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Electrolytic removal of zinc from simulated chloride wastewaters using a novel flow-by fixed bed electrochemical reactor

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Abstract

The cathodic deposition of zinc from simulated chloride wastewater was used to characterize the mass transport properties of a flow-by fixed bed electrochemical reactor composed of vertical stack of stainless steel nets, operated in batch-recycle mode. The electrochemical reactor employed potential value in such a way that the zinc reduction occurred under mass transport control. This potential was determined by hydrodynamic voltammetry using a borate/chloride solution as supporting electrolyte on stainless steel rotating disc electrode. The results indicate that mass transfer coefficient (K_m) increases with increasing of flow rate (Q) where $K_m \propto Q^{0.402}$.The electrochemical reactor proved to be efficient in removing zinc and was able to reduce the levels of this metal to lower than 0.7 ppm starting from initial concentration of 48.4 mg dm^{-3} ppm in 120 minutes using ratio of cathode volume/catholyte volume equal to 0.0075. Sherwood and Reynolds numbers were correlated to characterize the mass transport properties of the reactor as follows: $Sh = 0.0644Re^{0.3686}Sc^{1/3}$

Key Words: Heavy metals, Electrochemical reactor, Zinc, Flow-by electrode, Mass transfer

Introduction

Preventing of pollution and environmental damage by industrial waste causes governments to implement stricter environmental legislation. Industrial wastewater containing toxic ions represents a challenging case owing to the difficulty of removing these ions by biodegradation [1]. Pollution by toxic metals including Cu, Cd, Cr, Pb, Hg and Zn is generated by a wide range of manufacturing industries such as mining, metal finishing, electroplating, photographic development, printed circuit board production and battery [2]. Several methods have been used to remove toxic metals from wastewater effluents; including chemical precipitation [3], electrodialysis [4], ion exchange process [5,6], adsorption onto activated carbon [7, 8], low cost adsorbents such as kaolin, bentonite, blast furnace slag and fly ash [9], ion imprinted polymer [10], organic-based ligand precipitation [11], membrane and reverse osmosis processes [12]. The industrial utilization of these methods has been found to be limited, because of the high capital and