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

Tran Van Man[1, 2], Tran Thanh Nhan[1], Nguyen Thi Phuong Thoa[1, 2], Le My Loan Phung[2]

[1]Applied Physical Chemistry Laboratory, University of Science, Vietnam National University – Ho Chi Minh City (VNU-HCM), Vietnam
[2]Department of Physical Chemistry, University of Science, VNU-HCM, Vietnam
227 Nguyen Van Cu Street, District 5, Ho Chi Minh City, Vietnam

Abstract

Silica (SiO_2) and modified silica (M-SiO_2) 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 SiO_2 and M-SiO_2 were synthesized from tetraethoxysilane (TEOS) and (3-mercatopropyl) trimethoxysilane (MPTMS). The obtained SiO_2 and M-SiO_2 were characterized by FTIR, Raman, BET and TEM. The ion exchange capacity (IEC) was used to determine sulfur content in M-SiO_2 materials. The dynamic light scattering (DLS) results showed a narrow particle size distribution of amorphous SiO_2 and M-SiO_2, which are of about 20-30 nm. The Raman spectra proved the success of M-SiO_2 synthesis by silica modification.

Polyvinylidene difluoride (PVDF) and Nafion composite membranes were prepared by mixing PVDF or Nafion with SiO_2 and M-SiO_2 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-SiO_2 than SiO_2 in PVDF matrix. Differential scanning calorimetry (DSC) curves of PVDF and composites illustrate the influence of SiO_2 and M-SiO_2 concentration on thermal properties of composite by increasing the melting temperature of composite versus polymer. The content of M-SiO_2 in Nafion composites enhanced swelling degree and water uptake, the latter is proportional to concentration of M-SiO_2 phase in matrix. The results in $LiClO_4$ 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.

Acknowledgement: The authors acknowledge the support of VNU-HCM through the grant for B2011 – 18 – 01TD project and Ministry of Science and Technology through the grant for NCCB – DHUD.2011/G11 project.

References

1. D. Takemura, S. Aihara, K. Hamano, M. Kise, T. Nishimura, H. Urushibata and H. Yoshiyasu, J. Power Sources, **146** (2005).
2. J. W. Kim, W. J. Cho and C. S. Ha,, J. Polym. Sci., Part B: Polym. Phys., **40** (2002).
3. K. Ikari, K. Suzuki and H. Imai, Langmuir, **22** (2005).
4. K. Moller, J. Kobler and T. Bein , J. Mater. Chem.,**17** (2007).
5. K. Wilson, A. F. Lee, D. J. Macquarrie and J. H. Clark, Appl. Catal., A, **228** (2002).
6. D. Kumar, M. Suleman and S.A. Hashmi, Solid State Ionics, **202** (2011).
7. Y. Jin, S. Qiao, L. Zhang, Z. P. Xu, S. Smart, J. Costa and G. Q Lu, ,J. Power Sources, **185** (2008).
8. C.-C. Ke, X.-J. Li, S. Qu, Z. Shao and B.-L. Yi, Int. J. Hydrogen Energy, **36** (2011).
9. M. Amirinejad, S. S. Madaeni, E. Rafiee, S. Amirinejad, J. Membr. Sci., **377** (2011).
10. H. L. Tang and M. Pan, J. Phys. Chem. C, **112** (2008).

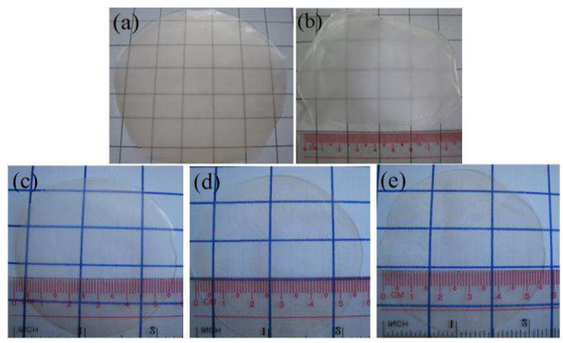

Figure 1. Photograph of a) PVDF, b) PVDF/SiO_2 5% composite membrane, c) Nafion, d) Nafion/M-SiO_2 1% and e) Nafion/M-SiO_2 3% composite membrane.

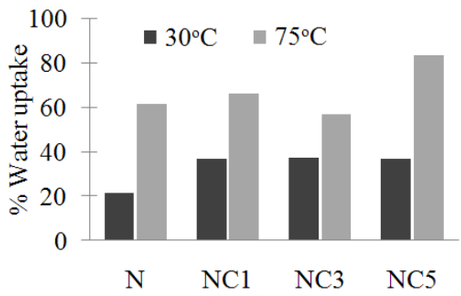

Figure 2. Water uptake of Nafion and Nafion/M-SiO_2 composite membranes for 24h at 30°C and 75°C.

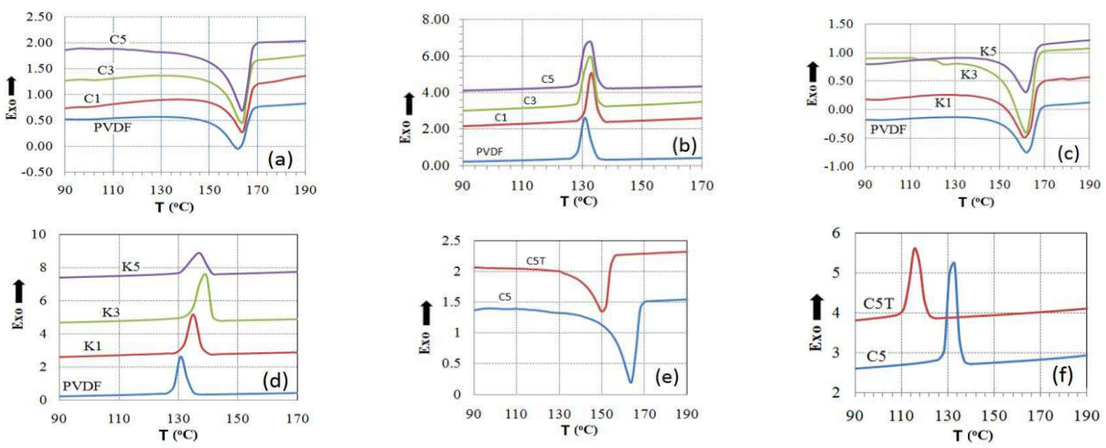

Figure 3. DSC curves of PVDF, PVDF/SiO_2 and PVDF/M-SiO_2 membranes