Preface

This volume begins with a tribute to Dr. Brian E. Conway by Dr. John O'M. Bockris, which is followed by six chapters. The topics covered are state of the art Polymer Electrolyte Membrane (PEM) fuel cell bipolar plates; use of graphs in electrochemical reaction networks; nano-materials in lithium ion batteries; direct methanol fuel cells (two chapters); and the last chapter presents simulation of polymer electrolyte fuel cell catalyst layers.

David and Valerie Bloomfield begin the first chapter with a discussion of the difficulties encountered when confronting bipolar plate development and state that the problems stem from the high corrosive nature of phosphoric acid. The water problems are mitigated but the oxidation problems increase. Bipolar plates are still not cheap, reliable or durable.

In Chapter 2, Thomas Z. Fahidy reviews analysis of variance (ANOVA) and includes one-way, two-way, three-way classification, and Latin squares observation methods. He moves on to a discussion of the applications of the analysis of covariance (ANCOVA) and goes over certain variables such as velocity, velocity and pressure drop, and product yields in a batch and flow electrolyzer. His conclusion is that proper statistical techniques are time savers which can save the experimenter and the process analyst considerable time and effort in trying to optimize the size of statistically meaningful experiments.

In Chapter 3 Charles R. Sides and Charles R. Martin present the effect of nanomaterials in lithium-ion battery electrode design and they describe the template-synthesis of lithium-ion battery electrode materials using polymeric templates. They present a plasma-assisted method to create a carbon replica of an alumina template membrane, which serves as a nanostructured anode for lithium-ion battery design.

Keith Scott and Ashok K. Shukla begin their discussion in Chapter 4 with a review of various types of fuel cells: phosphoric acid fuel cells, alkaline fuel cells, polymer electrolyte fuel cells, molten electrolyte fuel cells, solid oxide fuel cells, and direct methanol fuel cells. They follow this by reviewing the advances made in the performance of DMFCs since their inception. These fuel cells need to be able to stand higher temperatures than 200 ºC which require more temperature stable membranes. These fuel cells have a great potential to be used in mixed reactant systems due to the simplicity of the fuel cell stack design which may result in reduced costs.

In Chapter 5, Brenda L. Garcia and John W. Weidner review direct methanol fuel cells (DMFCs). High temperature operation of DMFCs has not been achievable without pressure on the cathode side and researchers have not been able to obtain good performances at temperatures above the boiling point of water. Novel polymers that operate well with temperatures above the boiling point have not been developed yet. One solution proposed in the literature is to laminate a layer of methanol impermeable polymer between two Nafion® membranes. This solution still requires hydration at high potentials and adsorption of methanol limits the reaction rate at low potential. Two-dimensional models have been developed to explain the variation of the current along the flow path. Transient models have been proposed but not much work has been accomplished in this area.

Partha P. Mukherjee, Chao−Yang Wang, and Guoqin Wang in Chapter 6 discuss the direct numerical simulation of polymer electrolyte fuel cell catalyst layers and they present a systematic development of the direct numerical simulation model which was developed at Penn State Electrochemical Engine Center. This method is used to describe the oxygen, water, and charge transport at the pore level within 2-D and 3-D computer-generated catalyst microstructures and indicates the importance of developing high-performance catalyst layers.

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