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The Nanotechnology Period in Chemistry (mini review)

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ABSTRACT: The technologies which give direction to our era can be classified under 4 headings: Space technology, gene technology, communication technology and nanotechnology. The technology of the knowledge era is not only the communication technology but also the nanotechnology. The principle technology of the knowledge and the communication era that we are in is the nanotechnology. In fact, nanotechnology is the basis of the gene and the space technologies. In other words, the technology of our present and future era is the nanotechnology. In this paper, the general information about the present and future of nanotechnology will be summarized considering the probable developments and applications in this area.

Introduction

What is nanotechnology?

Nanotechnology is the understanding and the control of the physical, chemical and biological events which are in nanometric scale and development and the production of the functional equipments, tools and systems in such sizes. Nanotechnology evaluates incidents in nanoscales and opens new perspectives in science by developing and applying similar events. Nanotechnology deals with materials, apparatus and systems which have at least one size between 1 to 100 nm. It aims at developing more different and superior featured mechanical, electrical, thermal, optic and chemical materials and systems. Nanotechnology comprises:

- Analysis of nanoscale structures
- Investigation and understanding of physical characteristics of the nanoscale structures
- Production of nanoscale materials
- Development and production of nanosensitive instruments
- Investigation and development of methods that help to keep connection between the nanoscopic and macroscopic world.

All the World countries are making nanotechnological researches and plans of application and give start to such studies. Each country and special organization has determined the most appropriate and primary nanotechnologic areas. In future, nanotechnology will be the most invested area and the most larged employment sector. For example, in Germany, those who are working on nanotechnology are more than 100 000 people (only in the vicinity-surroundings of Dresden, approximately 20000 people work by chip and electronic production) (1).

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Potential Application Areas of Markets for Nanotechnology

(a) Industrial Area

Development of micromachines, micropumps, microsensors, production and assembly of optoelectronic elements, nanoscale coating, control of reactions by monolayered catalyst, nanomaterials for fuel cells, nanomaterials for hydrogen storage fuel cells, carbon nanotube electronic components, nanoparticles for pigments, self cleaning windows, connection between the nanoscale elements, chip and CD production. Nanotechnology is fundamentally a branch of engineering (2).

(b) Medicine/Health Care

Micro-nano surgery (especially eye surgery and neurosurgery), diagnostic kits, determination and repair of cellular and molecular (ie, DNA) injury, artificial muscle, bio-nanosensors for diagnostics, targeted drug and gen delivery, engineering artificial organs.

(c) Scientific Researches

Surface characterization and modification, transportation of microorganisms, DNA-modification.

Typical Examples of Application Areas for Nanotechnology at the Present Time

1. Carbon nanotube and nanolitography.
2. Production of carbon fibers to use as hydrogen battery.
3. Nano libraries.
4. Novel data storage systems.
5. Cell repair units.
6. Coating the plastic bottles with monolayered silicone dioxide so that combining the superior characteristics of the glass and plastic.
7. Chain structure change in polyethylene production and strong carrier rope production (Kevlar).
8. n and p type transistors and production of electronic circuits.
9. Measuring the many chemical and physical properties of molecules by femto second-nanotechnology.
10. Production of nano robots and drug carriers in nano scale.
11. Nanosurgery
12. Nanotechnology application in textile industry such as production of carbonfiber in nm scale and manufacturing of fabric from these fibers or monolayer coating on fabric material for water or fire resistance (3-8).

Nanolitography

Nanolitography is the process of production of micro and nano scale materials and collection or transportation of atoms and molecules to desired place. The nanolithography comprises:

– Production of nanoscale robots similar to macroscale robots, and by this way, production of nanomaterials from atoms and molecules and,

– Orientation and management of atoms and molecules by using macro instruments or devices for desired purpose. With help nanolithography can be product: (1) Making of electronic circuits whose dimensions can be compared to atoms and molecules (2) Improving nano machines and nano robots at molecular size (3) Synthesizing various materials by bonding atoms and molecules like making of a building as constructing from bricks (a) Changing the formation of a material that exists. Changing the carbon structure for making a diamond is a good example (b) Synthesizing big molecules from small ones, synthesizing sugar and starch of a plant from water and carbon dioxide is a good example (4) In near future nanotechnology will find an application at making intelligent circuits. Today limits of using nanotechnology will also enlarge towards dote semi conductors as lithographic examples.

1. The making of electronic circuits whose sizes can be compared to atom and molecules.
2. The advancement of nanomaterials that are big as much as one molecule and robots.
3. To synthesize several materials by capturing atoms and molecules one by one just like making a building by tiles and bricks. This is achieved as follows: a. Changing the order of atoms of a material. To produce diamond by chancing the carbon structures is a good example of this case. b. To synthesize the small molecules from the bigger ones, a good example for this is to synthesize sugar and starch like water and carbon dioxide.
4. In the near future, nanotechnology has a chance in the making of clever circuits. Today, proper lithographic samples coorted on the semi-conductors are forcing the limits.

Who can make Nanotechnology?

Nanotechnology is fundamentally a branch of engineering. But every researcher who deals with materials can use nanotechnology and make researches in this area. Nanotechnology is a multidisciplinary branch of science. It needs analytical techniques and methodologies of a number of disciplines including chemistry, physics, molecular biology, materials science and electrical engineering. The results of such studies can be used by every application scientist basically by the electronic and the computer manufacturers. Thus, they can improve application areas of their profession. By looking with this perspective, it can be said that all the basic and application scientists principally including the chemists and the physicists, namely the engineers, medicine doctors, veterinarians, agricultures can take role in developing and application of nanotechnology. Solid state physicists, electrical engineers, materials scientists, polymer chemists, organic chemists, electrochemists, biochemists and the biologists are potential researchers in nanotechnology. However, it is an important and a reliant new field on the collaboration of academics who are highly skilled in their own disciplines.

In our era, the level of the industry has reached to such a point that includes both the great big scale production that can cover the public needs and also high quality advanced technological products which are gradually getting smaller in nanometric size as well. Thus, operations at sub cellular molecular levels and conveying this to the technological advances (ie., gene technology) could be possible.

Especially the analytical chemists had to change their traditional analysis techniques as well as to develop new analysis techniques appropriate to the new technology to answer the questions directed at the composition and the structure of the materials produced by this technology. Without analytical chemists and analytical techniques, nanotechnology cannot be developed.

Materials, Tools and Devices Used in Nanotechnology

The most important tools used in investigation of nanotechnology and control of the systems and products include the scanning probe microscopes, especially the atomic force microscope and the scanning tunnel microscope. The developments in nanotechnology not only accelerate the development and enlarge the usage areas of probe microscopes but also increase the application area of nanotechnology by using these apparatus as nanomanipulator (micro-robot).

The new developments and discoveries in technology make the following tools and techniques as irresistible laboratory equipments: surface analysis techniques such as electron-ion spectroscopy, electron microscope in the place of optic microscope, tunnel electron microscope, imaging techniques that give opportunity to visualize the molecular size such as atomic force and work function spectroscopy, optic sensors, laser and fiberoptic, semi-permeable measuring systems with detector that can measure the nano even femto seconds.

Very different kinds of numerous analytic microscopes have been found such as:

1. Transmission and reflecting optic microscope, phase contrast and UV microscope,
2. Transmission-, reflecting-and scanning electron emission microscopy, field electron emission microscope (TEM, REM, SEM, EEM, FEM)
3. Ion microscopes: transmission ion, scanning ion, field ion microscopes (TIM, SIM, FIM)
4. Other microscopes: Tunnel, scanning tunnel, atomic force, work function, magnetic force, near field optic scanning, ballistic electron emission microscope (TUEM-TM, STM, AFM, WFM, MFM, NSOM, BEEM) and dozens of microscopes are used for nanotechnology for different purposes.

Today the microscopic techniques are used for

- Investigating homogeneity and effect of coating,
- Identification of surface components and its morphologic and topographic structure such as solid phase catalyst surface,
- Increasing the effect of sun batteries used for taking advantage of sun energy, and
- Medical technology

The two major members of the probe microscope family are atomic force microscopy (AFM) and the scanning tunnel microscope (STM).

Atomic force microscopy is a system which is capable of visualization of surface topography of liquid or solid samples and measuring the intermolecular forces (nN, pN).

The interactive force between the needle and sample results in a lever mechanism which moves in nm scale. By getting use of this movement, the data is transferred to the computer and gathered together with the help of software. So that it is possible to obtain the image of the sample or to measure the interactions between the needle and the sample.

Atomic Force Microscopy and its Study Principles

Characteristics and Utilization Areas

The basic principle is the scanning of the surface by a sensitive needle that gives a high resolution 3D image of the surface. The advantages can be aligned as follows:

- The sample is no need to be conductive
- It is alternative to SEM since it is easy to prepare the sample, easy to use and occupies a lesser area.
- It can give image in air, fluid and vacuum environment.
- It can give a detailed image of biological samples, coatings, ceramics, composites, glass, membranes, metals, polymers and semi-conductive materials and determine several properties such as electrical and magnetic charge, adhesive or hydrophilic behaviors.

– It is possible to measure the interactive force between the molecules by immobilizing the tip of the needle.

Atomic force microscopy functions as nano medicine, nano machines and nano library.

Surface Modification, Experimentation by Unmodified Needles Afm Needle (Afm Tip, Si3n4)

Biosensors**:** They are tools which are used in analysis of several materials containing biological active substances and located in biological environments. Modified needles can be used as biosensors.

Electronic and Computer Industry

The most common analysis techniques used for nanotechnology in electronic and computer industry comprises combined mass spectroscopy techniques which are used in purity control of semi-permeable elements such as ultra pure silica and germanium and in analysis of impurity of solid structures (such as GF-ICP-MS, SS-MS, Laser-MS, ESCA-MS) and determination of other metals (such as Li, As, Ga, Co, Au, Ag) those are doted or coated on these semi-conductor elements, ESCA, SIMS, NPMS, TXRF and principally different electron microscopes used in surface analysis and in depth profile analysis.

Intelligent Molecules

The molecules which are termed as intelligent molecules are sensitive to environment and show reaction to any impulse (i.e., electric, heat, light, sound frequency, pH change) that come from the environment. The large and synthetic molecules which have especially a polymeric structure show this sensitivity. The most important examples of this class are thermo-sensitive polymers.

N-isopropyl acryl amide which is designated as NIPAA is a thermo-sensitive polymer. It is hydrophilic at polymer lower critical solution temperature (LCST) and dissolves in water, but is hydrophobic above that temperature and does not dissolve in water. This LCST is 31-32 $^{\circ}$C.

This structure gains very superior characteristics to NIPAA. Micro and nano spheres can be prepared by using co-mono polymer cross binders and starters. Since the LCST value of NIPAA is close to body temperature and this value can be adjusted by several co-monopolymers, it is used widespreadly in biomedical practices. It is also reported to be used as a drug carrier in the form of hydrogel, bioconjugant and polymeric micelles.

Intelligent Polymers

N-isopopyl acryl amide proteins are used in separation and purification of biomolecules such as DNA and RNA and immobilization of certain enzymes. In our country, the nanotechnology is principally used for developing these kinds of intelligent polymers and for taking under control of reaction type of intelligent molecules. Intensive studies directed to develop and produce probe microscopes used in nanotechnology are held in polymer laboratories of some of our universities. Some of the researchers aim to develop polymers in the form of nano particles that can be used in gene therapy. The polymer is polymerized with a (+) charged co-monomer for electrostatic counteraction with a (-) charged DNA. While the transporter can bind firmly to (-) charged DNA above the LCST, it releases DNA at a lower temperature. This can be controlled by thermoregulation. A researcher has developed micro spheres from polymers such as chitosan and alginate. Iron powders are locked in the polymers to gain magnetic structure to these microspheres. They are used in enzyme immobilization and removing metals such as copper (9-19).

Conclusion

In this paper, the present and future of nanotechnology have been summarized and the probable developments and applications have been outlined. In addition, materials, tools and devices used in nanotechnology have been indicated.

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