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The Emergence of Nanotechnology and its Applications

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ABSTRACT

Nanotechnology deals with the application of nano-sized particles in the range of 1 to 100 nm, and due to their sizes they exhibit unique properties which enhance a wide range of utility in various field of application. This paper reported the application of nanotechnology in the areas of wastewater treatment, biomedical and drug delivery system as well as in semiconductors and electronics. It was reported that nanotechnology can be effective in the removal of pathogenic microorganisms as well as inorganic and organic pollutants from wastewater; also the use of nanotechnology was reported to be effective in biomedical and drug delivery system as well as in electronics and semiconductors.

INTRODUCTION

The emergence of nanotechnology has led to the design, synthesis, and manipulation of particles in order to create a new opportunity for the utilization of smaller and more regular structures for various applications. In recent years, nano-sized metal oxide particles have gotten much attention in various fields of application due to its unique optical, electrical, magnetic, catalytic and biomedical properties as well as their high surface to volume ratio and specific affinity for the adsorption of inorganic pollutants and degradation of organic pollutants in aqueous systems [1-29].

However, the use of nano-sized metal oxide particles in water treatment operations is faced with a series of challenges. Firstly, the high tendency for nano-sized metal oxide particles to aggregate in fluidized system leads to a loss in its activity and thereby restricts its usage in water treatment. Secondly, it is economically undesirable to separate most of the exhausted nano-sized metal oxide particles (exception for magnetic nanoparticles) from the treated water for reuse purpose. Thirdly, the fate and potential adverse effect of nano-sized metal oxide particles on human health, and the ecosystem is a major concern which should not be underestimated [6, 32-44].

The application of membrane separation technology has played a vital role in the purification water and waste water systems, due to their ability to provide a barrier for microorganisms, inorganic and organic pollutants. Membrane separation technology has also been reported to meet sustainability criteria in terms of environmental impacts, land usage, ease of use, flexibility and adaptability [45]. However, most membrane separation systems are hydrophobic and pressure-driven which necessitate the need for pumps to promote the trans-membrane pressure thereby leading to the demerits of fouling (which leads to a decline in membrane permeability) and high energy consumptions respectively [45]. The high energy consumption problems associated with a pressure-driven system can be eliminated by the use of an alternative system in which the membrane separation technology is design to operate with gravity as the driven force for water treatment. While the fouling problem associated with membrane separation technologies can be minimized by chemical modifications of the membrane such as hydrophilic modification of membrane before fabrication, blending with hydrophilic agent or foulant (nano-sized metal oxides) particles and grafting or coating hydrophilic polymers on the membrane surface [43, 45-46].

In order to maximize the merits and minimized the demerits of nano-sized metal oxide particles and membrane separation technology when used individually for water treatment, it is imperative to utilize a chemical modification which involves the incorporation of nano-sized metal oxide particles into the nano-membrane polymer matrix, this therefore gives rise to Mixed-matrix membranes (MMMs) which are also called polymer nano-composite membranes are often considered as a class of hybrid organic-inorganic membranes containing liquid, solid, or both liquid and solid fillers embedded in a polymer matrix [42-43, 46-58].

Application of Nanotechnology

Nanotechnology has been reported to be effective in various areas, among the various areas of application of nanotechnology a few is summarized below.

Application in Water and Wastewater Treatment

Nano silver particles which have been shown to have a high antimicrobial activity in the removal of *Bacillus subtilis*, *Bacillus megaterium*, *Escherichia coli*, *Salmonella typhimurium*, and *Staphylococcus aureus* from wastewater. It was reported that Silvernano particles are more effective towards *Escherichia coli* and *Staphylococcus aureus*, than other micro-organisms. The effect of concentration of silver nanoparticles on *Escherichia coli* is saturated from 100-60% while that of *Staphylococcusaureus is* 100-80%. It is least effective towards *Salmonella typhimurium* [8, 10-11, 33-35, 39]. The use of three dimensional polyvinyl alcohol/CNTs nanoporous architectures (3DPCA) has been successfully used in the removal of nickel (II) ion from wastewater and shows a maximum adsorption capacity of 225.6 mg/g for initial concentration of 400 mg/g, which is 18 times higher than when carbon nanotubes powder is singly used in the removal of nickel from wastewater. It was reported that an adsorption capacity reached 92% at 100 min relative to equilibrium adsorption capacity, indicating that the adsorption rate of 3DPCA for Ni (II) ions was rapid [49].

Nano-size metal oxides, nanosilica and nanocomposites have been effectively used in the removal of organic and inorganic contaminants such as heavy metals from wastewater; pectin-iron oxide magnetic nanocomposite has been used as an effective adsorbent in the removal of copper from wastewater by showing a maximum adsorption capacity of 48.99 mg/g. Furthermore, the adsorbents can be regenerated using 0.01 M EDTA, remaining 93.70% of its original capacity after the first regeneration cycle, and still reaching 58.66% of the original capacity after the fifth cycle[12-13, 16, 43-47].The Functionalization of titania with iron oxide (TiO_2/Fe_3O_4) nano magnetic particles has been reported to be effective in the prevention of eutrophication in an experiment that showed 70-80% phosphate removal from wastewater [50].

Application in Biomedical and Drug Delivery System

Biodegradable Polycaprolactone (PCL) nanomembrane and PCL Nanomembrane containing allopathic drug TH (Tetracycline hydrochloride) has been successfully studied, the result showed a strong antibacterial activity against *Staphylococcus aureus* and *Klebsiellapneumoniae*. A bacterial reduction of a 100% (2% TH/10% PCL) was reported when drug loaded specimens were used while the drug free nanofibre did not show any bacteria reduction.

This thereby indicate that drug loaded PCL nanomembrane was able to inhibit the growth of the bacteria which indicate that it could act not only as a drug delivery system but also in the treatment of wound healing or dermal bacterial infections thereby proving a potential application for use as a wound dressing [51].Magnetic iron oxide nanoparticles has been successfully applied in biomedical activities such as magnetic resonance imaging, drug deliver and *in vitro* bioseparation as well as biomedical disorder, therefore Iron oxide nanoparticles are being used in patients for both diagnosis and therapy [21-22, 24, 51-53].Functionalized gold nanoparticles with various biomolecules such as proteins, DNA, amino acids and carboxylic acids have been used in cancer therapy and provide excellent drug delivery system.

Targeted delivery and programmed release of therapeutic drugs to the specific site is achieved by using gold nanoparticles because they can bear high drug load and release it to the specific site through various administration routes and can interact with cancerous cell [38]. It has been reported that modification of titanium to improve wear resistance, corrosion resistance and biological properties enhances its usage in biomedical devices and components, especially as hard tissue replacement as well as in cardiac and cardiovascular application [54].

The formulation of mesoporous silica nanoparticles and its application in inject able delivery system has been successfully conducted, it was reported that MSN is a versatile and robust drug delivery systems terms of delivering combinations of chemotherapeutic agents [55].

Application in Electronics and Semiconductors

Cadmium Sulphide (CdS) is a semiconductor material which has gained much attention due to its direct band gap develops in the emission of visible wavelength. CdS nanoparticles with a particle size of around 3-10 nm has been successfully synthesized using the chemical precipitation method by chemical and green route. It has been reported that the particle size obtained by EDTA capped CdS nanopartcle is 1.88 nm and *Murraya Koeniggi* leaf extract capped CdS nanoparticles is 1.79 nm, while the conductivity (in seimen) of EDTA capped and Ni-doped CdS nanopartcle are 1.24 and 0.68 respectively [25].

Heterogeneous photocatalytic systems *via* metal oxide semiconductors like TiO_2 and ZnO, are capable of operating effectively and efficiently for waste water treatment which has been discussed along with other nanotechnology routes that can be useful for water treatments. Multifunctional photocatalytic membranes using ZnO nanostructures are considered advantageous over freely suspended nanoparticles due to the ease of its removal from the purified water [56-58].Lithium ion and Polymer electrolyte membrane fuel cells are used in many energy storage devices, batteries and fuel cells because of their high energy density; they are also used in portable electronic devices such as mobile phones, laptops, and medical microelectronic devices [45].

Conclusion

Nanotechnology has been reported to be effective in the removal of organic and inorganic pollutants as well as pathogenic microorganisms from water in order to enhance its purification. Recently, it has been reported to be applicable in the area of biomedical devices an drug delivery systems, thereby resulting to its importance in modern civilization. Finally, it was reviewed that nanotechnology is efficient in semiconductors and electronic systems.

References

[1] Gnanasangeetha, D., and SaralaThambavani D. One Pot Synthesis of Zinc Oxide Nanoparticles via Chemical and Green Method. Research Journal of Material Sciences, 2013,1 (7): 1-8

[2] Yong, N.L., Ahmad, A., Mohammad, A.W. Synthesis and Characterization of Silver Oxide Nanoparticles by a Novel Method. International Journal of Scientific & Engineering Research, 2013, 5 (4): 153-158

[3] Rajput, N. Methods of Preparation of Nanoparticles – A Review. International Journal of Advances in Engineering and Technology, 2015,7(4): 1806-1811

[4] Rafiee, H., Serri, F., Yari, S., Pourghadir, M., and Abdousi, V. A review: Silver Nanoparticles Synthesis through plants in comparison with chemical and biological Methods. Fire Journal of Engineering and Technology. 2015,1(1):46-50

[5] Rodríguez-León, E., Iñiguez-Palomares, R., Navarro, R.E., Herrera-Urbina, R., Tánori, J., Iñiguez-Palomares, C and Amir Maldonado, A. Synthesis of silver nanoparticles using reducing agents obtained from natural sources (Rumex hymenosepalus extracts). Nanoscale Research Letters, 2013, 8:318: 1-9

[6] Bekkeri, S. A Review on Metallic Silver Nanoparticles. Journal of Pharmacy, 2014, 4(7): 38-44 38

[7] Laurent, S., Forge, D., Port,M., Roch, A., Robic, C., Elst, L.V., and Robert N. Magnetic Iron Oxide Nanoparticles: Synthesis, Stabilization, Vectorization, Physicochemical Characterizations, and Biological Applications. Chem. Rev. 2008, 108, 2064–2110

[8] Balu S.S., Bhakat, C., and Harke, S. Synthesis of Silver Nanoparticles by Chemical Reduction and Their Antimicrobial Activity. International Journal of Engineering Research and Technology, 2012, 1 (6):2278-0181

[9] Landage S.M., Wasif A.I., Dhuppe, P. Synthesis of Nanosilver Using Chemical Reduction Methods. International Journal of Advanced Research in Engineering and Applied Sciences, 2014, 3 (5):14-22

[10] Logeswari, P., Silambarasan, S., and Abraham, J. Ecofriendly synthesis of silver nanoparticles from commercially available plant powders and their antibacterial properties. Scientia Iranica F, 2013, 20 (3):1049–1054

[11] Dhand, V., Soumya , L., Bharadwaj, S., Chakra, S., Bhatt, D., and Sreedhar, B. Green synthesis of silver nanoparticles using Coffea arabica seed extract and its antibacterial activity. Materials Science and Engineering C 58 (2016) 36–43

[12] Mahlambi, M.M., Ngila, C.J., and Mamba, B.B. Recent Developments in Environmental Photocatalytic Degradation of Organic Pollutants: The Case of Titanium Dioxide Nanoparticles- A Review. Journal of Nanomaterials, 2015, 1-29

[13] Knapik, E., and Stopa, J. Laboratory Experiments for Crude Oil Removal from Water Surface Using Hydrophobic Nano-Silica as Sorbent. Agh Drilling, Oil, Gas, 2014, 32 (2): 281-288

[14] Singh, M., and Naveen, B.P. Molecular Nanotechnology: A new avenue for Environment Treatment. Journal of Environmental Science, Toxicology And Food Technology, 2014, 8 (1): 93-99

[15] Singh, M., Manikandan, S., and Kamaraguru, A.K. Nanoparticles: A New Technology with Wide Applications. Research Journal of Nanoscience and Technology, 2010:1-11

[16] Hua,M., Zhang, S., Pan, B., Zhang, W., Lv, L., Zhang, Q. Heavy metal removal from water/wastewater by nanosized metal oxides: A review. Journal of Hazardous Materials 211–212 (2012) 317– 331

[17] Tiwari, D.K., Behari, J., and Sen, P. Application of Nanoparticles in Waste Water Treatment. World Applied Sciences Journal, 2008, 3 (3): 417-433

[18] Arora, A.K., Jaswal, V.S., Singh, K and Singh, R. Metal/Mixed Metal Oxides and Their Applications as Adsorbents. Int. J. Chem. Sci.,2016, 14(4): 3215-3227

[19] KATHAD, U AND GAJERA, H.P."Synthesis of Copper Nanoparticles by Two Different Methods and Size Comparison" Int J Pharm Bio Sci, 2014, 5 (3): 533-540

[20] Ghorbani, H.R., Safekordi, A.A., Attar, H., and Sorkhabadi, S.M. Biological and Non-biological Methods for Silver Nanoparticles Synthesis. Chem. Biochem. Eng. Q. 25 (3) 317–326 (2011)

[21] Ingale, A.G and Chaudhari, A.N. Biogenic Synthesis of Nanoparticles and Potential Applications: An Eco-Friendly Approach. J Nanomed Nanotechol 2013, 4(2):1-7

[22] Kandasamy, S and Prema, R.S. Methods of synthesis of nano particles and its applications. Journal of Chemical and Pharmaceutical Research, 2015, 7(3):278-285

[23] Schmidt, H. Nanoparticles by chemical synthesis, processing to materials and innovative applications. Appl. Organometal. Chem. 2001; 15: 331–343

[24] Pozzato, V.G., Pereira, A.G., Gerolis, L.G.L., Gonçalves, L.S., Pedrosa, T.A. and Neves, M.J. Gadolinium Nanoparticles: Chemical Synthesis and Biogenic Synthesis by Saccharomyces cerevisiae. 23rd Congress of the International Union for Biochemistry and Molecular Biology, 44th Annual Meeting of the Brazilian Society for Biochemistry and Molecular Biology, Foz do Iguaçu, PR, Brazil, August 24th to 28th, 2015

[25] Pooja, S and Preeti, J. Synthesis and Characterization of CdS Nanoparticle and Measurement of Conductivity of Different Sample. Int. J. Res. Chem. Environ., 2015, 5 (4): 22-25

[26] Sierra-Ávila, R., Pérez-Alvarez, M., Cadenas-Pliego, G., Padilla, V.C., Ávila-Orta, C.,Camacho, O.P., Enrique, J., Ernesto, H and Jiménez-Barrera, R.M. Synthesis of Copper Nanoparticles Using Mixture of Allylamine and Polyallylamine. Journal of Nanomaterials, 2015: 1-9

[27] Qiu-li, Z., Zhi-mao, Y., Bing-jun, D., Xin-zhe, L. and Ying-juan, G. Preparation of copper nanoparticles by chemical reduction method using potassium borohydride. Trans. Nonferrous Met. Soc. China 20(2010) s240−s244

[28] Kekutia, S., Saneblidze, L., Mikelashvili, V., Markhulia, J., Tatarashvili, R., Daraselia, D and Japaridze. Synthesis of Nanoparticles for Biomedical Applications. Eur. Chem. Bull., 2015, 4(1), 33-36

[29] Visai, L., Nardo, L.D., Punta, C., Melone, L., Cigada, A., Imbriani, M and Arciola, C.R. Titanium oxide antibacterial surfaces in biomedical devices. Int J Artif Organs, 2011; 34 (9): 929-946

[30] Shawaqfah, M. Use of Titanium Dioxide Reaction for Degradation of Chlorophenol. Jordan Journal of Civil Engineering, 2010, 4 (1): 31 – 39

[31] Dhermendra, K., Behari, J and Sen, P. Application of Nanoparticles in Waste Water Treatment. World Applied Sciences Journal, 2008, 3 (3): 417-433

[32] Elkins, K.E., Vedantam, T.S., Liu, J.P., Zeng, H.,Sun, S., Ding, T., and Wang, Z.L. Ultrafine FePt Nanoparticles Prepared by the Chemical Reduction Method. Nanoletters, 2003, 3(12): 1947-1949

[33] Guzmán, M.G., Dille, J., and Godet, S. Synthesis of silver nanoparticles by chemical reduction method and their antibacterial activity. International Journal of Chemical and Biomolecular Engineering, 2009, 3(2): 104-111

[34] Aashritha, S. Synthesis of silver nanoparticles by chemical reduction method and their antifungal activity. International research journal of pharmacy, 2013, 4 (10): 111-113

[35] Dong, P.V., Ha, C.H., Binh, L.T., and Kasbohm, J. Chemical synthesis and antibacterial activity of novel-shaped silver nanoparticles. International Nano Letters 2012, 2:9

[36] Hussain, J.I., Kumar, S., Hashmi, A.A., Khan, Z. Silver nanoparticles: preparation, characterization, and kinetics. Adv. Mat. Lett, 2011, 2(3): 188-194

[37] Ghorbani, H.R. Chemical Synthesis of Copper Nanoparticles. Orient. J. Chem., 2014, 30(2):803-806

[38] Khan, A., Rashid, R., Murtaza, G and Zahra, A. Gold Nanoparticles: Synthesis and Applications in Drug Delivery. Tropical Journal of Pharmaceutical Research, 2014, 13 (7): 1169-1177

[39] Kholoud, M.M., El-Nour, A., Eftaiha, A., Al-Warthan, and Ammar, R.A.A. Synthesis and applications of silver nanoparticles. Arabian Journal of Chemistry, 2010, 3(3):135–140

[40] Umer, A., Naveed, S., and Ramzan, N., Rafique, M.S. Selection of a Suitable Method for the Synthesis of Copper Nanoparticles, Nano: Brief Reports and Reviews, 2012, 7 (5): 1-19

[41] Solomon, S.D., Bahadory, M., Jeyarajasingam, A.V., Rutkowsky, S.A., and Boritz, C. Synthesis and Study of Silver Nanoparticles. Journal of Chemical Education, 2007, 84 (2): 322-325

[42] Zhang, Y., Wu, B., Xu, H., Liu, H., Wang, M., He, Y., and Pan, B. Nanomaterials-enabled water and wastewater treatment. NanoImpact, 3–4 (2016) 22–39

[43] Pandey, N., Shukla, S.K., and Singh, N.B. Water purification by polymer nanocomposites: an overview. Taylor and Francis Group, Nanocomposites, 2017, 3 (2): 47-66

[44] Qu, X., Alvarez, P.J.J. and Li, Q. Applications of nanotechnology in water and wastewater treatment. Water research 4 7 (2 0 1 3) 3 9 3 1 e3 9 4 6

[45] Le, N.L. and Nunes, S.P. Materials and membrane technologies for water and energy sustainability. Sustainable Materials and Technologies 7 (2016) 1–28

[46] Saxen, S. and Saxena, U. Development of bimetal oxide doped multifunctional polymer nanocomposite for water treatment. Int Nano Lett (2016) 6:223–234 DOI 10.1007/s40089-016-0188-5

[47] Gong, J., Wang, X., Zeng, G., Chena, L., Deng, J., Zhang, X and Niua, Q. Copper (II) removal by pectin–iron oxide magnetic nanocomposite adsorbent. Chemical Engineering Journal 185-186 (2012) 100– 107

[48] Jakšić, Z and Matovic, J. Functionalization of Artificial Freestanding Composite Nanomembranes. Materials, 2010, 3: 165-200

[49] Wang, H., Wang,W., Zhao, Y., Xu, Z., Chen, L., Zhao, L., Tian X and Sun, W. Superior adsorption of 3D nanoporous architectures for Ni(II) ions adsorption using polyvinyl alcohol as cross-linking agent and adsorption conveyor. RSC Adv., 2018, 8, 7899-790.

[50] Antwi, D.M.B, Acheampong, M.A., Mike, A. A. Modification of Titanium Dioxide Nanoparticles for Phosphate Removal from Wastewater. Journal of Applied Science, Technology and Management. 2016, 1:1

[51] Chellamani, K.P., Balaji,R.S. and Sudharsan, J. Antibacterial Properties of Allopathic Drug Loaded Polycaprolactone Nanomembrane. Journal of Academia and Industrial Research,2013, 2 (6): 341-344

[52] Laurent, S., Forge, D., Port, M., Roch, A., Robic, C., Elst, L.V. andMuller, R.N.Magnetic Iron Oxide Nanoparticles: Synthesis, Stabilization, Vectorization,Physicochemical Characterizations, and Biological Applications. Chemical Reviews, 2008, 108 (6): 2064-2110

[53] Manoj, S., Manikandan, S and Kumaraguru, A.K. Nanoparticles: A New Technology with Wide Applications. Research Journal of Nanoscience and Nanotechnology, 2010: 1-11

[54] Liu, X., Chu, P.K and Ding, C. Surface modification of titanium, titanium alloys, and related materials for biomedical applications. Materials Science and Engineering R 47 (2004) 49–121

[55] Wani, A.S."Formulation Devlopment Of Mesoporous Silica Nanoparticles As An Injectable Delivery System" (2013).Wayne State University Dissertations. Paper 713.

[56] Baruah, S., Pal, S.K.and Dutta, J..Nanostructured Zinc Oxide for Water Treatment. Nanoscience and Nanotechnology-Asia, 2012, 2 (2): 90-102

[57] Kulkarni, S.S. Optical and Structural Properties of Zinc Oxide Nanoparticles. International Journal of Advanced Research in Physical Science. 2015, 2(1):14-18

[58] Sobczyński, A. and Dobosz, A. Water Purification by Photocatalysis on Semiconductors. Polish Journal of Environmental Studies,2001, 10(4):195-205.

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