Photocatalytic treatment of palm oil mill effluent by visible light-active calcium ferrite: Effects of catalyst preparation technique

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ABSTRACT
Palm oil mill effluent (POME) is a serious and expensive environmental problem in Malaysia. In this paper, CaFe\textsubscript{2}O\textsubscript{4} is introduced as a novel photocatalyst for the degradation of POME under visible light irradiation. Two synthesis routes, auto-combustion and co-precipitation, and two calcination temperatures 550 °C and 700 °C were used to produce four CaFe\textsubscript{2}O\textsubscript{4} catalysts AC550, AC700, CP550 and CP700. CP550 exhibited the greatest photocatalytic degradation at 56% chemical-oxygen-demand (COD) removal after 8 h of irradiation which dropped to 49% after three consecutive cycles indicating reasonable conversion and high recyclability. BET analysis indicated CP550 had the highest $S_{BET}$ (27.28 m\textsuperscript{2}/g) and pore volume (0.077 cm\textsuperscript{3}/g) which dropped precipitously for CP700 upon increasing the calcination temperature to an $S_{BET}$ of 9.73 m\textsuperscript{2}/g and pore volume of 0.025 cm\textsuperscript{3}/g due to annealing which created a smoother surface area as evidenced by the SEM images. UV–Vis DRS indicated CP550 had the highest band-gap (1.52 eV) which is likely due to the presence of a highly crystalline pure CaFe\textsubscript{2}O\textsubscript{4} phase compared to the other products which existed as a mixture of Fe oxidation states evidenced by the XRD data. The PL spectra for all catalysts indicated significantly lower recombination rate for both CP550 and CP700. Introduction of IPA into the reaction mixture to eliminate hydroxyl radicals resulted in a diminishing of COD removal from 56% to 7% proving hydroxyl radicals to be the primary reactive species responsible for photodegradation of POME.

KEYWORDS:
Calcium ferrite; Photocatalysis; POME; Visible light; Co-precipitation; Auto-combustion