Nanosilica synthesis and modification for PVDF and Nafion composite membranes used in power sources

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Abstract
Silica (SiO2) and modified silica (M-SiO2) are materials which are widely used in catalysis, absorption, chromatography and power sources. In this work, we focus on the synthesis of nanosilica and nanosilica based composite membranes. The SiO2 and M-SiO2 were synthesized from tetraethoxysilane (TEOS) and (3-mercaptopropyl) trimethoxysilane (MPTMS). The obtained SiO2 and M-SiO2 were characterized by FTIR, Raman, BET and TEM. The ion exchange capacity (IEC) was used to determine sulfur content in M-SiO2 materials. The dynamic light scattering (DLS) results showed a narrow particle size distribution of amorphous SiO2 and M-SiO2, which are of about 20-30 nm. The Raman spectra proved the success of M-SiO2 synthesis by silica modification.

Polyvinylidene difluoride (PVDF) and Nafion composite membranes were prepared by mixing PVDF or Nafion with SiO2 and M-SiO2 in dimethylformamide (DMF) solvent. The mixture was cast onto Petri dishes and dried at 80°C for 5 h. The optical microscopy showed a better compatibility of M-SiO2 than SiO2 in PVDF matrix. Differential scanning calorimetry (DSC) curves of PVDF and composites illustrate the influence of SiO2 and M-SiO2 concentration on thermal properties of composite by increasing the melting temperature of composite versus polymer. The content of M-SiO2 in Nafion composites enhanced swelling degree and water uptake, the latter is proportional to concentration of M-SiO2 phase in matrix. The results in LiClO4 electrolyte uptake for PVDF composite and in water uptake for Nafion composite showed that these membranes could be used for application in power source.

Keywords: Nafion composite, PEMFC, PVDF, silica, silica modification.

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References

Figure 1. Photograph of a) PVDF, b) PVDF/SiO2 5% composite membrane, c) Nafion, d) Nafion/M-SiO2 1% and e) Nafion/M-SiO2 3% composite membrane.

Figure 2. Water uptake of Nafion and Nafion/M-SiO2 composite membranes for 24h at 30°C and 75°C.

Figure 3. DSC curves of PVDF, PVDF/SiO2 and PVDF/M-SiO2 membranes.