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Selected Nanotechnology Applications in Industrial Waste Water Treatment: A Review

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Abstract: Nanotechnology is considered the future of the world in most physics and chemical solutions that cannot be applied in many scale level. This review aimed to highlight 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 is defined by some as nanomaterials, and these materials has unusual properties not present in ordinary materials. Nano, typically employed as a prefix, is defined as one billionth of a quantity or term that is represented mathematically 10^{9-}. Generally, refers to the processes that produces and use matter at the nanometre level. From the review Nano-technology can be used to minimize the cost, accelerate the process and improve the efficiency of industrial waste water treatment. Nanoparticles found to be one of the best solution in the field of industrial waste water treatment.

Keywords: Nanotechnology, Nanoparticles, Industrial, Environment, Advanced Treatment, Waste.

INTRODUCTION

Nanotechnology proves its present in many fields such as Sensing of pollutants, Catalysts for environmental contaminants treatment and removal [1], including in pesticides remediation, contaminated soils treatment, control of air and water pollution [2], also used as chelating agents for polymer to enhance ultrafiltration process and purification of drinking water, without the need for chlorination [3].

The nanotechnology is a promising market; it is expected to grow by 30 percent annually in the recent decade [4]. This growth will enhance the individual's awareness of the nanotechnology impact on the world [5].

Oxygen-demanding wastes are the normal organic wastes while ammonia, iron, or any other oxidizable compound resulted from industrial wastes. as food processing wastes and paper mill production. These wastes are easily destroyed by bacteria if there is enough oxygen in the water [6].

Nanotechnology offers a promising chances to develop water supply systems, the application of different nanomaterial's such as metal nanoparticles, metal oxides, carbon compounds, zeolite, Nano filtration membranes, etc., in the field of wastewater treatment [7].

Nanoparticles of metal oxides such as titanium dioxide (TiO2), zinc oxide (ZnO), and tungsten oxide (WO3) beside other nanoparticles of metal oxides used perfectly in water purification techniques due to their superior abilities to improve the chemical and biological properties of water [8].

FILTRATION

Removal of solids from water by passing the water through a medium able to blocks the particulate contaminants called filtration [9]. The porous medium can be capable of removing mainly macroscopic particles. While the microscopic particles and microbial specimens cannot be efficiently removed out using standard filtration methods [10]. In any case, imaginative filtration innovations, for example, microfiltration, ultrafiltration and Nano-filtration have risen to deal with these issues [11].

Heavy metals removal from water is urgent as these metals are non-biodegradable and can cause different wellbeing dangers to both human and creature life [12]. An assortment of strategies can be connected to expel these metals from water which incorporate substance precipitation (typically utilized for inorganic effluents and not much successful for follow measure of solvents), coagulation and flocculation (higher cost and lower efficiency), invert osmosis (compelling however costly) and adsorption and filtration (efficient and cost powerful). Substantial metal adsorption is an outstanding procedure that uses mass exchange system to remove the heavy metals [13].

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CARBON NANOTUBE

Water contaminated with heavy metal ions, pesticides, organic compounds, and nutrients (phosphates, nitrates, nitrites) from the industrial and agriculture activities, so it is very important to treat this waste Furthermore, incidental sludge from theses treatment process highly contaminated with toxic compounds [14]. So, advanced technologies such as nanotechnology needed for water treatment. The low fouling membranes for MBR technology increasing water permeability was considered to be provided by the inclusion of carbon nanotubes (CNTs) into the pores of polymeric membranes because it is suitable for the development of high flux separation systems. The pore diameter CNT can constitute mass/volume barriers [15]. By the way molecular size, lateral channel dimensions, and molecular entropy considered the three factors can affect the separation of pollutants using the CNTs [16].

NANOMEMBRANES

Membrane components controlled the separation properties, so fabrication components (main polymer, solvent, additives like nanoparticles, pore forming agents, etc.) must selected carefully to achieve the treatment objective, this can be clear in Fig. (1) [17]. Also parameters such as evaporation time, temperature, and coagulation can have affected the design approach to avoid the membranes fouling problems [18]. Membrane materials for membrane systems fabrication could selected according to their physical and chemical properties, such as chemical, heat, mechanical and cleaning resistance and easy fabrication. The fouling causes a decrease in membrane performance, either temporarily or permanently [19]. The fouling mechanism includes the interaction between the membrane surface and the foulants (inorganic, organic, and biological substances in many different forms) [20].

Over the past few years, nanoparticles (NPs) are outlined as particles having the scale of 1-100 nm and that they have distinctive magnetic, electrical, optical, mechanical and structural properties, as example chitosan, silver nanoparticles (nAg), photocatalytic TiO2, and carbon nanotubes (CNT). Moreover, some nanoparticles, such as silver (Ag), copper (Cu), zinc oxide (ZnO2), titanium oxide (TiO_2) [21].

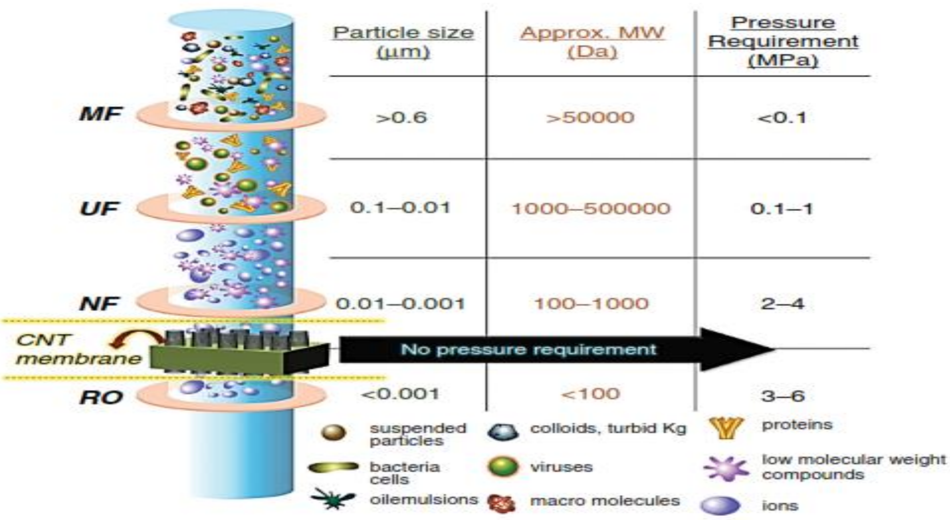

Figure 1. Different filtration system and its abilities [17]

NANOSTRUCTURED CATALYTIC MEMBRANES

NCMs Nanostructured catalytic membranes provide many advantages like high uniformity of chemical action sites, capability of optimization, limiting contact time of catalyst [22]. As example nanostructured TiO_2 films and membranes under UV and visible-light irradiation used for decomposition of organic pollutants, inactivation of microorganisms, antibiofouling process, and physical separation of contaminants [23].

Nanostructured material forming multifunctional membrane like The N-doped “nut-like” ZnO2 thought-about terribly economical in removing water contaminants by enhancing photo degradation method in presence of visible light irradiation. Also it found that it has antibacterial activity and helped in getting constant high flux during water purification processes [24].

While metallic nanoparticles in membrane like cellulose ester, polyvinylidene halide PVDF, polysulfone, chitosan found terribly effective in dechlorination and degradation of poisonous contaminants [21].

With the advancement in nanotechnology several novel nanostructured catalytic membranes have been synthesized lead to increasing permeability, selectivity, and resistance to fouling [22].

ADSORPTION

Adsorbents classified by IUPAC according the pore sizes into three classes: macrospores (>25 nm), mesoporous (1–25 nm), and micropores (<1 nm) [25]. Beside that nanomaterials such as carbon nanotubes and graphene using in adsorption process in water, wastewater and industrial wastewater treatment because it has high sorption capacity [26].

DYES DEGRADATION

The dyes, in most cases based on organic compounds with AZO bond (R–N=N–R′) that flow discharging into canals and rivers and other water bodies. Using the enhanced photocatalytic property of metal nanoparticles, these dyes could be degraded before exposure to the atmosphere [27].

Nano-silver compounds achieved around 75% dye degradation in the presence of solar exposure after 8 hours as contact time. Finally, (O^{2-}) oxidizes the azo bond of the dye molecules absorbed on the surface of nanoparticles and produces less harmful by-products such as NO_3^-, NH_4^+ [28].

Nanoparticles Mercury detector

During 2015 silver nanoparticles was used as green synthesized suspension for colorimetric detection of Hg. The dark brown suspension of nanosilver was only decolorize by Hg^{2+} contrariwise Cd^{2+}, Pb^{2+}, Zn^{2+}, Cr^{3+} not affect the color of the dark brown suspension of nanosilver [26].

FLUORIDE, NITRATE, AND PHOSPHATE REMOVAL

A novel nanocomposite was prepared from chitosan and Fe_3O_4/ZrO_2 under mild conditions. The nanocomposite had 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 intraparticle diffusion. The study results advised that the nanocomposite which prepared from chitosan and Fe_3O_4/ZrO_2 under mild conditions could be a promising adsorbent for nutrient removal from contaminated solutions [30].

HEAVY METALS REMOVAL USING NANOCOMPOSITE

There is a high demand for effective removal of heavy metals, polymer-functionalized nanocomposites (PFNCs) used as surface assimilation materials. PFNCs retain the inherent exceptional surface properties of nanoparticles, whereas the compound support materials give high stability and process efficiency. These nanoparticle-matrix materials area unit of nice interest for metals and metalloids removal because of the practical teams of the compound matrixes that give specific bindings to focus on pollutants [31].

The commonly used nanoparticles for the wastewater treatment are made of alumina, cadmium sulfide, cobalt ferrite, copper oxide, gold, iron, iron oxide, iron hydroxide, nickel oxide, silica, titanium oxide, zinc oxide, zinc sulfide, zirconia, and some alloys [32].

Heavy metals removal from waste exploitation inorganic nanoadsorbents as metal oxides and CNTs area unit the foremost wide studied and utilized materials as nanoadsorbents for significant metal removal in water. Most notably, ZnO hollow nanospheres and ZnO nanoplates showed complete removal of Cu(II) in binary compound solutions. stratified structures were designed to boost the properties of metal oxides for significant metal removal. every of those distinctive stratified kind structures incontestable increased surface assimilation capabilities compared to non-modified nanoparticles [33].

MERCURY REMOVAL FROM COAL-BURNING POWER PLANTS

Mercury pollution is from coal-burning power plants contribute about 48 tons of mercury to the U.S. environment each year. Mercury found in liquid effluents comes from water-based processes the facilities used to scrub, capture, and collect the toxic material [34]. according the Centers for Disease

Control and Prevention (CDC) 12.5% from women suffering mercury concentrations more than safety limits in their bodies [35].

ANTIMICROBIAL CHARACTERISTIC

The antimicrobial characterization of chitosan and chitosan-based nanocomposites as chitosan silver nanocomposite (CSN) films are well established. The antibacterial properties of chitosan may be attributed to the static interaction between the negatively charged components in the microbial cell membranes and the positively charged amine groups on the chitosan backbone. The barrier property is altered thanks to this binding between cell wall components and chitosan and thus leads to cell death, Chitosan has many blessings over different kinds of disinfectants as a result of it possesses a broader spectrum of activity, a higher antibacterial activity, and a lower toxicity toward mammalian cells. It was suggested that chitosan-based materials are more effective toward gram-negative microorganisms compared with gram-positive species, as a result of their dilutant murine wall, which may allow them to be more rapidly absorbed [36].

CONCLUSION

This "Nano science" became involved in many fields and still achieve more success. But also scientist still need to take care of the by-products of the process and technologies to achieve the best environment protection.

RECOMMENDATIONS

Even the nanotechnology had the great results in pollutants removal but as any technique have a variety of effects on the environment the society. Nanotechnology is no exception; the results will be determined by the extent to implementer of this technology. There are two opinions about the environmental effects of nanotechnology one positive and the other is negative, so each of us must take care of the side effects on the environment during nanotechnology applications, Research has to be centered on the look of nanocomposites that may tackle each chemical and biological contamination. Further, the property and cost-effectiveness of nanocomposites ought to even be taken into consideration.

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