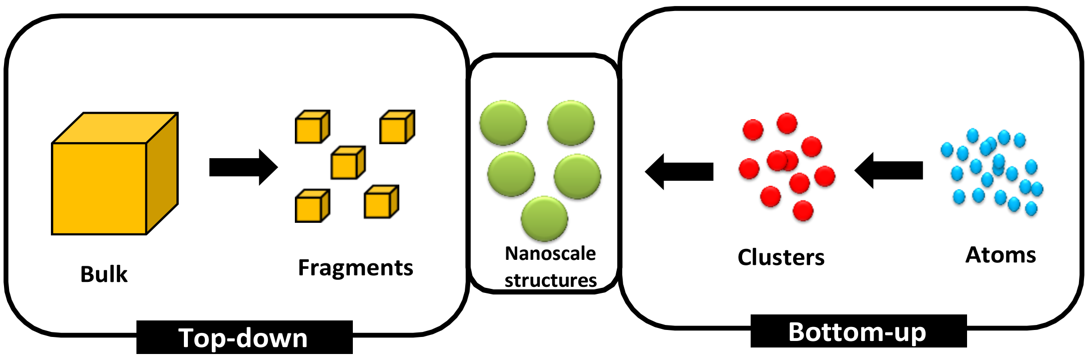

Figure-1 : Schematic representation of Top-down and bottom –upapproaches.

According to these two approaches, there are three different types of synthesis procedures, which are illustrated in the flow chart below. Materials are manufactured using the physical approach according to the top-down process principle. A few physical processes that can be carried out by the vapour phase are laser ablation, ultra sonication, radiolysis, vaporization, and Solvated Metal Atom Dispersion (SMAD). Melt mixing and high energy ball milling are examples of mechanical processing.

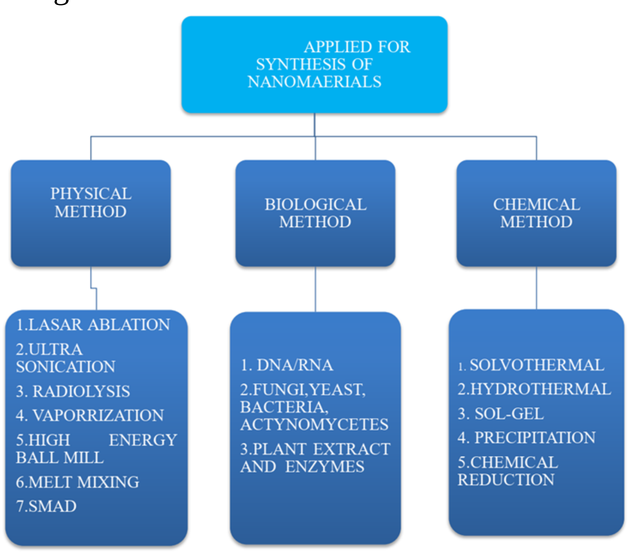

Figure-2 : Various type of synthetic methods of nano particles

The bottom-up strategy can be used to operate chemical methods. Some examples of chemical synthetic processes are solvothermal, hydro thermal, sol-gel method, co-precipitation. Utilizing plant extracts, fungi, yeast, bacteria, and actynomycetes, as well as DNA/RNA membrane templates, biological methods are used to create nanomaterials. Over physical and biological methods of synthesis, chemical methods offer many advantages, including:

- Very understandable approaches.

- The potential for self-assembly or patterning.
- The production of significant amounts of synthetic materials.
- The potential for doping with alien atoms.
- Reasonable instrument prices.
- It is possible to synthesize nanomaterials in a variety of sizes and forms.

As a result, many people now embrace chemical approaches for creating nanomaterials. Below is a representation of a few synthesis techniques.

SOL –GEL METHOD

With this technique, a system transitions from a liquid to a solid state. To put it another way, the system transitions from a colloidal phase to a gel phase known as "Sol gel." The self-assembly of the nanomaterials is based on a wet chemical process. The four phases of the sol-gel technique are

I hydrolysis,
(ii) condensation,
(iii) growth, and
(iv) particle agglomeration.

The sol-gel process can be used to create nanoparticles, and these materials have great mechanical strength, dependability, and thermal stability. Nanowires, nanorods, and nanotubes, among other materials, are produced using the sol-gel process.

CO-PRECIPITATION METHOD

The simplicity and low cost of the experimental setup make the Co-Precipitation approach appealing. Precursor material will be reduced by the reducing agent after being added while being constantly stirred and with an optimal pH. The particle's size and form will thereafter be under control. Following this procedure, the precipitate will appear and be centrifuged for a while. The final product will be dried for NPs after centrifugation.

SPRAY PYROLYSIS METHOD

Spray pyrolysis was used to create high purity ceramic nanopowders. This method uses a lot of electricity to create a lot of homogeneously crystalline oxide powder that is less than 100 nm in size. Through the spray nozzle attached to the atomizer, the droplets of the precursor solution spray onto the heated surface. Spray pyrolysis produces highly flexible nanomaterials and has a high production rate when compared to other synthesis methods.

HYDROTHERMAL METHOD

Due to its narrow crystallite size distribution, low aggregation level, and one-step synthesis process, the hydrothermal approach has many benefits over the sol-gel, co-precipitation, and spray pyrolysis procedures. Additionally, this technique may produce materials with high purity, outstanding particle shape (tubes, dots, sheets, rods, cubes, and flowers), and controlled size. As a result, the hydrothermal approach is employed in the current research. The hydrothermal technique additionally demonstrated extraordinary skill in the production of inorganic semiconducting materials. The ability to form nanostructures is a result of the surrounding pressure and temperature conditions. Additionally, the concentration, pH level, pressure, duration, templates, or additives will all play a role in the formation of the nanostructures. The aforementioned experimental conditions make it simple to create inorganic semiconducting nanostructures.

CONCLUSION

Day to day the synthesis of novel nanomaterials are increasing. The nanomaterials with mixed compositions are also synthesizing to apply in different fields. The facile synthesis methods will produce the nanoparticles of desired size, shape and property one which can withstand the external conditions but still, they need some improvement. Nowadays wide research in going into the fields of biomedicine, electronic storage devices, and sensor.

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