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Studies on self-humidifying membranes and electrochemical catalysts for low and high temperature proton exchange membrane fuel cells

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In this study, the electrolyte membranes and electrodes for both the low and high temperature polymer electrolyte membrane fuel cells (PEMFC) were fabricated, and their electrochemical properties and cell performance of membrane electrode assembly (MEA) were evaluated and discussed. For low temperature self-humidifying composite membrane of PEMFC, the Nafion/Pt-SiO_2 composite membrane and Nafion/Pt-TiO_2/graphene oxide composite membrane were prepared to improve the humidifying system arising from the inherent characteristics of Nafion. In composite membrane case, the content of nanoparticles such as SiO_2 and Pt-TiO_2, were critical in the aspect of proton conductivity and cell performance. Also dual catalyst electrode comprising Pt-C and Pt-TiO_2 layers was designed and adopted to PEMFC. The results exhibited that the dual catalyst electrode would be highly competitive in the aspect of water producing and retention ability in self-humidifying PEMFC.

The second part was related to the catalyst for PEMFC. As an effort to maximize the Pt utilization with minimum Pt loading for cost reduction, microporous carbon molecular sieve (CMS) was synthesized using zeolite Y as a template, to which Pt nanoparticles were deposited. The cell test also showed that the cell performance was strongly affected by the pore structure of carbon support. Also, the gas diffusion electrode (GDE) fabricated with catalyst layer, supporting layer and gas diffusion layer (GDL) was prepared for high temperature PEMFC. In the final section, the effect of boron doping level into graphene on electrochemical properties including cell performance was discussed. B-doping led to a narrower Pt nanoparticle size distribution with a more uniform dispersion, increasing the Pt content deposited onto graphene by at least 13 % upon B-doping, in comparison to Pt-Gr, and was proportional to the B-doping level. Rotating disk electrode experiments demonstrated an enhancement in the oxygen reduction reaction (ORR) upon B-doping.

As a summary, these comprehensive studies regarding membrane and electrochemical catalysts would provide important fundamentals and several prospective routes for the further development of low and high temperature PEMFC.

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Born in 1986 in Seoul, Republic of Korea, Heena Yang graduated with a Ph.D. degree in Materials Chemistry and Engineering from Konkuk university in 2016. During this time, she worked as an undergraduate research assistant in the field of nanostructured materials and proton exchange fuel cells at Konkuk university. Her doctoral thesis focused on self-humidifying membranes and electrochemical catalysts for low and high temperature proton exchange membrane fuel cells.