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The Comprehensive Comparison of Water Transport Characteristics through Different Types of Nafion Membrane

Ngoc Van Trinh[1], Ngoc Dat Nguyen[1], Hiep Hoang Le[1], Younghyeon Kim[1], Sangseok Yu[2]
[1]Department of Mechanical Engineering, Graduate School, Chungnam National University, Daejeon, Republic of Korea
trinhngoc55hkxd@gmail.com; dat.nguyenngoc.hust@gmail.com; hiep.lehoang98@gmail.com; viny9198@naver.com;
[2]School of Mechanical Engineering, Chungnam National University, Daejeon, Republic of Korea
sangseok@cnu.ac.kr

Extended Abstract

Humidity is a critical parameter in the proton exchange membrane fuel cell (PEMFC) as it directly influences the system's performance and longevity [1,2]. The water content at both the anode and cathode sides is contingent upon the water transport mechanism within the membrane. Two mechanisms directly influence the performance of water transport across the membrane: diffusion and permeability. Diffusion is the primary mechanism for water transport over the membrane, while permeability is the critical factor influencing the efficiency and speed of the diffusion process. Furthermore, the humidity levels at the outer layers of the membrane will influence the diffusion of water across it. The operating temperatures and pressures will govern the humidity conditions within the system. Therefore, an experimental arrangement is established to examine the diffusion and permeability mechanism of water across the membrane. The test chamber (Test Jig) is designed in a parallel shape to put the membrane in the middle to test the membrane. The test chamber is divided into the wet side and dry side.

Firstly, this study evaluates a flat membrane module within a test chamber engineered for isothermal conditions to examine the impact of pressure on water permeability over the membrane. Since the driving force for permeability is only the pressure difference between the wet and dry side of the Test Jig. Therefore, two sides of the Test Jig are controlled at the same relative humidity ranging from 10% to 100% and temperature ranging from 30 to 90 degree Celsius. The findings indicate that when relative humidity increases, the permeation coefficient rises simultaneously. Secondly, this study evaluates diffusion characteristics of Nafion 117 and Nafion 211 and the impact of temperature on water absorption and transport over the membrane. Since the water content determines the proton conductivity in the fuel cells, it is important to measure the water content of the membrane. The water content will be measured based on relative humidity, temperature, and pressure with the same humidity for both types of membrane. When the temperature and the relative humidity increases, the water content in the membrane increases significantly. A parametric study is performed at the same operating pressure of 1 bar for both sides, with temperatures varying at 30, 50, 70, and 90 degrees Celsius, and relative humidity levels ranging from 10% to 100%. The results demonstrate that the diffusion coefficient is directly proportional to the operating temperature, attaining its maximum at 1 bar and a temperature of 90 degrees Celsius. Generally, the performance of Nafion 211 is much higher than the Nafion 117. Moreover, as humidity escalates, the water flux concurrently increases throughout working pressure for both membrane types. For Nafion 211, the water flux at 90 degrees is approximately 20 times higher than the water flux at 30 degrees. Finally, an experimental diffusion coefficient correlation for electrolyte membrane is proposed for both types of membrane using the water content and operating temperature.

Keywork: Diffusivity, Permeability, Convection mass transfer, Proton exchange membrane fuel cells.

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