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Thin-film (FTO/BaTiO3/AgNPs) for enhanced piezo-photocatalytic degradation of methylene blue and ciprofloxacin in wastewater

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Advanced oxidation processes (AOPs) including photocatalysis and piezocatalysis have been extensively used for wastewater treatment. In this study, barium titanate/silver nanoparticles (BaTiO3/AgNPs) was fabricated and supported on Fluorine-doped Tin Oxide (FTO) glass to produce thin-film (FTO/ BaTiO3/AgNPs) for the degradation of organic waste pollutants (Methylene blue and Ciprofloxacin). The prepared piezo-photocatalyst materials were characterized by XRD, SEM, TEM, EDS, UV- DRS, TGA, PL, BET, EIS, and chronoamperometry. The UV-DRS showed surface plasmon resonance (SPR) of Ag nanoparticles on the surface of BaTiO3 at a wavelength of 505 nm. TEM images revealed the average Ag nanoparticles size deposited on the surface of BaTiO3 to be in the range of 10-15 nm. The chronoamperometry showed that the photoreduction of silver nanoparticles (AgNPs) onto BaTiO3 (BTO) resulted in piezo-electrochemical current enhancement from 0.24 mA to 0.38 mA. The composites (FTO/ BaTiO3/AgNPs) achieved a higher degradation of MB and CIP when the photocatalysis and piezocatalysis processes were merged. Under both ultrasonic vibration and UV light exposure, FTO/BTO/AgNPs degraded about 72 % and 98 % of CIP and MB from wastewater, respectively. These piezoelectric thin films were shown to be efficient and reusable even after 3 cycles, suggesting that it is highly stable. Furthermore, the reactive oxygen species (ROS) studies demonstrated that hydroxyl radicals (•OH) were the most effective species during the degradation of MB, with minor superoxide radicals (•O2-) and holes (h+). From this study, we were able to show that these materials can be used as multifunctional materials as they were able to degrade both the dye and pharmaceutical pollutants. Moreover, they were more efficient through the piezo-photocatalytic process.

Recent Publications

1. Masekela D, Yusuf TL, Hintsho-Mbita NC, and Mabuba N (2022) Low Cost, Recyclable and Magnetic Moringa Oleifera Leaves for Chromium(VI) Removal From Water. Front. Water 4:722269.
2. Masekela, Daniel & Hintsho-Mbita, Nomso & Mabuba, N. (2020). Diethylamine functionalised Moringa oleifera leaves for the removal of chromium(VI) and bacteria from wastewater. International Journal of Environmental Analytical Chemistry. 1-21

Biography

Daniel Masekela completed his master's degree in nanoscience (Nanochemistry) at the age of 24 from the University of Johannesburg (RSA), and BSc honors (Chemistry) from the University of Limpopo (RSA). His research focuses on nanomaterials synthesis and fabrication, application of nanomaterials in wastewater and water treatment/purification, medicine, biology, energy, and electro-catalysis. Focusing on nanoscience and nanotechnology, he is aiming to develop new technologies and nanomaterials for water and wastewater treatment, solar energy conversion, transmission, and storage with a high impact on the environment and economy.

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