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A SEMI-EXPERIENTIAL ELECTRICAL EQUIVALENT CIRCUIT FOR MODELING THE ANODE IMPEDANCE OF A DIRECT METHANOL FUEL CELL USING A RATIONAL FUNCTION

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Abstract. *In this paper, a new electrical equivalent circuit (EEC) suitable for the simulation of the electrochemical impedance spectroscopy (EIS) of a direct methanol fuel cell (DMFC) anode is developed from a rational mathematical function. Applying the criterion for estimating the orders of polynomials, the suitable rational function with the smallest simulation error and the prevention of over-modeling dynamics is theorized from the rational function which was transformed from the conventional EEC. Incorporating the specific electrical component for interpreting the physicochemical phenomena of methanol oxidation reaction (MOR) in a DMFC anode, the suitable rational function is transformed into a semi-experiential EEC taking into account the anode/membrane interface, the porosity of the catalyst layer, and the gas diffusion layer (GDL). The differences of the anode EIS between the kinetics of the MOR at various operating conditions are utilized to clarify the efficiency of the EEC simulation. A comparison with the conventional EECs verifies the accuracy of this semi-experiential EEC for modeling the anode impedance spectrum. Furthermore, the variance between the fitting values of the electrical components, corresponding to the physicochemical characteristics of the MOR, demonstrates the reliability of applying this semi-experiential EEC to analyze the anode impedance of a DMFC during the practical operation.*

Keywords: Electrical equivalent circuit (EEC), Electrochemical impedance spectroscopy (EIS), Rational mathematical model, Gas diffusion layer

1. **Introduction.** Several advantages, such as easy storage of fuel, a low operating temperature, and a high energy density, make the direct methanol fuel cell (DMFC) a most promising system for portable electronic devices. The cell performance is dependent on the membrane electrode assembly (MEA), which consists of a polymer electrolyte membrane, an anode electrode, and a cathode electrode. However, the questionable performance and