International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 1 [January. 2023] PP: 23-26

Nanotechnological Applications in Industrial Effluent Treatment: a Review

Dr. Mishu Singh
Assistant Professor
Department of Chemistry
Pt. Deen Dayal Upadhyay Govt. Girls P.G. College
Lucknow

Abstract
Nanotechnology is taken into account as the future of the world in most physics and chemical solutions that cannot be smeared in various scale level. This review aimed to spotlight the different uses of nanotechnology in industrial waste water treatment system because it is very important issue to protect the environment from the different liquid industrial pollutants. Nanoparticles are defined by some as nanomaterials, and these materials have unusual properties not present in ordinary materials. Nano, typically employed as a prefix, is defined as the billionth of a quantity or term that is represented mathematically 10^{-9}. It generally refers to the processes that produces and uses matter at the nanometre level. From the review Nano-technology is used to minimize the cost, accelerate the method and improve the efficiency of industrial waste water treatment. Nanoparticles found to be one among the best solution in the field of industrial waste water treatment.
Keywords: *Advanced Treatment, Environment, Industrial Waste Water, Nanotechnology, Nanoparticles.*

Date of Submission: 20-12-2022 Date of acceptance: 02-01-2023

I. INTRODUCTION

Nanotechnology marks its presence in various fields such as Detecting of pollutants, Catalysts for treatment and removal of environmental contaminants and pollutants [1], including pesticides remediation, polluted soils management, control of air and water pollution [2], and purification of drinking water [3]. Nanotechnology is a promising arcade and is expected to grow by 40 percent annually in the recent decade [4]. Organic wastes with high biological and chemical oxygen demand, or any other oxidizable compound produced from industrial wastes such as food processing wastes and paper mill production etc. can easily be destroyed by microorganisms like bacteria if there is enough oxygen in the water [5, 6]. Nanotechnology offers a promising treatment method to develop water supply systems where by the submission of nanomaterials such as metal nanoparticles, metal oxides, carbon compounds, zeolite, Nano filtration membranes, etc., the treatment of industrial effluent is more effective [7]. Nano- metal oxides such as titanium dioxide, zinc oxide, and tungsten oxidealong with other nanoparticles are used in water purification techniques due to their greater abilities to increase the chemical and biological properties of water [8].

II. APPLICATIONS

a. Filtration

Removal of solids from wastewater by passing through a porous medium which is able to stop anymacroscopic particulate contaminants called filtration [9]. While all the microscopic particles and microbial specimens cannot be efficiently removed out using the normal filtration methods, filtration innovations such as microfiltration, ultrafiltration and Nano-filtration have risen to deal with these challenging issues [10] [11]. Removal of heavy metals from water is crucial as these are non-biodegradable and can cause dangers to humanlife[12]. Ancollection of strategies can be connected to remove these metal ions from wastewater which integrates substance precipitation, coagulation and flocculation, reverse osmosis and adsorption and filtration. Substantial metal adsorption Nano technique is an exceptionalprocess that uses mass exchange system to remove the heavy metal ions [13].

b. Carbon Nanotubes

Contaminated waterwith heavy metal ions, pesticides, organic compounds, and nutrients (phosphates, nitrates, nitrites) from the industrial and agriculture activities is a threat to human and aquatic life, so it is very important to treat this waste water. Additionally, sludge generated during these treatment processesis highly adulterated with toxic substances [14]. So, innovative technologies such as nanotechnology are needed for such contaminated water. The low fouling membranes for MBR (membrane bio- reactor) technology which increases water permeability was considered to be provided by the inclusion of carbon nanotubes (CNTs) into the apertures of polymeric membranes because it is appropriate for the progress of high flux separation systems. However, the molecular size, lateral channel dimensions, molecular entropy, and pore diameter CNT can create mass/volume barriers in separation of pollutants [15], [16].

c. Nanomembranes

The separation properties are controlled by membrane components hence it is required to select the fabrication components such as polymer, solvent, additives like nanoparticles, pore forming agents, etc. carefully to attain the treatment objectives, [17]. Parameters such as evaporation time, temperature, and coagulation can affect the design method to elude the membranes fouling glitches [18]. Membrane materials for membrane systems fabrication are selectedaccording to their physico-chemical properties, such as chemical, heat, mechanical and cleaning resistance and easy fabrication. Fouling decreases the membrane performance temporarily or permanently [19]. The fouling mechanism includes the contact between the membrane surface and inorganic, organic, and biological substances in many different forms [20]. Over the past few years, nanoparticles have beenbordered as particles of the scale of 1-100 nm and that they have distinctive magnetic, electrical, optical, mechanical and structural properties, as example chitosan, silver nanoparticles, photo catalytic Titanium oxide, and carbon nanotubes [21].

d. Nano- Catalytic Membranes

Nano-catalytic membranes offer many benefits like high homogeneousnessand uniformity of chemical action sites, competence of optimization, and controlling contact time of catalyst [22]. Nano- titanium oxide films and membranes under UV and visible-light irradiation are used for disintegration of organic pollutants, inactivation of microorganisms, and physical separation of contaminants [23]. It is also found that Nano catalytic membranes have antibacterial activity and help in getting constant high flux during water purification processes [24]. Metallic nanoparticles in membrane like cellulose ester, polyvinylidene halide, polysulfone, chitosan are found dreadfully effective in dichlorination and degradation of poisonous contaminants [21]. With the improvement in nanotechnology numerousunique nanostructured catalytic membranes have been synthesized which offer high permeability, selectivity, and resistance to fouling [22].

e. Adsorption

Adsorbents are classified according to the pore sizes into three classes: macrospores (>25 nm), mesospores (1–25 nm), and microspores (<1 nm) [25]. In additionthe nanomaterials such as carbon nanotubes and graphene are used in adsorption process indomestic and industrial wastewater treatment because of its high sorption capacity [26].

f. Colorants/Dyes Degradation

Theazo-dyes that are discharged into water bodies can be disintegrated by using the enhanced photo catalytic property of metal nanoparticles, before their exposure [27]. Nano-silver compounds have achieved around 75% dye degradation in the presence of solar exposure after 8 hours of contact timeand produces less harmful by-products such as NO_3^-, NH_4^+ [28].

g. Removal of Fluoride, Nitrate, and Phosphate

Nanocomposite prepared from chitosan and Fe3O4/ZrO2 under mild conditions has the ability to adsorb both nitrate and phosphate. The maximum adsorption process fitted well to the pseudo-first-order kinetic rate model, and the mechanism involved simultaneous adsorption and intra-particle diffusion [29].

h. Heavy Metal Ion Removal Using Nanocomposite

The study results have recommended that the nanocomposite prepared from chitosan and Fe3O4/ZrO2 under mild conditions could be an effective adsorbent for removal of contaminants from effluents [30]. There is a great demand for effective elimination of heavy metals. Polymer-functionalized nanocomposite used as surface assimilation materials retain the inherent exceptional surface properties of nanoparticles, whereas the compound support materials give high stability and process efficiency [31]. The commonly used nanoparticles for the wastewater treatment are made of alumina, cadmium sulphide, cobalt ferrite, copper oxide, gold, iron, iron oxide, iron hydroxide, nickel oxide, silica, titanium oxide, zinc oxide, zinc sulphide, zirconia, and some alloys [32]. Most notably, ZnO hollow Nano spheres and ZnONano plates showed complete removal of Cu(II) in binary compound solutions [33].

i. Removal of Mercury from Coal Power Plants

Mercury produced from the coal power plants add about 48 tons of mercury to the U.S. environment every year. In liquid effluents mercury comes from water-based processes the facilities used to scrub, capture, and collect the toxic material [34].

III. ANTIMICROBIAL CHARACTERISTIC

The antimicrobial classification of chitosan and chitosan-based nanocomposites as chitosan silver nanocomposite films are well recognized [35]. The antibacterial properties of chitosan may be ascribed to the stationary interaction between the negatively charged components in the microbial cell membranes and the positively charged amine groups on the chitosan backbone. It isrecommended that chitosan-based materials are more effective toward gram-negative microorganisms compared with gram-positive species [36].

IV.CONCLUSION

The "Nano science" involved in various fields has to still achieve more success. This paper gives a summary of the various aspects of nanotechnology for waste water treatment, mainly looking at it from the side of applications rather than from the risk side. Nanotechnology based treatment offers effective, efficient, durable and eco-friendly approaches. Certain precautions are to be taken to avoid any threat to human health or environment due to different nanomaterials. To overcome these obstacles, collaboration between research institutions, industry and government is important.

REFERENCES

[1]. Kaur, J., Pathak, T., Singh, A., & Kumar, K. (2017). Application of Nanotechnology in the Environment Biotechnology.In Advances in Environmental Biotechnology (pp. 155-165).Springer, Singapore.

[2]. Qu, X., Alvarez, P. J., & Li, Q. (2013). Applications of nanotechnology in water and wastewater treatment.Water research, 47(12), 3931-3946.

[3]. Anis, M., AlTaher, G., Sarhan, W., &Elsemary, M. (2017). Environment and Remediation Applications.In Nanovate (pp. 87-112).Springer, Cham.

[4]. Kagan, C. R., Fernandez, L. E., Gogotsi, Y., Hammond, P. T., Hersam, M. C., Nel, A. E., ... & Weiss, P. S. (2016). Nano Day: celebrating the next decade of nanoscience and nanotechnology.

[5]. Manahan, S. (2017). Environmental chemistry.CRC press.

[6]. Alrumman, S. A., El-kott, A. F., &Keshk, S. M. (2016). Water pollution: source & treatment. American Journal of Environmental Engineering, 6(3), 88-98.

[7]. Mahadik, S. (2017). Applications of Nanotechnology in Water and Waste Water Treatment. AADYA-Journal of Management and Technology (JMT), 7, 187-191.

[8]. Gunti, S., Kumar, A., & Ram, M. K. (2018). Nanostructured photocatalysis in the visible spectrum for the decontamination of air and water. International Materials Reviews, 63(4), 257-282.

[9]. Walsh, S. E., &Denyer, S. P. (2012). Filtration sterilization (pp. 343-370).Wiley- Blackwell.

[10]. Baruah, S., Khan, M. N., &Dutta, J. (2016). Perspectives and applications of nanotechnology in water treatment. Environmental chemistry letters, 14(1), 1-14.

[11]. Levy, E. (2018). U.S. Patent Application No. 15/839,365.

[12]. Onoyinka, A. A., &Titilayo, H. A. (2017). Accumulation of Lead, Cadmium and Iron in Topsoil of Ori-Ile Battery Waste Dumpsite and Surrounding Gradient Point Areas at Olodo, Ibadan, Nigeria.International Journal of Mineral Processing and Extractive Metallurgy, 2(5), 68.

[13]. Sharma, R., & Kumar, D. (2018). Nanoadsorbents: An Approach Towards Wastewater Treatment. Nanotechnology for Sustainable Water Resources, 371-405.

[14]. Okereke, J. N., Ogidi, O. I., &Obasi, K. O. (2016). Environmental and health impact of industrial wastewater effluents in Nigeria-A Review. Int. J. Adv. Res. Biol. Sci, 3(6), 55-67.

[15]. Voyiatzis, G. A., Kouravelou, K., Karachalios, T., Beobide, A. S., &Anastasopoulos, J. A. (2017). Study of carbon nanotubes' embedment into porous polymeric membranes for wastewater treatment.In Application of Nanotechnology in Membranes for Water Treatment (pp. 81-110).CRC Press.

[16]. Anastasopoulos, J. A., Beobide, A. S., Karachalios, T., Kouravelou, K., &Voyiatzis, G. A. (2017). Study of carbon nanotubes' embedment into porous polymeric membranes for wastewater treatment.In Application of Nanotechnology in Membranes for Water Treatment (pp. 141-170).CRC Press.

[17]. Vilakati, G. D. (2015). Fabrication and characterisation of highly water permeable ultrafiltration membranes as supports for forward osmosis thin film composite membranes (Doctoral dissertation, University of Johannesburg).

[18]. Tijing, L. D., Woo, Y. C., Choi, J. S., Lee, S., Kim, S. H., &Shon, H. K. (2015). Fouling and its control in membrane distillation—a review. Journal of Membrane Science, 475, 215-244

[19]. Mohammad, A. W., Teow, Y. H., Ang, W. L., Chung, Y. T., Oatley-Radcliffe, D. L., &Hilal, N. (2015). Nanofiltration membranes review: Recent advances and future prospects. Desalination, 356, 226-254.

[20]. Choudhury, R. R., Gohil, J. M., Mohanty, S., &Nayak, S. K. (2018). Antifouling, fouling release and antimicrobial materials for surface modification of reverse osmosis and nanofiltration membranes. Journal of Materials Chemistry A, 6(2), 313-333.

[21]. Jeevanandam, J., Barhoum, A., Chan, Y. S., Dufresne, A., &Danquah, M. K. (2018). Review on nanoparticles and nanostructured materials: history, sources, toxicity and regulations. Beilstein journal of nanotechnology, 9, 1050.

[22]. Ying, Y., Liu, D., Zhang, W., Ma, J., Huang, H., Yang, Q., &Zhong, C. (2017). High-Flux Graphene Oxide Membranes Intercalated by Metal–Organic Framework with Highly Selective Separation of Aqueous Organic Solution. ACS applied materials & interfaces, 9(2), 1710-1718.

[23]. Bhat, A. H., Rehman, W. U., Khan, I. U., Khan, I., Ahmad, S., Ayoub, M., &Usmani, M. A. (2018). Nanocomposite membrane for environmental remediation.In Polymer-based Nanocomposites for Energy and Environmental Applications (pp. 407-440).

[24]. Nakata, K., &Fujishima, A. (2012). TiO2 photocatalysis: Design and applications. Journal of Photochemistry and Photobiology C: Photochemistry Reviews, 13(3), 169-189.

[25]. Güzel, F., Sayğılı, H., Sayğılı, G. A., &Koyuncu, F. (2015). New low-cost nanoporous carbonaceous adsorbent developed from carob (Ceratoniasiliqua) processing industry waste for the adsorption of anionic textile dye: characterization, equilibrium and kinetic modeling. Journal of Molecular Liquids, 206, 244-255.

[26]. Liang, R., Hu, A., Hatat-Fraile, M., & Zhou, N. (2014). Fundamentals on Adsorption, Membrane Filtration, and Advanced Oxidation Processes for

[27]. Roy, K., & Ghosh, C. K. (2017). Environmental and Biological Applications of Nanoparticles. Nanotechnology: Synthesis to Applications.

[28]. Ramamoorthy, V., Kannan, K., &Thiripuranthagan, S. (2018). Photocatalytic Degradation of Textile Reactive Dyes—A Comparative Study Using Nano Silver Decorated Titania-Silica Composite Photocatalysts. Journal of Nanoscience and Nanotechnology, 18(4), 2921-2930.

[29]. Roy, K., Sarkar, C. K., & Ghosh, C. K. (2015). Rapid colorimetric detection of Hg2+ ion by green silver nanoparticles synthesized using Dahlia pinnata leaf extract. Green Processing and Synthesis, 4(6), 455-461.

[30]. Aswin Kumar, I., &Viswanathan, N. (2018).Development and Reuse of Amine-Grafted Chitosan Hybrid Beads in the Retention of Nitrate and Phosphate.Journal of Chemical & Engineering Data.

[31]. Lofrano, G., Carotenuto, M., Libralato, G., Domingos, R. F., Markus, A., Dini, L., &Chattopadhyaya, M. C. (2016). Polymer functionalized nanocomposites for metals removal from water and wastewater: an overview. Water research, 92, 22-37.

[32]. Sharma, R., & Kumar, D. (2018). Nanocomposites: An Approach Towards Pollution Control. In Nanocomposites for Pollution Control (pp. 3-46). Pan Stanford.

[33]. Ray, P. Z., & Shipley, H. J. (2015). Inorganic nano-adsorbents for the removal of heavy metals and arsenic: a review. RSC Advances, 5(38), 29885-29907.

[34]. Percival, R. V., Schroeder, C. H., Miller, A. S., &Leape, J. P. (2017). Environmental regulation: Law, science, and policy. Wolters Kluwer Law & Business.

[35]. Liu, K., Wang, S., Wu, Q., Wang, L., Ma, Q., Zhang, L., ...&Hao, J. (2018). A Highly-resolved Mercury Emission Inventory of Chinese Coal-fired Power Plants. Environmental science & technology.

[36]. Dhanavel, S., Manivannan, N., Mathivanan, N., Gupta, V. K., Narayanan, V., & Stephen, A. (2018). Preparation and characterization of cross-linked chitosan/palladium nanocomposites for catalytic and antibacterial activity. Journal of Molecular Liquids, 257, 32-41.