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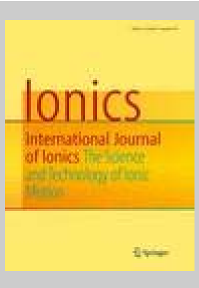

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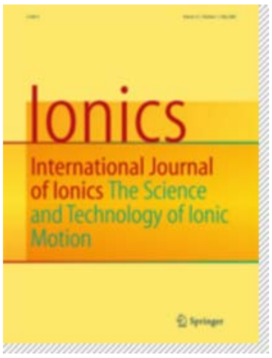

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ORIGINAL PAPER

Strong correlation between membrane effective fixed charge and proton conductivity in the sulfonated polysulfone cation-exchange membranes

Bambang Piluharto · Veinardi Suendo · Tati Ciptati · Cynthia L. Radiman

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Abstract The effectiveness of fixed charge in sulfonated polysulfone membranes and its correlation with proton conductivity and physicochemical properties have been investigated in this work. The membranes were prepared with various concentrations of sulfonating agent (6% to 10% *v*/*v*) and followed by the characterizations that include membrane potential measurements, proton conductivity, and physicochemical properties (contact angle, water uptake, and ion-exchange capacity). Here, the effective fixed-charge concentrations of the membranes were obtained based on the data of membrane potential measurements using the Teorell–Meyer–Siever equation. The analysis results exhibit that a strong correlation between effective charge concentration and proton conductivity, which is expressed by the linear increase of proton conductivity with *QX*. This correlation is also supported by the membranes physicochemical data, such as water uptake, ionic exchange capacity, surface contact angle against water and functional analysis using FTIR. Finally, it was also developed an ionic conductivity equation that describes the correlation between proton conductivity and *QX* values.

Keywords Effective charge · Sulfonated polysulfone · Membrane potential · Proton conductivity · TMS equation

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Introduction

Transport properties of a charged membrane deal with its ability to transfer both ionic and non-ionic matter from one phase to another. The transport processes are affected by two effects, namely, the sieving and Donnan effects. For non-ionic species, the sieving effect is more dominant, while the Donnan effect is for ionic ones [1]. In its applications, ionic transport becomes an interesting study that covers many industrial processes such as electrodialysis, nanofiltration, metal ion recovery, and fuel cells [1–6].

Sulfonated polysulfone (SPSF) is a charged membrane that is widely used as a proton exchange membrane (PEM) in fuel cell systems .This membrane plays the selective role in the transport of protons from the anode to the cathode [4–6]. The main factor that affects the ionic transport in a charged membrane is the properties of fixed-charge groups. The effectiveness of charged groups depends on its physicochemical properties such as water content, ionic valency, ion-exchange capacity (IEC), and counter-ion radii [3, 7, 8]. To understand the mechanism of ionic transport, many studies about PEM concerning the relationship between physicochemical and ionic transport properties have been carried out. Some factors such as the nature of polymer matrices, solvent polarity of polymer, and degree of sulfonation were considered [3–10], however studies about the effective charge of SPSF and its correlation with