The Preliminary Nonlinear Analysis of the Influence of Mass Transfer on Packed Bed Electrodes

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A generalized non-linear model for a packed bed electrode reactor is solved using the approximate Adomian polynomial method. The model consists of a set of second-order ordinary differential equations; a one-dimensional Poisson equation, describing the effect of the electric field and a coupled one –dimensional mass balance equation on this system. The model accounts for mass transport and heterogeneous electrochemical reaction. Solution of this model is used to determine lateral distributions of overpotential, concentration and current density, overall cell polarisation and effectiveness factors and to simulate the effects of important system and operating parameters.

$$\frac{d^2\Phi}{dX^2} = \mu \frac{C}{\frac{1}{\exp(\alpha\Phi)} + \frac{1}{\gamma}}$$

$$\frac{d^2C}{dX^2} = s \frac{C}{\frac{1}{\exp(\alpha\Phi)} + \frac{1}{\gamma}}$$

$$X = 0, \frac{d\Phi}{dX} = 0, \frac{dC}{dX} = 0$$

$$X = 1, \Phi = 1, C = 1 \text{ or } \frac{d\Phi}{dX} = \mu I, \frac{dC}{dX} = sI$$

where

Φ dimensionless potential variable $= \phi / \phi_1$

ϕ dimensionless potential $= \beta\eta$

α dimensionless parameter $= \alpha_a \phi_1$

μ dimensionless parameter $= -\nu^2 / \phi_1$

ν^2 dimensionless parameter $= a i_0 L^2 \beta / \kappa$

s dimensionless parameter $= \dfrac{a i_0 L^2}{nFD_i c_R^0}$

X dimensionless distance

C dimensionless concentration

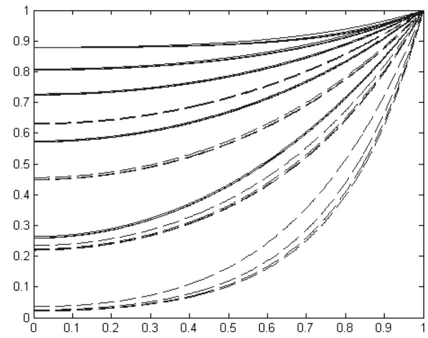

Fig.1 The approximate distributions of relative dimensionless potential Φ and dimensionless concentration C (dished line) with values of ϕ_1 at membrane by Adomain deposition method.

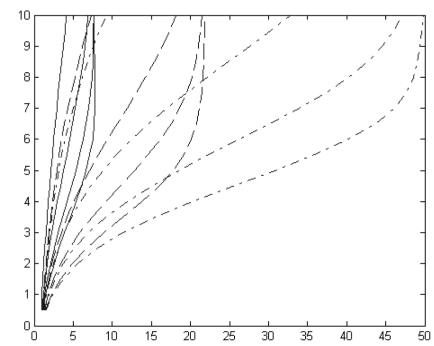

Fig 2 Variations of dimensionless potential ϕ_1 with dimensionless current density I for different values of transfer coefficient α_a =0.25, 0.5, 0.75, 1.0(from left to right).

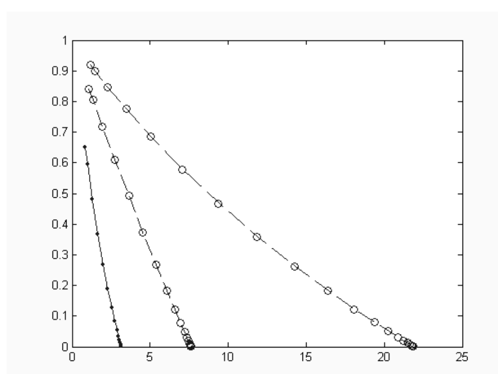

Fig .3 The comparison of decomposition data with numerical data for the dependence of effectiveness factor E and the dimensionless total current I for a Tafel reaction influenced by mass transport .

● , ○ Numerical data for different values of ϕ_1 by using Newman's BAND program.

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