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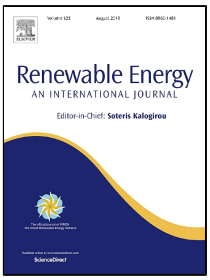

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A Graphene-based Microporous Layer for Proton Exchange Membrane Fuel Cells: Characterization and Performance Comparison

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Abstract

Water management is a critical issue for proton exchange membrane (PEM) fuel cells, and the use of a microporous layer (MPL) substantially improves the PEM fuel cell performance, reliability and durability through improved water management. In this study, graphene, technically a yet-to-be-developed category of material, is investigated as a potential MPL material, due to its high electrical and thermal conductivity. MPLs made of graphene (G-MPL) have been fabricated and assessed through morphological, microstructural, physical, and electrochemical characterizations and performance testing in a single scaled-up cell. Comparison is also made with MPLs made of a conventional material, Vulcan (V-MPL). The results show that the G-MPL has a unique morphology composed of horizontally packaged graphene flakes that improves water management, in-plane electrical conductivity (up to 2 times), catalyst activity, and platinum (Pt) utilization (up to 10%). The cell with the G-MPL has a better performance than the cell with the V-MPL under both fully (100% RH) and partially (40% RH) humidified conditions, with the peak power densities of 0.98 W cm^{-2} and 0.60 W cm^{-2}, respectively – these peak power densities are about 7% and 43% higher than those obtained for the cell with the V-MPL at 100% and 40% RH, respectively.

Keywords: Proton exchange membrane fuel cell; Water management; Gas diffusion layer; Microporous Layer; Graphene-based microporous layer

1. Introduction

Proton exchange membrane (PEM) fuel cell is a promising electrochemical device that efficiently converts the chemical energy of hydrogen and oxygen into electricity through electrochemical reactions and produces only water and heat as the by-products [1–4]. A PEM fuel cell system is generally equipped with an external humidifier to ensure a desirable humidification level for the membrane-electrode assembly (MEA). However, such a method of humidification not only reduces the overall efficiency (by triggering parasitic power