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Synthesis and Characterization of Sulfonated Aromatic Hydrocarbon Polymers Containing Trifluoromethylphenyl Side Chain for Proton Exchange Membrane Fuel Cell

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Abstract : Proton exchange membranes as a key component in fuel cells have been widely studying over the past few decades. As proton exchange, membranes should have some main characteristics, such as good mechanical properties, low oxidative stability and high proton conductivity. In this work, trifluoromethyl groups had been introduced on polymer backbone and phenyl side chain which can provide densely located sulfonic acid group substitution and also promotes solubility, thermal and oxidative stability. Herein, a series of novel sulfonated aromatic hydrocarbon polyelectrolytes was synthesized by polycondensation of 4,4''''-difluoro-3,3''''- bis(trifluoromethyl)-2'',3''-bis(3-(trifluoromethyl)phenyl)-1,1':4',1'':4'',1''':4''',1'''':4'''',1''''-quinquephenyl with 2'',3''',5'',6''-tetraphenyl-[1,1':4',1'': 4'',1''':4''',1''''-quinquephenyl]-4,4''''-diol and post-sulfonated was through chlorosulfonic acid to given sulfonated polymers (SFC3-X) possessing ion exchange capacities ranging from 1.93, 1.91 and 2.53 mmol/g. ^{1}H NMR and FT-IR spectroscopy were applied to confirm the structure and composition of sulfonated polymers. The membranes exhibited considerably dimension stability (10-27.8% in length change; 24-56.5% in thickness change) and excellent oxidative stability (weight remain higher than 97%). The mechanical properties of membranes demonstrated good tensile strength on account of the high rigidity multi-phenylated backbone. Young's modulus were ranged 0.65-0.77GPa which is much larger than that of Nafion 211 (0.10GPa). Proton conductivities of membranes ranged from 130 to 240 mS/cm at 80 °C under fully humidified which were comparable or higher than that of Nafion 211 (150 mS/cm). The morphology of membranes was investigated by transmission electron microscopy which demonstrated a clear hydrophilic/hydrophobic phase separation with spherical ionic clusters in the size range of 5-20 nm. The SFC3-1.97 single fuel cell performance demonstrates the maximum power density at 1.08W/cm^2, and Nafion 211 was 1.24W/cm^2 as a reference in this work. The result indicated that SFC3-X are good candidates for proton exchange membranes in fuel cell applications. Fuel cell of other membranes is under testing.

Keywords : fuel cells, polyelectrolyte, proton exchange membrane, sulfonated polymers
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