Catalytic performance of hierarchical metal oxides for per-oxidative degradation of pyridine in aqueous solution

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Abstract

In present study, we have proposed a generalized template free hydrothermal approach for the synthesis of hierarchical metal oxides (Mn_3O_4, Co_3O_4 and NiO) and further used as a catalysts for the degradation of highly toxic heterocyclic compound pyridine from aqueous solution by using the catalytic peroxidation (CPO) method in presence of hydrogen peroxide as an oxidant. The synthesized hierarchical metal oxides (HMOs) catalysts have been characterized by various characterization techniques such as thermogravimetric analysis (TGA), X–ray diffraction (XRD), field–emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDX), transmission electron microscopy (TEM), and N_2 adsorption–desorption pore size distribution analysis. Characterization results shows that HMOs have higher surface properties and tunable porosity (BET surface area: 233.3–186.4 m^2g^{-1}, pore volume: 0.88–0.65 cm^3g^{-1} and pore size: 6.8–7.4 nm). The effects of different operating parameters such as dose of catalysts, H_2O_2 concentration, initial pyridine concentration, solution pH, and treatment temperature have been studied and optimized the CPO method for pyridine removal. More than 90-95% pyridine and 85-90% total organic carbon (TOC) were removed at the optimum condition. The qualitative and quantitative analysis of intermediates byproducts formation and their final products generation was determine by high performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), ion chromatography (IC) and inductively coupled plasma-atomic emission spectroscopy (ICP-AES). A plausible degradation pathway has been proposed on the basis of the results of analysis. Synthesized HMOs presented the stable performance throughout the reuse for five cycles with negligible metals leaching. Kinetics and thermodynamic study of the parameters have also been evaluated.