Accepted Manuscript

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PII: S0013-4686(18)32167-4

DOI: 10.1016/j.electacta.2018.09.171

Reference: EA 32761

To appear in: *Electrochimica Acta*

Received Date: 30 July 2018

Revised Date: 24 September 2018

Accepted Date: 24 September 2018

Please cite this article as: A. Unnikrishnan, N. Rajalakshmi, V.M. Janardhanan, Kinetics of electrochemical charge transfer in HT-PEM fuel cells, *Electrochimica Acta* (2018), doi: https://doi.org/10.1016/j.electacta.2018.09.171.

Kinetics of electrochemical charge transfer in HT-PEM fuel cells

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Abstract

This paper presents experimental and modeling study of high temperature polymer electrolyte membrane fuel cell performance. The experiments are performed using in-house prepared MEA with an active area of 2.25 cm^2. The experiments are simulated using a one dimensional distributed charge transfer model that resolves the properties along the thickness of the MEA. Six different HOR models and two different ORR models are subjected to initial studies. The model predictions are compared with cell performance on pure H_2 and H_2 with CO contamination. A detailed sensitivity analysis is carried out to understand the influence of various model parameters on cell performance over a range of potentials.

Key words: Kinetics, CO poisoning, Modeling, Experiments, HOR,ORR

1. Introduction

High temperature polymer electrolyte membrane fuel cells (HT-PEMFC) hold some key advantages over the nafion based low temperature polymer electrolyte membrane fuel cells (LT-PEMFC). The most important ones being the simplified water management and improved CO tolerance. Numerical modeling helps to understand the intricate physical and chemical processes within the cell. Models that range form simple analytical models to three dimensional and system level models are available in the literature [1–9]. However, the ones that study the kinetic aspects of oxygen reduction reaction (ORR) and hydrogen oxidation reaction (HOR) under HT-PEM fuel cell operating conditions are rather limited in the literature.

The fundamental aspects of HOR and ORR are experimentally studied using rotating disc electrodes (RDE) typically at room temperature [10, 11]. The exchange current densities are then calculated from RDE measurements by extrapolating the data from room temperature to fuel cell operating temperatures. There are reports which points to the draw back of RDE to accurately measure HOR rates in acid electrolytes due to the very fast kinetics of HOR in acid media compared to alkaline media [11, 12]. It has been found that the exchange current densities calculated using Butler-Volmer equations are much higher than the ones measured usnig RDE [11, 13]. When it comes to ORR it is well known that the performance of PEM fuel cells is limited by

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