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Research article

Photocatalytic remediation of methylene blue using hydrothermally synthesized H-Titania and Na-Titania nanotubes

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ABSTRACT

Although nanotube is among the most effective morphology of Titania due to its unilateral pathway for photo-generated charge transfer and mechanical stability, its performance is still hampered by high recombination. In the present study, to further improve the photocatalytic degradation performance of Titania, univalent elements of H and Na were respectively ion-exchanged into the Titania nanotubes (TNTs). The photocatalyst was characterized using XRD, TEM, ICP-AES, and FTIR. The modified samples displayed enhanced photocatalytic degradation performance over Degussa TiO_2 under UV-A light illumination of MB. The rate constants of NaTNT and HTNT were 16 and 13 times that of Degussa TiO_2. Specifically, the Na-TNTs showed better photocatalytic degradation activity than H-TNTs with a rate constant of 0.12 min^{-1} while the latter showed 0.09 min^{-1}. The optimum adsorption and photocatalytic performance of NaTNT were determined at pH 6 achieving about 99% MB removal within 10 min of irradiation. The ion exchange NaTNT displayed excellent reusability after the fifth cycle of the photocatalytic tests and superoxide radicals were experimentally determined to be the main reactive oxygen species involved in the photocatalytic degradation of MB.

1. Introduction

Clean water is progressively scarce owing to increased pollution of the existing water sources particularly due to discharge of various contaminants [1]. Pollution is one of global environmental issues caused by hazardous substances. Common sources of environmental degradation include mining, smelting, textile industry and electronic waste disposal, and agricultural activities (pesticides and fertilisers) [2]. Dyes are organic contaminants which when released into the environment have potential to endanger both living organisms on land and under water [3]. Various organic contaminants such as pharmaceutical [2, 4], plastic, textile [5], paint [6], fungicide [7] and cosmetic are being discharged directly from the manufacturers into the source of water bodies [2, 5]. The release of organic pollutants and other carcinogenic petrochemicals have been a great concern among chemical engineers and environmentalists [5, 7]. Pollutants released from industrial wastewater are a crucial environmental concern with grave consequences on humans, environment and economic prospects [5, 8].

The removal of dye from contaminated waters is an essential task to safeguard the ecosystems and humans towards realization of eco-friendliness and sustainability of the environment [9]. The chemical compositions of most of the existing dyes are somewhat complicated and

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