Development of Fuel Cells for Medium- and High-Temperature Operation

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Polymer electrolyte fuel cells convert fuel into electricity using a polymer membrane as an electrolyte, rendering them suitable for clean energy generation, particularly in home settings. However, the suboptimal performance of organic-polymer-based proton conductors limits the power output of fuel cells. To address this challenge, we developed a fuel cell in which conventional polymer materials, such as NafionTM, which exhibit low performance above 120 °C, were replaced with an eggshell membrane, enabling high-temperature operation compared to conventional technologies. The eggshell membrane is a thin film with a uniform thickness of approximately 70 μm and a protein structure that remains stable up to 200 °C. We hypothesized that this thermal stability would enable its application in the power-generation unit of fuel cells to facilitate operation above 120 °C. The eggshell membranes were obtained by dissolving chicken eggshells in vinegar and cutting the membranes into approximately 4 cm2 pieces. The membranes were coated with platinum using a vacuum sputter-coating method. Glycerin, that is low volatility liquid, was applied to one side of the membrane, and wires were connected before conducting current–voltage characteristic measurements in a circuit. The increase in power generation with increasing temperature indicates that the enhanced chemical reaction rate significantly influences the performance. These findings highlight the potential of eggshell membrane-based materials to improve the power generation efficiency of fuel cells. This result contributes to the advancement of high-temperature fuel cell technology and is a milestone for the development of bio-based electrolytes for energy conversion systems.

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