International Journal of Current Trends in Pharmaceutical Research

Journal Home Page: www.pharmaresearchlibrary.com/ijctpr

Review Article **Open Access**

Nanochemistry: Recent Advances and Future Perspectives: A Review

Amol S Dighe*[1], Sunil A. Nirmal[1], Nachiket S. Dighe[1], Ravindra B. Laware[2], Santosh B. Dighe[3]

[1]*Department of Pharmaceutical Chemistry, Pravara Rural College of Pharmacy, Pravaranagar, Loni, Maharashtra, India.*
[2]*Dept. of Quality Assurance and technique, Pravara Rural College of Pharmacy, Pravaranagar, Loni, Maharashtra, India.*
[3]*Departments of Pharmacology, Pravara Rural College of Pharmacy, Pravaranagar, Loni, Maharashtra, India.*

A B S T R A C T

Nanoscience and nanotechnology represent one of the main directions of natural science of the twenty-first century and are being actively and rapidly developed. Nanoscience deals with the search and description of fundamental phenomena, relationships, and properties typical of small-scale particles of the nanometer size. Nanotechnology implements the achievements of nanoscience in new processes, materials, and devices. In nanoscience and nanotechnology, the fundamental and applied problems are intertwined, and the latest achievements of theoretical and experimental physics, chemistry, biology, material science, and technology are used. Nanoscience is a multi-branch direction of natural science that combines the features typical of living organisms and the inorganic world. Nanochemistry forms an important part of nanotechnology, because a lot of processes and syntheses of new materials start from atoms, molecules, clusters, nanoparticles.

Keywords: Nanotechnology, Nanoscience.

A R T I C L E I N F O

CONTENTS

Article History: Received 06 January 2016, **Accepted** 20 February 2016, **Available Online** 15 March 2016

***Corresponding Author**
Amol S Dighe
Department of Pharmaceutical Chemistry,
Pravara Rural College of Pharmacy,
Pravaranagar, Loni, Maharashtra, India.
Manuscript ID: IJCTPR2806

PAPER-QR CODE

Citation: Amol S Dighe, *et al.* Nanochemistry: Recent Advances and Future Perspectives: A Review. *Int. J. Curnt. Tren. Pharm, Res.*, 2016, 4(2): 100-103.

1. Introduction

- Nanochemistry is a branch of nanoscience, deals with the chemical applications of nanomaterials in nanotechnology.
- Nanoscience deals with the scientific study of objects with sizes in the 1–100 nm range in at least one dimension. Nanotechnology deals with using

objects in the same size range to develop products with possible practical application. It is usually based on nanoscience insights.

- Nanotechnology is the creation of functional materials, devices, and systems through control of matter on the nanometer (1 to 100 nm) length scale and the exploitation of novel properties and phenomena developed at that scale.
- A scientific and technical revolution has begun that is based upon the ability to systematically organize and manipulate matter on the nanometer length scale.
- Nanochemistry involves the study of the synthesis and characterization of materials of nanoscale size.
- Nanochemistry 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 characterized chemical reactions.
- Nanochemistry 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 sizes.
- 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 synthesized, there are naturally occurring nanoparticle assemblies e.g. phospholipids vesicles, polypeptide micelle of the iron storage protein, ferritin.
- Nanoparticles are VERY tiny aggregations of atoms BUT bigger than most molecules.
- This science use methodologies from the synthetic chemistry and the materials chemistry to obtain nanomaterials with specific sizes, shapes, surface properties, defects, self-assembly properties, designed to accomplish specific functions and uses [3]. Nanomaterials can be created from virtually any material, such as metals, semiconductors and polymers, both in their amorphous and crystalline forms.
- Nanochemical methods can be used to create carbon nanomaterials such as carbon nanotubes (CNT),graphene and fullerenes, which have gained attention in recent years due to their remarkable mechanical and electrical properties.

2. Nanomaterial

This science use methodologies from the synthetic chemistry and the materials chemistry to obtainnano-materials with specific sizes, shapes, surface properties, defects, self-assembly properties, designed to accomplish specific functions and uses [3]. Nanomaterials can be created from virtually any material, such as metals, semiconductors and polymers, both in their amorphous and crystalline forms. Nanochemical methods can be used to create carbon nanomaterials such as carbon nanotubes (CNT), grapheneand fullerenes, which have gained attention in recent years due to their remarkable mechanical and electrical properties.

Nanocrystal:

A Nanocrystal is a crystalline particle with at least one dimension measuring less than 1000 nanometers (nm), where 1 nm is defined as 1 thousand-millionth of a meter (10^{-9} m).Nanocrystals have a wide variety of proven and potential applications. They have been used in the manufacture of filters that refine crude oil into diesel fuel. Nanocrystals can also be layered and applied to flexible substrates to produce solar panels. Research at the University of Queensland (Australia) has yielded promising results in this field. Titania nanocrystals can be suspended in liquid form and applied to surfaces, making it possible to literally paint a solar panel onto an exterior wall or roof. Possible future uses of nanocrystals include:

- Production of hydrogen
- Removal of pollutants and toxins
- Medical imaging
- Bio-tags for gene identification
- Drug manufacture
- Protein analysis
- Flat-panel displays
- Illumination
- Optical and infrared lasers
- Optoisolators
- Magneto-optical memory chips
- Self-organized smart materials.

Nanocrystal is also a registered trademark of Elan Pharma International Ltd. (Ireland) for a technology that improves the bioavailability of drugs by rendering them as nanoscale particles that can be suspended in liquids, made into powder, pressed into tablets or encapsulated.

Nanoclusters: When studying nanoparticles a distinction must necessarily be made between condensed “hard” matter nanoparticles, generally termed nanoclusters, and “soft” bio-organic nanoparticles and large molecules. A nanocluster is a nanometer sized particle made up of equal subunits. These

subunits can be atoms of a single element, molecules or even combinations of atoms of several elements in subunits with equal stoichiometries (alloys, etc.) E.g.: Nan, (SF_6)n, (H2O)n, (Cu_3Au)n, $(ClCH_3C_6H_3\ CO_2H)$n, (TiO_2)n, . . . The greatest difference arises from the fact that molecules have functionality which directly depends on the inter-positioning of their atoms, whereas the properties of nanoclusters are solely guided by the number of subunits they contain. Once the particles are small enough- nanoclusters - these properties vary greatly with every addition or subtraction of an atom.

Nanotubes:

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1,[6] significantly larger than for any other material. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material(s) in some (primarily carbon fiber) baseball bats, golf clubs, car parts or Damascus steel [7,8]. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. These sheets are rolled at specific and discrete ("chiral") angles and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is a metal or semiconductor. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nano-tubes (MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by van der Waals forces, more specifically, pi-stacking.Applied quantum chemistry, specifically, orbital hybrid-dization best describes chemical bonding in nano-tubes. The chemical bonding of nanotubes is composed entirely of sp^2 bonds, similar to those of graphite. These bonds, which are stronger than the sp^3 bonds found in alkanesand diamond, provide nanotubes with their unique strength.

Graphene:

Grapheneis an allotrope of carbon in the form of a two-dimensional, atomic-scale, hexagonal lattice in which one-atom forms each vertex. It is the basic structural element of other allotropes, including graphite, charcoal, carbon nano-tubes and fullerenes. It can also be considered as an indefinitely large aromatic molecule, the limiting caseof the family of flat polycyclic aromatic hydrocarbons.

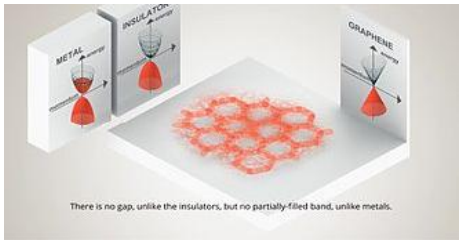

Figure 1: Graphene and its band structure and Dirac Cones, effect of a grid on doping

Graphene has many extraordinary properties. It is about 207 times stronger than steel by weight,[9] conducts heat and electricity efficiently and is nearly transparent [11]. Researchers have identified the bipolar transistor effect, ballistic transport of charges and large quantum oscillations in the material.Scientists have theorized about graphene for decades. It is quite likely that graphene was unwittingly produced in small quantities for centuries through the use of pencils and other similar applications of graphite, but it was first measurably produced and isolated in the lab in 2003 [5]. Research was informed by existing theoretical descriptions of its composition, structure and properties [6]. High-quality graphene proved to be surprisingly easy to isolate, making more research possible.Andre Geim and Konstantin Novoselov at the University of Manchester won the Nobel Prize in Physics in 2010 "for groundbreaking experiments regarding the two-dimensional material graphene" [7].The global market for graphene is reported to have reached $9 million by 2014 with most sales in the semiconductor, electronics, and battery energy and composites industries [8].

Fullerene:

A fullerene is a molecule of carbon in the form of a hollow sphere, ellipsoid, tube, and many other shapes. Spherical fullerenes are also called buckyballs, and they resemble the balls used in football (soccer). Cylindrical ones are called carbon nanotubes or buck tubes. Fullerenes are similar in structure to graphite, which is composed of stacked graphene sheets of linked hexagonal rings; but they may also contain pentagonal (or sometimes heptagonal) rings [1]. The first fullerene molecule to be discovered, and the family's namesake, buck minster fullerene (C_{60}), was prepared in 1985 by Richard Smalley, Robert Curl, James Heath, Sean O'Brien, and Harold Kroto at Rice University. The name was homage to Buckminster Fuller, whose geodesic domes it resembles. The structure was also identified some five years earlier by Sumio Iijima, from an electron microscope image, where it formed the core of a "bucky onion" [2]. Fullerenes have since been found to occur in nature [3]. More recently, fullerenes have been detected in outer space [4]. According to astronomer Letizia Stanghellini, "It's possible that buckyballs from outer space provided seeds for life on Earth [5]. The discovery of fullerenes greatly expanded the number of known carbon allotropes, which until recently were limited to graphite, diamond, and amorphous carbon such as sootand charcoal. Buckyballs and buckytubes have been the subject of intense research, both for their unique chemistry and for their technological applications, especially inmaterials science, electronics, andnanotechnology.

3. Effects

- Properties depends on size, composition and structure
- Nano size increases the surface area
- Change in surface energy (higher)
- Change in the electronic properties
- Change in optical band gap
- Change in electrical conductivity
- Higher and specific catalytic activity

- Change thermal and mechanical stabilities
- Different melting and phase transition temperatures
- Change in catalytic and chemical reactivities

4. Application

This discipline involves both new materials and new principles, as powerful tools for an extremely effective action again disease. For example a physicochemical phenomenon called Surface Plasmon Resonance is used to develop a technology for drug discovery, antibody screening, ligand fishing and therapeutics.Futuristic kinds of nanorobots have been even imagined, able not only to take care of our health from inside our body, but also to replicate themselves or to modify themselves according to the specific problem to be solved.Increasing funding initiatives are supporting this fascinating and promising research field.

- We are talking about the manufacture of new catalysts, coatings, computer components, highly selective sensors, lighter strong materials etc.
- The large surface to volume ratio will allow the development of new industrial catalysts.
- Nanomaterials can be used to make sensors that detect specific molecules.
- These detectors will find applications in detecting and monitoring pollutants in water.
- Nanotubes can be fabricated into strong and light materials, sometimes as composites with other non-nanomaterials.
- Such materials can used in such diverse applications as aircraft construction (fuselage, wings etc.) and sports equipment.
- The increased reactivity and small size of nanoparticles compared to larger ones are two important factors, which frequently crop up when studying the function of nanomaterials.
- Nanoparticles have a high surface are to volume ratio, this increases their rate of chemical reaction (greater reactivity) and this also enhances their catalytic effect.
- Nanomaterials can even be used for such mundane-unexciting applications as in self-cleaning ovens and self-cleaning windows!, but not mundane to domestic work in the home, but will it put window cleaners out of business, I doubt it. Nanoparticles are already being used in deodorants, sun blockers (sun tan creams)

5. Conclusion

As a conclusion to this topic I would like to say that Nanotechnology is a brand new technology that has just began, a revolutionary science will change all what we knew before. The future that we were watching just in science fiction movies will in the near future be real. This new technology will first of all, keep us healthy because of nanorobots that will repair every damage that we have in our body. Secondly it will give scientists the ability to manipulate the combination of atoms in an object and to turn it into a lighter, stronger, and more durable object than before, just by using carbon nanotubes that are known to be a hundred times stronger than steel and in addition to that they are very flexible. That will lead to the creation of objects that can change their forms and have multiple purposes as the Nokia Morph for example, which is a prototype that will soon be out on the market. Thirdly, Nanotechnology will give us an abundant energy because it will transform energy more effectively, for example windmills which are known to have the ability to transform wind energy into electrical energy, well new windmills that will use Nanotechnology will have lighter and stronger blades (using carbon nanotubes) that will transfer a lot of more energy that Nanotechnology covers a lot of domains today and will cover a lot more in the near future, it is infinitely big and will make a lot of inventions come true like teleportation for example which scientists are working on today.

6. References

[1] Nanochemistry: What Is Next, Ozin, Geoffrey A. and Cademartiri, Ludovico, 2009 Wiley-VCH Verlag, Weinheim small.**2009**, 5, 11, 1240–1244

[2] Grass, R. N.; Athanassiou, E. K.; Stark, W. J. (**2007**). "Covalently Functionalized Cobalt Nanoparticles as a Platform for Magnetic Separations in Organic Synthesis". Angewandte): *4909.* doi*:*10.1002/anie.200700613.

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

[4] A., and Tour, James Mark M. (**2000**). "Computing with Molecules." Scientific American 282(6):86–93.

[5] Service, Robert F. (**2000**). "Atom-Scale Research Gets Real." Science 290:1524–1531.

[6] "Definition of graphene noun from the Oxford Advanced Learner's Dictionary".

[7] Andronico, Michael (14 April 2014). "5 Ways Graphene Will Change Gadgets Forever".

[8] "Graphene properties". www.graphene-battery. net. 29 May **2014**.

[9] This Month in Physics History: October 22, 2004: Discovery of Graphene". APS News. Series II 18 (9): 2. **2009**.

[10] "The Story of Graphene". Www.graphene.manchester.ac.uk. the University of Manchester. 10 September **2014**.

[11] Gullapalli, S.; Wong, M.S. "Nanotechnology: A Guide to Nano-Objects" Chemical Engineering Progress. **2011,** 107(5): 28–32.

[12] Mintmire, J.W.; Dunlap, B.I.; White, C.T. (**1992**). "Are Fullerene Tubules Metallic?".Phys. Rev. Lett. 68 (5):631–634.