Published: 19 May 2017

Degradation of 2-Nitrophenol by Dielectric Barrier Discharge System: The Influence of Carbon Doped TiO_2 Photocatalyst Supported on Stainless Steel Mesh

- J. O. Tijani,
- M. E. S. Mouele,
- T. C. Tottito,
- O. O. Fatoba &
- L. F. Petrik

Plasma Chemistry and Plasma Processing **volume 37**, pages1343–1373 (2017)Cite this article

Abstract

This study investigated the degradation of 2-nitrophenol (2-NP) in aqueous solution by dielectric barrier discharge (DBD) system alone and its combination with supported TiO_2 photocatalysts. The TiO_2 photocatalyst supported on a stainless steel mesh was synthesised using sol–gel solution of 8% polyacrylonitrile (PAN)/dimethylformamide/$TiCl_4$ followed by pyrolysis in the furnace under N_2 atmosphere at temperatures of 300, 350, or 400 °C for 3 h holding time. The supported catalysts were characterized for their morphologies, functional groups, crystallinity, surface areas and elemental chemical states by high resolution scanning electron microscope (HRSEM), Fourier transform infrared, X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET) surface area, and X-ray photoelectron spectroscopy. The influence of solution pH on the degradation of 2-NP was investigated. The residual concentration of 2-NP and the intermediate compounds were quantified and identified using high-performance liquid chromatography coupled with mass spectrometry (HPLC–MS). The concentration of the dissolved ozone, hydrogen peroxide and hydroxyl radicals generated by the DBD in the presence or absence of a catalyst was monitored using ultraviolet–visible spectroscopy and photoluminescence spectroscopy. The HRSEM, HRTEM, XRD and BET analysis revealed that the optimal thermal conditions

to obtain well supported uniformly grown, highly active crystalline TiO_2 catalysts with high specific surface area was 350 °C at a 3 h holding time in N_2 atmosphere with a flow rate of 20 mL/min. The supporting procedure simultaneously carbon doped the photocatalyst. The DBD system alone without catalysts successfully mineralised 58.6% of 2-NP within 60 min while combined DBD/supported TiO_2 nanocrystals achieved 77.5% mineralisation within the same treatment time. The increase in mineralisation rate was attributed to the existence of a synergistic effect between the DBD system and the supported catalysts. 2-NP degradation proceeded via hydroxylation, nitration and denitration using DBD alone and combined DBD/Supported TiO_2 photocatalyst. Catechol, hydroquinone, hydroxyl-1,4-benzoquinone, 2-nitrohydroquinone, and 2,4-dinitrophenol were identified as major intermediate products. The order of production of free reactive species by DBD alone and combined DBD with supported photocatalyst was $OH^{\circ} > H_2O_2 > O_3$.The results showed that the combined system was more than effective than DBD alone for the degradation of the 2-NP in aqueous solution.

LinkL https://doi.org/10.1007/s11090-017-9824-8