

Kinetic Study of a Carbon Fiber Microelectrode in a Vanadium Redox Flow Battery System

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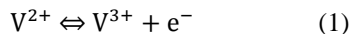
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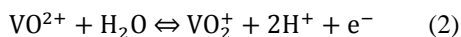
Redox flow batteries (RFBs) are among the most promising technologies for large-scale grid storage of energy generated by intermittent renewable power. Several RFB chemistries have been developed, including iron-chromium, all-vanadium, and bromine-polysulfide¹. Among all the potential chemistries, the all-vanadium flow battery (VRB) has been heavily developed due to the advantages of long cycle life, reduced active species cross-over, easy regeneration, deep discharging, and easy maintenance². Some prior research was focused on the modification of current electrode materials and/or development of new materials³⁻⁵. Cyclic voltammetry has been widely used for evaluating these materials in term of activity and kinetics. However, the results from different groups are hard to compare and more fundamental study is needed.

The use of an Ultra-microelectrode offers the ability to perform time-independent measurement due to rapidly recorded steady-state currents. The small electrode area allows the reaction happen on a small surface area with uniform current distribution and with an insignificant edge effect. In this work, (ultra)microelectrodes were prepared and applied for cyclic voltammetry study of following electrode reactions and ion diffusion in a VRFB system.

Negative electrode:



And positive electrode reaction



A series of microfiber electrodes with different diameters were synthesized and tested.

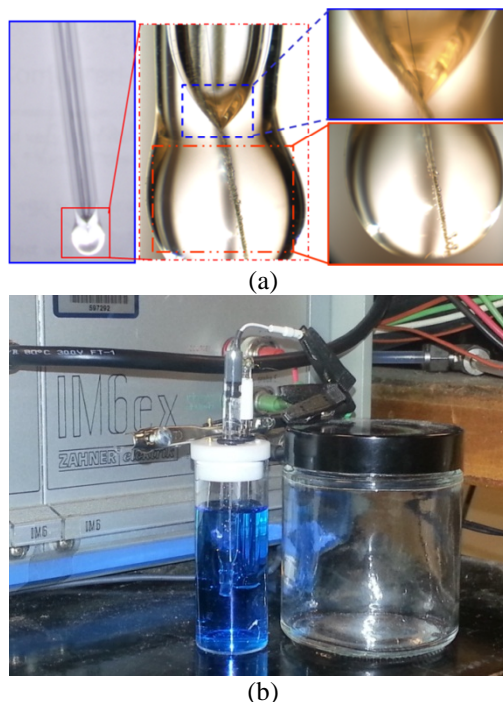


Figure 1. (a) Picture of the ultra-micro electrode and (b) the three electrode cell for cyclic voltammetry tests.

References

1. A.Z. Weber, M.M. Mench, J.P. Meyers, P.N. Ross, J.T. Gostick, Q.H. Liu, *Journal of Applied Electrochemistry*, 41 (2011) 1137–1164.
2. M. Skyllas-Kazacos, M.H. Chakrabarti, S.A. Hajimolana, F.S. Mjalli, M. Salleem, *Journal of the Electrochemistry Society*, 158 (2011) R55–R79.
3. V. Haddadi-Asl, M. Kazacos, M. Skyllas-Kazacos, *Journal of Applied Electrochemistry*, 25 (1995) 29–33.
4. P.X. Han, H.B. Wang, Z.H. Liu, X. Chen, W. Ma, J.H. Yao, Y.W. Zhu, G.L. Cui, *Carbon*, 49 (2011) 693–700.
5. Q.H. Liu, G. M. Grim, A. B. Papandrew, A. Turhan, T. A. Zawodzinski, and M. M. Mench, *Journal of the Electrochemistry Society*, 159 (2012) A1246–1252.