A REVIEW REPORT ON THE USE OF NANOCHEMICAL TECHNOLOGY

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ABSTRACT: Nanochemistry can be defined as a branch of nanoscience, which deals with the chemical applications of nanomaterials in nanotechnology. Nanochemistry is related with the production and the reactions of nanoparticles, nanostructures and their compounds. It is related to the unique properties associated with assemblies of atoms or molecules on a scale between that of the individual building blocks and the bulk material (from 1 to 100 nm). Nanochemical techniques can be used to create carbon nanomaterials such as carbon nanotubes (CNT), graphene and fullerenes have mechanical and electrical properties. Nanochemical technology can also be used for the manufacture of new catalysts, coatings, computer components, highly selective sensors, lighter strong materials, etc. Carbon nanotubes can be used as semiconductors and can replace silicon in a number of computing devices. Nanowires and nanoparticles help in the improvement of biological and chemical sensors. Nanocatalysis reactions are helpful for: 1. Green diesel production using Fischer-Tropsch Synthesis (FTS), 2. Core-shell nanocatalysts for fuel cell applications, 3. In-situ hydrogen production by reaction of ammonia and nanocatalyst. Nanotechnology is also effective in targeted drug delivery in Cancer.

Keywords: Nanochemistry, nanomaterials, graphene, fullerenes, nanocatalysis

1. INTRODUCTION

Nanochemistry can be defined as a branch of nanoscience, which deals with the chemical applications of nanomaterials in nanotechnology [1]. Nanochemistry is related with the production and the reactions of nanoparticles, nanostructures and their compounds. It is related to the unique properties associated with assemblies of atoms or molecules on a scale between that of the individual building blocks and the bulk material (from 1 to 100nm) [2]. At such a level, the quantum effects might become significant, as well as new ways of carrying out chemical reactions may become possible.

Nanochemistry basically uses methods from synthetic chemistry and material chemistry to obtain nanomaterials which have specific sizes, shapes, surface properties, defects, self-assembly properties which have been designed to fulfill specific functions and uses [3]. Different metals, semiconductors and polymers, both in their amorphous and crystalline forms can be used to create different nanomaterials.

Nanochemical techniques can be used to create carbon nanomaterials such as carbon nanotubes (CNT), graphene and fullerenes have mechanical and electrical properties.

Nanoparticles can display properties which are significantly different from the bulk material and such properties can be utilised for different uses. Nanoparticles have many novel uses compared to that of conventional industrially produced materials, e.g.

- Nanoparticles have higher surface to volume ratio which has a tremendous effect on their properties compared to non-nanoscale forms of the same material.
- At the macro level pieces of gold are gold-coloured, but gold nanoparticles are deep red or even black coloured when mixed with water.
- Titanium dioxide (TiO_2) is a white solid which used in house paint which reflects visible light. However, nanoparticles of TiO_2 are so small that they don't reflect visible light and are used in sunblock creams, as they block harmful UV light from the Sun without appearing white on the skin.
- Silver being a noble metal, the silver foil does not react with dilute hydrochloric acid (HCl) but silver nanoparticles rapidly react with HCl due to very large surface area to volume ratio.
- Due to nano size many properties affected, like there is:

Change in surface energy (higher), electronic properties, optical band gap, electrical conductivity, higher and specific catalytic activity, thermal and mechanical stabilities, different melting and phase transition temperatures, catalytic and chemical reactivities.

2. APPLICATION

Nanochemical technology can be used for the manufacture of new catalysts, coatings, computer components, highly selective sensors, lighter strong materials, etc. The large surface to volume ratio would help in the development of new industrial catalysts for various applications. It can be used to develop sensors that detect specific molecules and would find its use in detecting and monitoring water pollutants. Nanotubes can be used for manufacturing strong and light materials which can be used for construction of air crafts and sports equipments.

2.1 CARBON NANOTUBES

A carbon nanotube (CNT) is a very small cylindrical carbon structure, that has hexagonal molecules of graphite attached at the edges. CNT consist of tiny cylinders of carbon (and other materials like boron nitride). Nanotubes are not wider than a strand of DNA, having a wide range of properties which are of great use to material scientists. Nanotubes appear as a powder or black soot, but these are actually rolled-up sheets of graphene that form hollow strands with walls having a thickness of only one atom. Nanotubes, also known as buckytubes, were developed from the Fullerene as shown in **Fig. 1.**

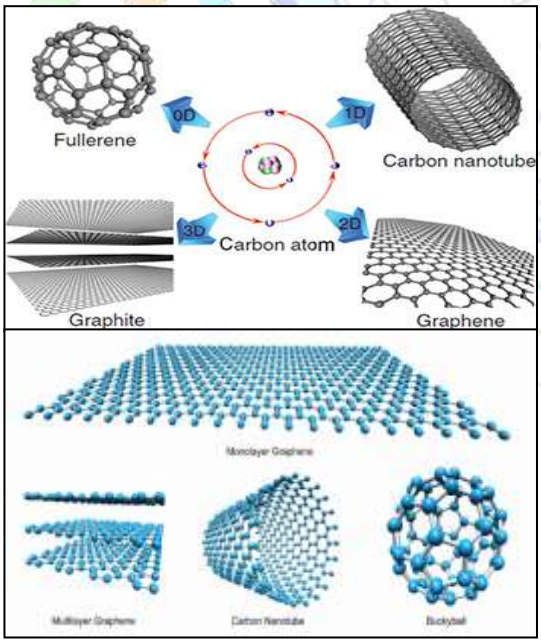

Fig. 1. Carbon Nanotube Structure

Nanotubes, are grown in laboratory and are strong and manifest many thermal and electrical properties which are useful to chip makers. Carbon nanotubes can be used as semiconductors and can replace silicon in a number of computing devices [4].

Nanotubes are one of the most widely used nanomaterials. Nanotubes can be stronger than steel with only $1/6^{th}$ of the weight. Some nanotubes are very good insulators, semiconductors or conductors.

2.2 IMPROVEMENT OF BIOLOGICAL AND CHEMICAL SENSORS

Nanotechnology can enable the chemical sensors to detect very small amount of chemical vapours. Different type of detecting elements like zinc oxide nanowires, carbon nanotubes or nanoparticles of palladium can be used in sensors based on nanotechnology. These nanoparticle based detecting elements change their electrical characteristics, like resistance or capacitance, as soon as they absorb a molecule of gas.

Due to the small size of nanotubes, nanowires or nanoparticles, a few molecules of gas are sufficient enough to change the electrical properties of the sensing element as shown in **Fig. 2.** Thus, it helps in the detection of very low concentration of chemical vapours. The application of such small sensors can be throughout an airport or any such facility with security concerns, to check for vapours emitted by explosive devices. Also, these sensors can be used in industries that use chemicals in manufacturing to detect the release of chemical vapours. A sensor that can detect escaped hydrogen, could be very useful in warning of a leak in cars using hydrogen fuel cells. Such devices can also be used for making network of air quality monitoring stations, to improve the tracking of sources of air pollution.

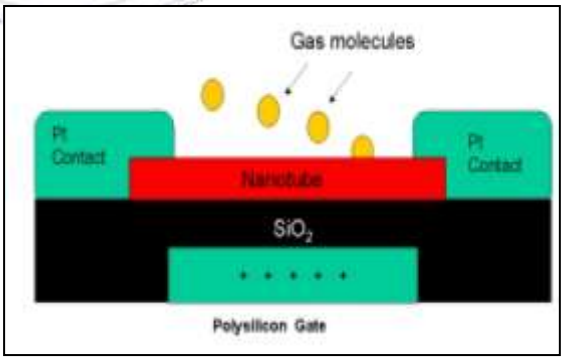

Fig. 2: Nanotube based Chemical Sensor

2.3 NANOCATALYSIS

Nanocatalysis involves the use of nanomaterials as catalysts for a variety of homogeneous and heterogeneous catalysis applications. Nanoparticles of metals, semiconductors, oxides and other compounds have been used widely for important chemical reactions.

Nanocatalysis aims at producing catalysts with 100% selectivity, extremely high activity, low energy consumption and long lifetime. It can be done only by controlling the shape, size, surface composition and electronic structure and thermal and chemical stability of the individual nanocomponents.

As, nanoparticles have a larger surface-to-volume ratio as compared to bulk materials, so they are more useful as catalysts. In the case of homogeneous catalysis (where catalyst is in the same phase as the reactants), nanoparticles made from transition metal in colloidal solutions are used as catalysts. In homogeneous catalysis, the colloidal transition metal nanoparticles are finely dispersed in an organic or aqueous solution or a solvent mixture.

The colloidal nanoparticle solutions shall be stabilized, so as to prevent aggregation of the nanoparticles as well as to be good potential recyclable catalysts. Metal colloids are quite efficient catalysts, as a large number of atoms are present on the surface of nanoparticles.

Some uses of nanocatalysis are given below:

1. **Green diesel production using Fischer-Tropsch Synthesis (FTS):-** Nanocatalysis helps to improve the FTS technology for production of high molecular weight waxes, which is followed by their hydrocracking to generate liquid fuels. It also improves the efficiency of slurry and fixed-bed reactors, used in FTS. It helps to produce long, linear-chain paraffin waxes in fixed bed & slurry FTS reactors.

The catalysts used are nano Fe and Co powders (10-50 nm) in slurry reactors, i.e. promoted by other metals like Mn, Cu & alkalis. These are produced by thermal plasma chemical vapour deposition (TPCVD) and cluster spray techniques.

2. **Core-shell nanocatalysts for fuel cell applications:-** Here, Platinum (Pt) atoms are placed at the surface of other metal nanoparticles. Therefore, all the Pt atoms are available for catalytic reaction at the surface. The Pt clusters on ruthenium nanoparticles produce high activity per unit of Pt mass. The catalyst used is smooth and compact Pt shell for better oxygen reduction reactions.

3. **In situ hydrogen production by reaction of ammonia and nanocatalysts:-** In this case Ammonia is stored as a coordination complex with a transition metal compound in solid composition. This acts as the hydrogen fuel precursor for internal combustion engine of a vehicle that is operated to use hydrogen or a combination of hydrogen and gasoline as fuel. Ammonia dissociation catalyst tube which contains a catalyst bed and which is maintained at 750°C is used to dissociate ammonia into nitrogen and hydrogen atoms.

Here, the dissociation catalyst is a mixture of nanometer size particles of Co-NiO-Cu-Zr catalyst which is deposited on high surface area of TiO_2 and 2% Pt deposited on alumina particles [5].

2.4 Nanotechnology in Drug Delivery - Cancer:

Ethylene glycol molecules are attached to nanoparticles that deliver therapeutic drugs to cancer tumors. The ethylene glycol molecules stop the white blood cells from recognizing the nanoparticles as a foreign material, thus, allowing them to circulate in the blood stream for enough time so as to attach to cancer tumors. Researchers at the University of California, San Diego believe that the time of circulation of nanoparticles in the blood stream can be increased by coating nanoparticles containing therapeutic drugs with membranes from red blood cells. Such coated nanoparticles would circulate in a mouse's blood stream for almost 48 hours, instead of the few hours observed for nanoparticles using ethylene glycol molecules. The targeted delivery of drugs using nanoparticles for treatment of Cancer can be seen in **Fig. 3.**

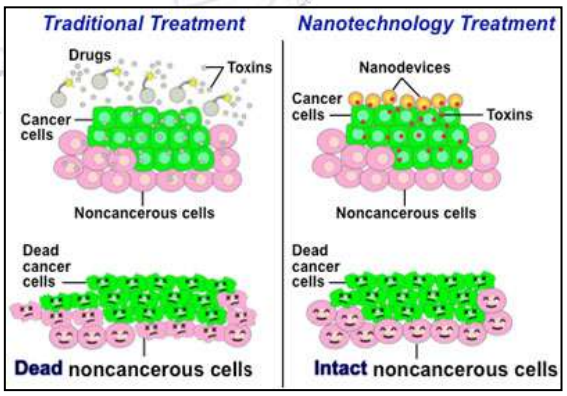

Fig. 3: Nanotechnological Cancer Treatment

Studies by scientists at MIT have shown, increased levels of drug delivery to tumors by the use of two types of nanoparticles. The first type of nanoparticle locates the tumor cells, while the second one (carrying the therapeutic drugs) homes in on a signal generated by the first type of nanoparticle.

The side effects of platinum cancer therapy may be reduced, by using gold nanoparticles to deliver platinum to cancer tumors. The basic principle is that the level of platinum toxicity depends upon the molecule it is bonded to. So, a platinum containing molecule that has low toxicity to attach to the gold nanoparticles has been chosen. When the nanoparticle consisting of platinum reaches a tumor it encounters a solution which is acidic, that changes platinum to its toxic state, in which it can kill cancer cells [6].

3. ADVANTAGES

Nanochemical technology has many advantages over the macro scale that can be used for various developments in different areas may it be industrial, scientific, medical, etc. Some advantages are:

The higher surface area to volume ratio of nanoparticles increases the rate of chemical reactions, thereby enhancing their catalytic effect.

Nanomaterials can be used to enhance the working efficiency of chemical and biological sensors that can be used for detection of specific and trace amount of specific molecules.

Gold nanoparticles can be used for the detection of Alzhemier's disease in its early stage.

Nano-engineered materials are used to make better quality household products like degreasers, air purifiers, filters, antibacterial cleansers and specialized paints [7].

4. DISADVANTAGES

Some of the disadvantages of nanoparticles are discussed here:

1. Very little information or research is being done and insufficient data is available on the side effects of nanomaterials.

2. The high reactivity of nanoparticles may lead to many adverse biological effects.

3. Most of the nanomaterials are persistent and their faith is not known once their utility is over.

CONCLUSION

The main motive of this study is basically to give an overall view of the use of nanochemistry in various areas, such as development of various industrial catalysts having enhanced working ability, targeted drug delivery for increasing the efficiency of different drugs, over the general methods used.

The use of nanotechnology along with chemistry has the potential to develop structures that are lighter in weight but much stronger than other metals used for the same purpose.

Although, many improvements can be made in the different processes by using nanotechnology with chemistry, care shall be taken if it has to be implemented in day to day life in order to avoid the harmful side effects. With the development in the field of nanotechnology, the various different side effects also need to be considered. Nano technology along with chemistry holds good promise for the development of various technologies regarding different aspects. Furthermore, it needs to be taken into account that detailed research need to be undertaken in the different areas of nanotechnology before their implementation.

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REFERENCES

1. http://nanochemistry/introduction_explained/potential_applications_uses_nanoparticles/nanotubes/gcse/igcse/gce/A_Level_AS_A2/chemistry_revision/notes.html

2. Concepts of nanochemistry, Cademartiri, Ludovico and Ozin, Goeffrey A. Wiley-VCH 2009 ISBN 978-3-527-32626-6

3. Nanochemistry: Ozin, Geoffrey A. and Cademartiri, Ludovico, 2009 Wiley-VCH Verlag, Weinheim small 2009, 5, No. 11, 1240–1244

4. http://whatis.techtarget.com/definition/nanotube-buckytubesR. Nicole, Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

5. http://www.nanowerk.com/spotlight/spotid=18846.php

6. http://www.understandingnano.com/nanotechnology-drug-delivery.html

7. www.nano.gov/nanotechnology-benefits

8. www.nanosphere.gu.se/nanosphere

9. G.A. Mansoori, United Nations Tech. Monitor, Special Issue, 53(2002).

10. G.A. Mansoori and T.A.F. Soelaiman, J. ASTM International 2, 21 pages (2005).

11. Filipponi. L. and Sutherland. D., Applications of Nanotechnology, 1-26 (2010).

12. C.P. Poole Jr. and F.J. Owens, "Introduction to Nanotechnology" John Wiley & Sons Inc., Hoboken, New Jersey (2003).

13. H. L. Lien and W. X. Zhang, "Nanoscale iron particles for complete reduction of chlorinated ethenes," Colloids and Surfaces A: Physicochemical and Engineering Aspects, Vol. 191, No. 1, pp. 97-105, (2001).

14. M. Haruta, "Catalysis and Electrocatalysis at Nanoparticle Surfaces", Ed., A. Wieckowski, E. R. Savinova, C. G. Vayenas, Marcel Dekker, New York, USA, P.645, (2003).