General Abstract

Anion exchange membrane fuel cell (AEMFC) provides the advantages of lower cost due to the possible utilization of non-noble metal catalysts and faster oxygen reduction reaction kinetics under alkaline conditions. Anion exchange thin films serve as binders and ion conduction channels in the triple-phase interface, which is related to the electrochemical performance of AEMFC. Hence, the investigation of anion exchange thin film is important. This research is mainly focused on the hydration and anion conduction properties of anion exchange thin films, especially the properties of OH^- form thin films.

Firstly, in situ OH^- conductivity and quartz crystal microbalance (QCM) measurements were newly established to investigate the OH^- conductivity and water uptake of thin films under a CO_2-free atmosphere. Poly[(9,9-bis(6′-(N,N,N-trimethylammonium)-hexyl)fluorene)-alt-(1,4-benzene)] (PFB-TMA) was chosen as a model anion conductive polymer. At 25 °C under 95% relative humidity (RH), the OH^- conductivity of 273 nm-thick PFB-TMA-OH thin film was 5.3×10^{-2} S cm^{-1}, which is similar to that of the membrane in the literature. Film thickness dependence of water uptake and OH^- conductivity were observed in PFB-TMA-OH thin films.

Secondly, to systematically observe OH^- conduction and hydration properties of thin films, fluorene-thiophene-based anion conductive polymers with different cations were synthesized and investigated as thin film form. Furthermore, in situ temperature dependence of OH^- conductivity measurement process was newly established to obtain the activation energy (E_a) of OH^- conduction in thin films. Similar E_a of OH^- conduction between the cationic groups of trimethylammonium (TMA) and N-methylpiperidinium (Pip), indicated that higher IEC, less hydrophobicity, and smaller size of TMA contributed to the higher OH^- conductivity of TMA-based thin films.

Finally, the effect of side chain length on the properties of anion exchange thin films was investigated. Poly[(9,9-bis(3′-(N,N,N-trimethylammonium)propyl)fluorene)-alt-(3,3′-dihexyl-2,2′-bithiophene)] (PFT3-TMA) was synthesized and investigated as thin film form. Under high hydration conditions, similar OH^- conductivity was observed in fluorene-thiophene-based thin films with n-propyl alkyl spacer and n-hexyl alkyl spacer. While higher OH^- conductivity was found in fluorene-thiophene-based thin film with n-propyl alkyl spacer than that of thin film with n-hexyl alkyl spacer under the low number of water molecules which provided new insight into the OH^- conduction properties of anion conductive polymers with different side chain lengths under low number of water molecules.

Keywords: Anion exchange thin film, Fuel cell; OH^- conductivity, Water uptake, Activation energy