

A non-aqueous redox flow battery using all organic redox couples

Joonmok Shim*, Jae-Deok Jeon, Se-Kook Park, Kyung-Hee Shin

*Korea Institute of Energy Research (KIER)
152 Gajeong-ro, Yuseong-gu, Daejeon, 305-343,
Republic of KOREA*

*Correspond to jmshim@kier.re.kr

Since the 20th century, redox flow battery (RFB) has been investigated as an energy storage system for large stationary application, loading level and renewable energy storage. It has the advantages of long life time, quick response time, deep-discharge capability and low maintenance cost. The RFB is an electrochemical energy-storage device providing reversible conversion between electrical and chemical energy, basically in two redox couples contained in external electrolyte tanks.

Various RFB systems have been proposed, such as all vanadium, iron/chromium, zinc/bromine and zinc/cerium and so on. These traditional RFBs with aqueous electrochemical couples are limited to low operating voltages due to the water electrolysis potential window [1]. Accordingly, a non-aqueous RFB is attractive system because it offers the expansion of the potential window which is directly related to the system energy and power density [2-3]. To increase the operating voltage, it is important to choose available and appropriate redox couples.

The majority of the redox-active molecules for the non-aqueous RFB have been concentrated on metal-coordinated redox couples, such as ruthenium bipyridine complex [4] and vanadium, chromium and manganese acetylacetonate-based systems [5-7]. However, their limited solubility in the electrolyte and complicated systems lead to low cell efficiency [1-2]. In this regard, redox-active organic molecules which can be obtained from natural sources would be suitable candidate active materials for the non-aqueous RFB.

In this study, 2,2,6,6-tetramethyl-1-piperidinyloxy and 5,12-naphthacenequinone were employed as active materials for the catholyte and anolyte, respectively. The quasi-reversible and stable redox reactions were investigated by cyclic voltammetry. Consequently, the operating voltage of the non-aqueous RFB system reached to over 2.0 V, and showed good cyclability during charge-discharge test.

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References

- [1] Z. Li, S. Li, S. Liu, K. Huang, D. Fang, F. Wang, S. Peng, *Electrochem. Solid-State Lett.*, **14** A171 (2011).
- [2] F.R. Brushett, J.T. Vaughney, A.N. Jansen, *Adv. Energy Mater.* **2** 1390 (2012).
- [3] W. Wang, Q. Luo, B. Li, X. Wei, L. Li, Z. Yang, *Adv. Funct. Mater.*, DOI: 10.1002/adfm.201200694 (2012)
- [4] Y. Matsuda, K. Tanaka, M. Okada, Y. Takasu, M. Morita, T. Matsumurainoue, *J. Appl. Electrochem.* **18** 909 (1988)
- [5] Q. Liu, A.A. shinkle, Y. Li, C.W. Monroe, L.T.

Thomson, A.E.S. Sleightholme, *Electrochem. Commun.* **12** 1634 (2010)

[6] Q. Liu, A.E.S. Sleightholme, A.A. Shinkle, Y. Li, L.T. Thomson, *Electrochem. Commun.* **11** 2312 (2009)

[7] A.E.S. Sleightholme, A.A. Shinkle, Q. Liu, Y. Li, C.W. Monroe, L.T. Thomson, *J. Power Sources* **196** 5742 (2011)