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Scale-up of a fixed bed electrochemical reactor consisting of parallel screen electrode used for *p*-aminophenol production

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Abstract

The behavior of a fixed bed consisting of amalgamated copper screens has been investigated for the electrolytic reduction of nitrobenzene to *p*-aminophenol under potentiostatic condition (controlled potential). The preparative electrolysis of nitrobenzene was carried out using supporting electrolytes consisting of 2 M H_2SO_4 in a solution of 50% 2-propanol/50% water (v/v). The criterion for scale-up (ε_n) was determined through application of one-dimensional model. The polarization curves that describe the reduction of nitrobenzene to *p*-aminophenol were obtained experimentally by using a pilot scale for different nitrobenzene concentrations and flow rates of catholyte.

It was found that the effectiveness factor (ε_n) increases with increasing flow rate, and decreasing nitrobenzene concentration. An optimum thickness of bed equal to 0.6 cm was obtained, in which the effectiveness factor not less than 0.588, to ensure a well distribution of current and potential.

Keywords: Nitrobenzene; *p*-Aminophenol; Fixed bed electrode; Effectiveness factor; Electrochemical reduction

1. Introduction

The design and scale-up of the electrochemical reactor play an important role in the development of industrial electrochemical processes. Therefore studying the controlling factors on scale-up make the operation of the system more efficient and economic on the commercialization stage. The most important tool in scale-up is the principle of similarity, first proposed by Newton and developed for the electrochemical system by Pickett [1].

In practice, in the course of developing large electrochemical cells on the basis of laboratory data obtained from small experimental cells, one is more likely to encounter the problems of increasing some of electrode dimensions. In other words, a scale-up of only some of the dimensions of the smaller cells would be involved. In this case for a given electrochemical system and set of operating conditions optimized in small laboratory cell, the scale-up involves: first considering the possible changes in the current and potential distribution on electrodes resulting from geometric and hydrodynamic changes as well as from the change in the relative importance of ohmic potential drop through the cell by determining the dimensionless groups (similarity criteria) which relate between these changes with current and potential distribution. Secondly, the optimum value of these criteria should be determined for scaling up to industrial conditions [2].

In recent years there has been great interest in so-called fixed bed or porous flow through electrodes (PFTE) were the working electrode consists of individual electronically conducting particles. Current flows to or from the bed by means of electronically conducting sheets, rods or gauze-termed current feeders. The electrolyte is passing through the porous spaces in the bed. Two important regimes can be distinguished depending on whether current and electrolyte flow are in parallel or at right angles to each other. The latter is often called a flow-by arrangement while the first is called a flow-through arrangement [3].

The study of the behavior of fixed bed electrode falls within the scope of electrochemical engineering considered to be the application of the principal of analysis and design of the chem-

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