

A Novel Photomineralization of POME over UV-responsive TiO₂ Photocatalyst: Kinetics of POME Degradation and Gaseous Product Formations

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ABSTRACT

Traditionally, palm oil mill effluent (POME) is treated *via* open ponding system, which however is land-intensive and requires long hydraulic retention time. For the first time, this paper reports, simultaneously, the kinetics of photocatalytic degradation of POME and the assessment of its gaseous product formations. Characterization of the as-received UV-responsive TiO₂ showed that anatase was the predominant crystalline phase with an estimated crystallite size of 45.7 nm and band gap energy of 3.15 eV based on the UV-vis DRS scanning. Moreover, N₂-physisorption revealed that the BET specific surface area for TiO₂ was 8.73 m² g⁻¹ with pore size of 22.4 nm. When the photoreactor was blanketed with N₂ gas only at a TiO₂ loading of 0.5 g L⁻¹, POME degradation was only 4%. Significantly, in the presence of O₂, the degradation of POME achieved 23%, and can even attain a maximum of 52.0% at TiO₂ loading of 1.0 g L⁻¹ after 240 min of UV-irradiation. This has demonstrated that the hydroxyl generation rate from water species (prevalent in N₂-blanket) was considerably slower compared to the hydroxyl generation from the superoxide pathway that originates from externally-supplied O₂. It was also found that the POME degradation kinetics adhered to the 1st-order reaction with specific reaction rates (*k*) ranging from 0.70 × 10⁻³ to 2.90 × 10⁻³ min⁻¹. Interestingly, our assessment of the gaseous product formations revealed that the photoreaction employing 1.0 g L⁻¹ TiO₂ produced the highest amount of CO₂ (38 913 μmol) while 0.5 g L⁻¹ TiO₂ produced the highest amount of CH₄ (361 μmol). From the FTIR scanning of used catalyst, we can confirm that the chemisorption of organics was practically absent. This has led us to believe that the primary role of TiO₂ was to generate hydroxyls for direct attack on the organic compounds in the POME and eventually decompose them into simpler intermediates, CH₄, CO₂, and water. Moreover, after 20 h under the UV irradiation, POME degradation attained 78.0% and the final COD level dropped to 37 ppm, which is safe to be discharged.

DOI: 10.1039/C5RA06922J