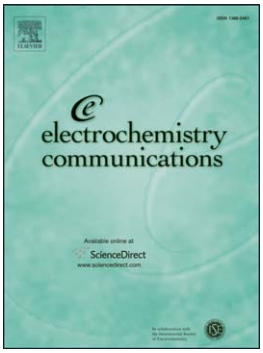

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Approximate analytical solution to MHM equations for PEM fuel cell cathode performance

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Abstract

We report approximate analytical solutions for the shapes of the overpotential, oxygen concentration and proton current density through the depth of a PEM fuel cell cathode and for the cathode polarization curve. The solution is obtained by applying a homotopy analysis method to the standard macrohomogeneous equations for the electrode performance. For typical cell parameters, the solutions are valid up to the cell current density on the order of $\simeq 500$ mA cm^{-2}.

Keywords: PEM fuel cell cathode, performance modeling, polarization curve

1. Introduction

Cathode catalyst layer (CCL) is "an engine" of a polymer electrolyte fuel cell: here, the oxygen reduction reaction (ORR) converts protons, electrons and oxygen into water. The largest potential loss in a cell occurs due to transport and kinetic processes in the CCL; this explains tremendous interest in experimental and modeling studies of the CCL performance. The most widely used is macrohomogeneous model (MHM) of the CCL, first introduced in the context of fuel cell electrode by Newman and Tobias in 1963 [1]. Since that time, MHM has been successfully used to model PEMFC polarisation curve and impedance in numerous works. The literature list on MHM modeling of CCL performance accounts for several tens of items; for the detailed review we refer reader to [2].

However, a complete set of MHM equations is strongly nonlinear and after pioneering works of Bernardi and Verbrugge [3] and Springer et. al. [4], a vast majority of works employed numerical solution to these equations. Analytical results have been obtained by Eikerling and Kornyshev [5] and Kulikovsky [6]

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