International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Nanomaterials: A Measure for Air Pollutant Remedial Technologies

G. Vani Padmaja

Deshbandhu College, Department of chemistry, University of Delhi, Delhi

Abstract: ***Latest research trends are coming out more on the nanomaterials based on polymer which are extensively applied in the active areas of energy storage and their conversions pharmacology, bio clinical areas, drug designing, drug delivery systems, environmental remediation, etc. This paper emphasizes more on the recent research developments in the application of nanomaterials for air cleaning remedies, specific adsorption mechanisms, improvements, control of toxicity and various techniques to control the hazardous pollutants present in the environment. Quick and rapid environmental monitoring of hazardous pollutants like pathogens, explosives, heavy metals, pesticides and insecticides can be extensively done by differently designed electrochemical sensors that incorporate biocompatible biomolecules like enzymes, antibodies, aptamers etc as recognition elements for designing of simple, low cost, compact, efficient biosensors. Nanoparticles have various special significant features like surface effects, size effects, quantum effects etc and exhibit much better performances than the conventional materials. Thus nanoparticles can be applied for various surface active adsorbant devices which can trap toxic gases and metals in the environment. Novel biohybrid nanomaterials had great potential as efficient and effective novel antimicrobial agents with high biocompatibility. Designing of hybrid nanocomposites by the conjugation of the natural and synthetic polymers with certain active elements like Ti, V etc creates certain advanced materials with the desired (tailored) properties, functions and applications. Control and minimization on the particulate pollutants in the air which is growing tremendously with the rapid increase in the technologies and industries leading to so many chronic diseases and various the health hazards has been studied. Specifically functionalized and designed nanomaterials has the great potential to treat particulate toxic pollutants and can offer many advantages and various methodologies to improve existing environmental pollution remediation technologies that is better than current technologies.***

Keywords: Air cleaning remedies, biohybrid, particulate pollutants, anti microbial agents, biocompatibility, biosensors and biodetectors

1. Introduction

Environmental nanotechnology is playing a most important and crucial role in designing and shaping up of environmental engineering and science. Current research at the nanoscale level has led to the development of various novel, highly effective, low cost efficient methodologies for pollution remediation, detection and analysis, catalysis etc. With the advancement of new research methods in the field of nanotechnology, nanoparticles and nanomaterials are widely applied with their high potential impact on the environment, its flora and fauna. Nanomaterials often differ from those of huge materials in their physical and chemical properties and also means monitoring health risks to workers, consumers to every individual and also potential risk to the environment. The combination of environment science with nanotechnology can be used as an important tool in fabricating the desired nanomaterials with tailored properties under the environment engineering nanotechnolgy. The small size of the nanoparticles has initiated the development of new and low cost techniques for the pollutant biosensors, pollutant detecting devices and monitoring, pollution remediation technologies etc. Being very effective and efficient, Nanocomposites and nanostructured materials are very widely used in various fields because of their small size and highly active large surface areas. Nowadays the field of nanotoxicolgy is in high demand to resolve the dreadful environmental contamination and pollution issues so as to attain safer, cleaner and healthier surroundings which is very much in consideration for the survival of future generations. Nanotechnology can be used to prevent the formation of pollutants or contaminants by applying the material technology, industrial processes and others novel techniques. Thus, three important applications of nanotechnology in the fields of pollution control can be classified as (a) remediation and purification of polluted material, (b) pollution detection and sensing (c) pollution prevention. The ratio of surface area to volume of nanomaterials is high and being small in size it can be used to detect very sensitive contaminants and pollutants.

2. Nano-Sized Materials

Various nanosized materials are being synthesized and specifically designed to solve the deadly upcoming environmental issues which are of great .There are two important ways through which nanotechnology is being used to reduce air pollution: a) nano-sized catalysts, which are constantly being improved and widely used in various areas b) nano-structured membranes, with highly active adsorbing and absorbing sites. Nano sized catalysts can be used to enhance the rate of any chemical reaction which can change one type of molecule into another at lower temperatures and can make the reaction more effective and effecient. Nanotechnology and their innovative technical methods can improve the performance, efficacy and cost of catalysts and are used to transform vapors escaping from cars or industrial plants into less harmful and less toxic gases. Because catalysts made from nanoparticles have a greater surface area of interaction with the reacting chemicals than the catalysts made from macro particles so the larger surface area of the catalysts allows more chemicals to interact simultaneously, thereby making the catalyst more effective and efficient [1-4].

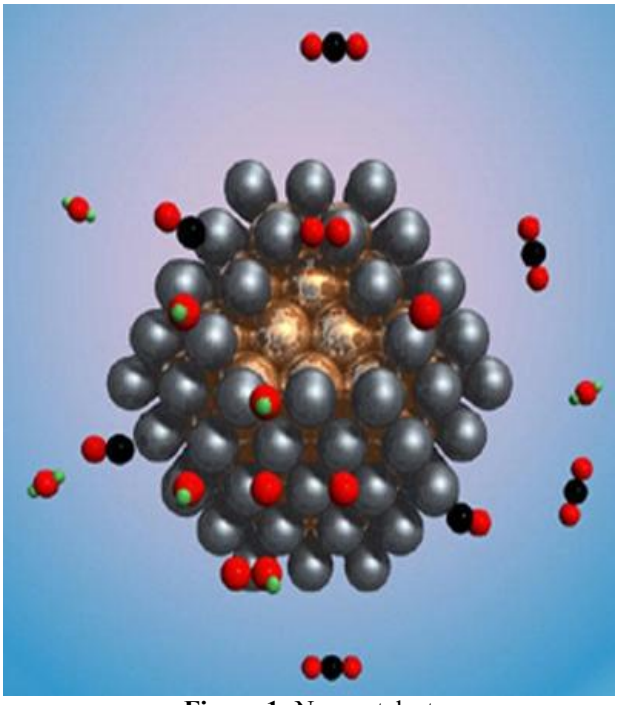

Figure 1: Nanocatalyst

3. Nanomembranes and Thin Films

Nanostructured membranes and thin films are being specially fabricated to isolate and entrap carbon dioxide from industrial plant exhaust streams and various gaseous effluents. The conventional and traditional methods of pollutant treatment methods which are used include carbon adsorption, ozonisation, chlorination, ultrafilteration, sedimentation etc. The newly designed and synthesized biocompatible nanomaterials of desired properties with exceptionally very high active and large surface areas could be a great tool for the pollutant treatment techniques over the traditional methods. The incorporation of certain transition metals like Ti, Zn etc in the nanomaterials enhances the desired adsorption properties of the molecule. Applying the concept and principles of environmental nanotechnology, depending upon the nature and complexity of the existing pollutants, specific biocompatible nanomaterials and thin films could be designed and synthesized encapsulated by certain metal ions which can be efficiently applied in the pollutant treatment technologies. Recent advances in the nanotechnology engineering have led to the production of reduced sized TiO_2 particles and such particles have applications in various environment treatment techniques. Nanotubes based membranes can be used for efficient removal of carbon dioxide from industrial effluents. CNT based membranes, nanostructured membranes and thin films, genetically engineered specifically designed bioactive enzymes are the newly developed nanomaterials which are useful in separating CO_2 and other pollutant gases from the power plant emissions and from the industrial smoke stacks[5-8].

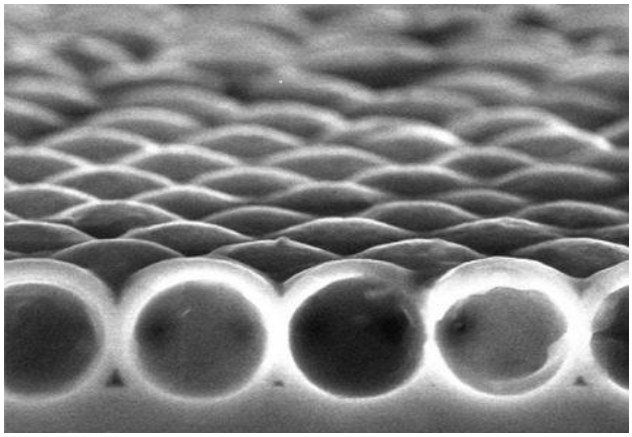

Figure 2: Nano shell and thin films

4. Air Pollution and Nanotechnological Applications

Pollution prevention on the one hand is a reduction of raw materials usage and other resources along with the reduction in the elimination of waste, on the other hand with the more efficient production of energy. Besides, nitrogen oxides and sulfur oxides, many volatile organic compounds (VOCs) in air increase the high percentage of ozone levels smog and particulate matter , as well as is an important cause for potentially damaging the human health also. Most of the modern air-purification systems and mechanisms are based on photo catalysts, adsorbents such as activated charcoal, or ozonolysis etc. These conventional systems are not very efficient for the chemical decomposition of organic pollutants at room temperature. A new material has been synthesized and developed that very effectively separates removes VOCs as well as nitrogen and sulfur oxides from air at room temperature. Gold Nanoparticles in Manganese Oxide are applied to remove VOCs from air. All three of the organic pollutants (acetaldehyde, toluene, and hexane) were found to be very effectively removed from air and degraded by the catalysts which are significantly better than with conventional catalyst systems. Synthetic 'gene,'" has been synthesized by the crystals of metal-organic frameworks in which the sequence of multiple functionalities of varying kind and ratios are present. These multivariate metallic organic frameworks can be taken to a new level of performance, by incorporating controlled complexity. These structures can be a boon for various industrial applications, such as conversion of gases and liquids like carbon dioxide to fuel or water to hydrogen, energy-related and other useful applications etc.

Recently one of the most important application of nanotechnology is the adsorption of toxic and hazardous pollutant gases in the atmosphere by the CNTs and by Au nanoparticles. The highly efficient adsorptive capacity of pollutants by CNTs is because of its small sized ultra pore structure and the presence of broad area of surface active functional groups of CNTs which can be fabricated and designed specifically by the optimum chemical or thermal treatment of the CNTs so as to have effective performance for a particular purpose. Nanomaterials like single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs) are unique macromolecules which have a one dimensional structure, thermal stability with exceptional chemical

properties and have huge potential as superior adsorbents to remove different types of organic and inorganic pollutants present in the environment. Current research trends have proved the fact that certain nanosubstances using TiO_2 nanomaterials like active filters of photo-catalyst covered by TiO_2 on silica cotton and on Al_2O_3 fibers are extensively used as air purifiers and cleaners. Long and Yang reported that CNTs are significantly better than activated carbon and γ-Al_2O_3 for removing dioxins is because of their nanotube curved surface compared with those for flat sheets which gives stronger interactive forces between dioxin and CNTs. Studies also showed that interaction of dioxin with CNTs is found to be nearly three times stronger than the interaction of dioxin with activated carbon. Besides these, studies showed that TiO_2/Apatite paint to kill bacteria was very successfully achieved. Various studies also show that CNTs can be used as an excellent adsorbent for the removal of oxides of sulphur, nitrogen and carbon on the highly porous manganese oxide with gold nanoparticles grown into it.

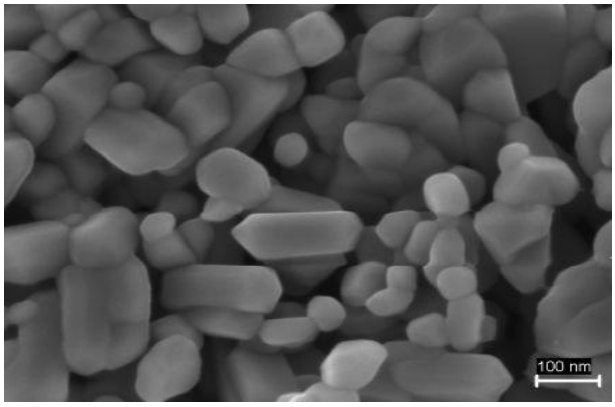

Figure 3: SEM micrographs of SiO_2

Researchers have also developed nanomaterials that are very effective and efficient in removing VOCs (volatile organic compounds), nitrogen and sulfur oxides and other harmful gases from air at room temperature. Recently nanobiosensors are used extensively for assessing environmental pollution and water quality monitoring. Besides these, the use of these sensors is economic (cost-effective) because they are synthesized with conventional microelectronics manufacturing equipments using simple electrochemical techniques[7-14]. A nanocontact biosensor has the ability to detect some metal ions without any preconcentration required and can be made in very small size and automatic mode so that it can be easily handled.

5. Nanodendrimers

Dendrimers are highly branched, star-shaped macromolecules with nanometer-scale dimensions with controlled composition. Dendrimers are constituted by three components: a central core, an interior dendritic structure and an exterior surface with functional surface groups. By varying the combination of these components products of different shapes and sizes with shielded interior cores can be formed that are ideal supramolecules for applications in both biological and materials sciences. Dendritic polymeric supramolecules in the form of chelating agents are used for the removal of metal contaminants. These can be specially fabricated with appropriate size of the cavity as “cage” to trap the contaminated metal ions in the environment. Thus the nanodendrimers can be extensively applied as the nanoscale chelating agents for various ultra filtration systems[15-18].

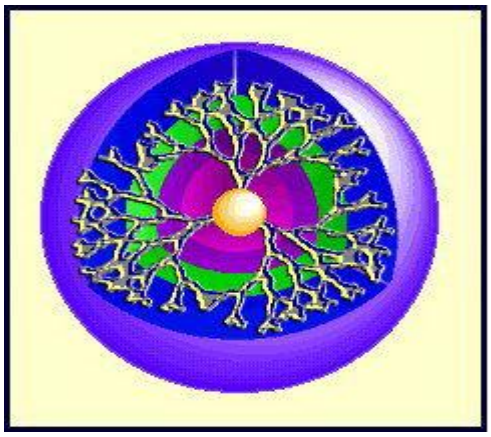

Figure 4: Dendrimers

6. Semiconducting Nanoparticles

TiO_2 and ZnO nanoparticles are semi conducting in nature and are extensively used in the photo catalytic pollution remediation. An electron hole pair is formed when the semi conducting materials are subjected to any source of irradiation because of their small band gap. Thus these kind of nanomaterials are capable of transferring the charge and induce the oxidation of organic pollutants to less harmful pollutants. The photo catalytic activity is enhanced when the TiO_2 and ZnO nanoparticles undergoes chemisorption of noble metals like Gold and Platinum. Silica- titania nanocomposites are extensively used for the removal of elementary Hg from the combustive sources where the Ti converts the mercury to less toxic form[19-23].

7. Conclusions

Nanotechnology and nanomaterials has been developed to maintain the environmental sustainability. Nanomaterials and nanoparticles being effectively smaller in size are surface active and highly reactive because presence of free active sites and presence of their large surface area to volume ratio. These unique desired properties of nanoparticles and specifically designed nanomaterials can be applied very well for solving the emerging potential environmental issues such as air, water, soil contamination and their remediation techniques. The science of nanotechnology is able to synthesize and develop an eco-friendly substances or materials which when applied can be easily replace the used toxic material(s). Thus, nanotechnology could be considered as an important platform to restructure the various methodologies and techniques employed for solving the existing and pressing environmental issues such as detectors, sensors, remediation, pollution control and prevention. It is the technology which can enhance and improve the conventional technological capabilities and new technologies which could replace the conventional technologies. The issues of air pollution and its remediation can be easily resolved by the interdisciplinary collaboration of many sciences like chemical sciences, physical sciences, material sciences, geological sciences etc.

Nanotechnological applications also include the synthesis of green materials, coatings, biocides, nanosensors, nanodetectors etc. to prevent the release of hazardous pollutants into the environment.

References

[1] **Environment protection agency**, US, *Environment Protection Agency Report*, EPA/B-07/001, EPA,Washington D.C.,2007.
[2] **Z Gu, JJ Atherton, ZP Xu** - *Chemical Communications,* 2015, 15, 3024- 3036.
[3] **Kok Bing Tana, Mohammadtaghi Vakilib, Bahman Amini Horria, Phaik Eong Poha, Ahmad Zuhairi Abdullahc, Babak Salamatiniaa, -** *Separation and purification technology,* 2015,150, 229–242.
[4] **Pankaj Ramnania, Nuvia M. Saucedob, Ashok Mulchandan** *Chemosphere,* 2015 *–Elsevier.*
[5] **Yuanhao Wu , Yubo Long , Qing-Lan Li , Shuying Han , Jianbiao Ma , Ying-Wei Yang, and Hui Gao,** *, ACS Appl. Mater. Interfaces,* 2015. **NAF Almeida, PR da Silva,** *Surface modification of Nanoparticle and synthetic polymeric fibres of TiO_2based nanocomposites***,** 2015**.**
[6] **Lu, G. Q. and Zhao, X. S.** "Nanoporous Materials - Science and Engineering " 2004.
[7] **G.Vani Padmaja,** *Biocompatible nanomaterials for pollutant treatment technologies,* IJSR, 4, 10, 2015.
[8] **Arash Shahmansouri and Christopher Bellona**, Water Science & Technology, 2015, 71, 3, 309–319.
[9] **Hoang Xuan Nguyen, Bart Van der Bruggen,** *Journal of membrane science and research,* 6, 1, 1, 2015, 34-40.
[10] **Long, R. Q. and Yang, R. T.** *J. Amer. Chem. Soc.,* 123: 2001, 2058-2059.
[11] **Bhushan, B.** *Springer Handbook of Nanotechnology*, 3, 2010.
[12] **Sinha, A. K. and Suzuki, K.** *Appl. Catal. B: Environ,* 70: 417-422, 2007.
[13] **Staiano, M., Baldassarre, M., Esposito, M., Apicella, E., Vitale, R., Aurilia, V. and D'Auri, S.** 2010. *Environ. Technol.,* 31: 935–942.
[14] **Gabrielle Palmer, Ross McFadzean1, Ken Killham, Alex Sinclair, Graeme I. Paton,** *Chemosphere,* 36, 12, 1998, 2683–2697.
[15] **Amar M. Chaudri, Bruce P. Knight, Vera L. Barbosa-Jefferson and others,** *Environ. Sci. Technol.,* 1999, 33 (11), 1880–1885.
[16] **T. Vossmeyer,B. Guse,I. Besnard,R.E. Bauer,K. Müllen,A. Yasuda**, *Advance materials,* 2002.
[17] **Ian Sofian Yunus , Harwin , Adi Kurniawan , Dendy Adityawarman Antonius Indarto,** *Journal Environmental Technology Reviews, 1,* 2012.
[18] **Lajos Balogh , Douglas R. Swanson , Donald A. Tomalia , Gary L. Hagnauer, Albert T. McManus ,** *Nano Letters*, 2001, 1 (1), 18-21.
[19] **Proceedings of the American Chemical Society Division of Polymeric Materials Science & Engineering**, San Diego, CA, *ACS*, 2001.
[20] **Jean M.J. Frechet and Donald A. Tomalia, J. Wiley & Sons** *Dendrimers and Other Dendritic Polymers* (2001).
[21] **W Cheng, SHL Yan** - *New Chemical Materials,* 2011.
[22] **XS Zhao, GQ Lu, GJ Millar -** *Journal of Porous Materials, Springer*, 1996.
[23] **JA Dias, VL Arantes, AS Ramos, TR Giraldi,** *Materials Science,* 2016.