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Effect of type and stoichiometry of fuels on performance of polybenzimidazole-based proton exchange membrane fuel cells operating at the temperature range of 120–160 °C

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A B S T R A C T

Herein, a proton exchange membrane fuel cell (PEMFC) equipped with phosphoric acid-doped polybenzimidazole (PA-PBI) membrane was exploited to determine the effects of changing type and stoichiometry of feed gas at operating temperature from 120 to 160 °C. Results show that maximum power density of proposed system increases as increasing temperature, and varying the type and stoichiometry of feed gas. For example, a typical power density of 0.254, 0.299 and 0.389 W/cm^2 was obtained when operating PEMFC at 120, 140 and 160 °C respectively with pure hydrogen (H_2) as feed gas. By contrast, power density of only 0.128, 0.194 and 0.243 W/cm^2 was achieved when operating the PEMFC under identical condition with reformed H_2 as feed gas. On the other hand, when varying oxygen (O_2) stoichiometry from 2 to 6, power density of PEMFC vary from 0.330 to 0.472 W/cm^2 at 160 °C. At high temperature and high O_2 diffusion rate, reaction kinetics of electrodes and membrane were boosted, resulting lower mass-transfer resistance and higher PEMFC performance. In addition, we conducted long-term operation of PEMFC at 160 °C for 500 h to examine durability of PA-PBI. PA-PBI membrane was not lose open circuit voltage (OCV) significantly, indicating its good PEMFC durability.

1. Introduction

In recent years, depletion of fossil fuels (oil, goal and natural gas) and increment of environmental pollution are being urged the humankind to seek alternative renewable energy sources with no or zero emission of pollutant gases (CO_2, CH_4 and N_2O). Proton exchange membrane fuel cell (PEMFC) is a renewable energy device that can be widely used to convert chemical energy of fuels to electricity without emitting pollutant gases. These fuel cells have a wide range of applications in power plants, automobiles and various consumer electronics, owing to their fast startup and blackout times, high conversion efficiency, high power density, compact design and environmental friendliness. Hydrogen (H_2), methanol, ethanol or formic acid is used as fuel for anode, while oxygen (O_2) or air is exploited as fuel for cathode during PEMFC operation [1–6]. Generally, PEMFC which operate at low temperatures (30–90 °C) use a perfluorosulfonic acid (PFSA) membrane, such as Nafion, as a proton-transport medium [7–9], because it has high proton conductivity, and mechanical and chemical stabilities. However, the water level must be continuously maintained for sulfonic acid (SO_3H) groups of Nafion membranes to enable efficient proton transport. Hence, an external humidifier must be installed to fully utilize Nafion membrane in PEMFC operating at

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