Analysis and Modelling of Electrochemical Oxidation of Recalcitrant Organic Wastewater

Abstract

In the present study, electrochemical oxidation was used for the degradation of recalcitrant organic wastewater. Lead dioxide was electrodeposited on mild steel (MS/PbO_2) from an alkaline electrolyte bath for its possible application as an electrocatalyst. The conditions for preparation of MS/PbO_2 were optimized and the electrode material was characterized by SEM, EDX, XRD, LSV and surface profilometer.

Methyl orange, malachite green and 2,4-dinitrophenol were degraded with the MS/PbO_2 electrode. The performance of the electrode in terms of energy consumption and current efficiency was calculated and was found comparable with that of other electrode materials. The applicability of the electrode as a photocatalyst and photoelectrocatalyst was also studied. Response surface analysis with Box-Behnken method was carried out to optimize the operational conditions and to study the interactive effect of the variables on the degradation of methyl orange, malachite green and 2,4-dinitrophenol. Pathways for degradation of these compounds were identified by HPLC-MS analysis. Toxicity analysis was carried out for samples collected at a constant time interval during the degradation.

The study was further extended for the degradation of textile industry wastewater. The wastewater was characterized and the parameters affecting the degradation were optimized using RSM. Coke oven plant wastewater characterized by high COD, low BOD, phenol, cyanide including thyocyanate and ammonia was also successfully degraded in 10 h. RSM analysis was carried out to simultaneously optimize the COD, phenol and cyanide including thiocyanate removal efficiency.

A parallel plate serpentine flow reactor was conceptualized for the continuous flow operation. Residence time distribution studies and flow modelling using COMSOL multiphysics was carried out to understand the flow characteristics. Mass transfer coefficient was calculated considering the reactor as an electrochemical plug flow reactor operating under mass transfer limiting conditions. Degradation of 2,4-dinitrophenol, synthetic textile wastewater and textile industry wastewater collected from the inlet of effluent treatment plant and outlet of activated sludge process were carried out in continuous flow mode. The energy consumption and mass transfer coefficients at varying operating conditions were calculated and was compared with that of other continuous flow reactors. Economic analysis was carried out for the degradation of the real wastewaters.

Keywords: PbO_2 anode, Degradation, Toxicity, Pathway, Response surface, Economic analysis.