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THE POTENTIAL OF TITANIUM DIOXIDE NANOAPARTICLES IN WASTE WATER TREATMENT

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Introduction

It is estimated that 10–20 million people die every year due to waterborne and nonfatal infection causes death of more than 200 million people every year. Every day, about 5,000–6,000 children die due to the water-related problem of diarrhea. There are currently more than 0.78 billion people around the world who do not have access to safe water resources resulting in major health problems. Nanotechnology has been considered effective in solving water problems related to quality and quantity. Nanomaterials (e.g., carbon nanotubes (CNTs) and dendrimers) are contributing to the development of more efficient treatment processes among the advanced water systems. There are many aspects of nanotechnology to address the multiple problems of water quality in order to ensure the environmental stability. This study provides a unique perspective on basic research of nanotechnology for water/wastewater treatment and reuse by focusing on challenges of future research

Pollutants Removal Using TiO_2 Nanoparticles

1) Disinfection: TiO_2 nanoparticles are among the emerging and most promising photocatalysts for water purification. The basic mechanism of a semiconductor based photocatalysts like low-cost TiO_2 having good photo activity and nontoxicity involves the production of highly reactive oxidants, such as OH radicals, for disinfection of microorganisms, bacteria, fungi, algae, viruses, and so forth . TiO_2, after 8 hours of simulated solar exposure, has been reported to reduce the viability of several waterborne pathogens such as protozoa, fungi, *E. coli*, and *Pseudomonas aeruginosa* . A complete inactivation of fecal coliforms under sunlight is reported in a study expressing the photocatalytic disinfection efficiency of TiO_2. The limited photocatalytic capability of TiO_2, that is, only under UV light, has improved drastically by extending its optical absorbance to the visible-light region. This was achieved by doping transition metals and anionic nonmetals such as nitrogen, carbon, sulfur, or fluorine into TiO_2. Recently, Ag doping of TiO_2 has resulted in improved bacterial inactivation either by complete removal or decreased time of *E. coli* inactivation thereby enhancing disinfection under UV wavelengths and solar radiations.

2**) Removal of Heavy metal and ions**

Different types of nanomaterials have been introduced for removal of heavy metals from water/wastewater such as nanosorbents including CNTs, zeolites, and dendrimers and they have exceptional adsorption properties. The ability of CNTs to adsorb heavy metals is reviewed by many researchers such as Cd2+, Cr3+, Pb2+, and Zn2+ and metalloids such as arsenic (As) compounds . Composites of CNTs with Fe and cerium oxide (CeO2) have also been reported to remove heavy metal ions in few studies. Cerium oxide nanoparticles supported on CNTs are used effectively to adsorb arsenic. Fast adsorption kinetics of CNTs is mainly due to the highly accessible adsorption sites and the short intraparticle diffusion distance. Metal based nanomaterials proved to be better in removing heavy metals than activated carbon, for example, adsorption of arsenic by using TiO_2 nanoparticles and nanosized magnetite. The utilization of photocatalysts such as TiO_2 nanoparticles has been investigated in detail to reduce toxic metal ions in water. In a study, the effectiveness of nanocrystalline TiO_2 in removing different forms of arsenic is elaborated and it has shown to be more effective photocatalyst than commercially available TiO_2 nanoparticles with a maximum removal efficiency of arsenic at about neutral pH value. A nanocomposite of TiO_2 nanoparticles anchored on graphene sheet was also used to reduce Cr(VI) to Cr(III) in sunlight . Similar Cr treatment was carried out by using palladium nanoparticles in another study.

3**) Removal of organic contaminants**

Metal oxide nanomaterials such as TiO_2 in addition to CeO_2 have also been used as catalysts for fast and comparatively complete degradation of organic pollutants in ozonation processes. Photocatalysts like TiO_2 nanoparticles are used effectively for the treatment of water contaminated with organic pollutants like polychlorinated biphenyls (PCBs), benzenes, and chlorinated alkanes. Removal of total organic carbon from wastewater was enhanced by the addition of TiO_2 nanoparticles in a study. TiO_2 nanoparticles were also used in a "falling film" reactor for the degradation of microcystins in water. Multiwalled CNTs functionalized with Fe nanoparticles have been proved effective sorbents for aromatic compounds like benzene and toluene. Decomposition of organic compounds can be enhanced by noble metal doping into TiO_2 due to enhanced hydroxyl radical production and so forth. For example, the doping Si into TiO_2 nanoparticles was effective to improve its efficiency due to the increase in surface area and crystallinity. TiO_2 nanocrystals modified with noble metal deposits and so forth were used for the degradation of methylene blue in the visible-light range. Nitrogen- and Fe(III-) doped TiO_2 nanoparticles were better in degrading azo dyes and phenol, respectively, than commercially available TiO_2 nanoparticles . TiO_2 nanoparticles deposited onto porous Al_2O_3 were used effectively for the removal of TOC in a study. TiO_2 nanocomposites with mesoporous silica were also used for the treatment of aromatic pollutants. A composite of nanosized SO_4 2−/TiO_2 was used for the degradation of 4-nitrophenol in one study. TiO_2 nanotubes have been used effectively to degrade toluene better than bulk structural materials and were found to be more efficient than TiO2 nanoparticles for degrading organic compounds

4) **Membrane**

The immobilization of metallic nanoparticles in membrane has also been proved effective for degradation and dechlorination of toxic contaminants. Inorganic membranes containing nano-TiO_2 or modified nano-TiO_2 have been used effectively for reductive degradation of contaminants, particularly chlorinated compounds. The use of TiO_2 immobilized on a polyethylene support and a TiO_2 slurry in combination with polymeric membranes has proved very effective in degrading 1,2-dichlorobenzene and pharmaceuticals, respectively. Polyethersulfone composite membranes with nano- TiO_2 as additive showed higher fluxes and enhanced antifouling properties. Ceramic composite membrane made of TiO2 nanoparticles inside a tubular Al_2O_3 substrate showed improved water quality and flux compared to Al_2O_3 membranes. By doping TiO_2 nanoparticles to the Al_2O_3 membrane, it was possible to control the membrane fouling by decreased adsorption of oil droplets to membrane surface in the treatment of oily wastewater

Conclusion

Safe water has become a competitive resource in many parts of the world due to increasing population, prolonged droughts, climate change, and so forth. Nanomaterials have unique characteristics, for example, large surface areas, size, shape, and dimensions, that make them particularly attractive for water/wastewater treatment applications such as disinfection, adsorption, and membrane separations. The review of the literature has shown that water/wastewater treatment using nanomaterials is a promising field for current and future research

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