

Development of New Redox Couples for High-Performance Redox Flow Batteries

Chunzhen Yang¹, Georgios Nikiforidis^{1,2}, Hye Ryung Byon^{1,2*}

¹ Byon Initiative Research Unit, RIKEN, 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan

² Electrochemical Materials Design Laboratory, Department of Chemistry,
Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea

*e-mail: hrbyon@kaist.ac.kr

Electrochemical storage system (ESS) technology has been highly paid attention to power load control, and would be pivotal to store intermittent renewable energy sources. Redox flow batteries (RFBs) are one of the most attractive ESSs, which can be feasibly sizeable and need low maintenance. However, low energy density in commercial RFBs requiring massive electrolyte reservoirs should be much improved, which can be solved by development of promising redox couples with high solubility and redox potential. We previously demonstrated triiodide/iodide (I_3^-/I^-) redox couple in aqueous catholyte, delivering high storage capacity (~98% of the theoretical capacity), Coulombic efficiency (>99.5%) and cycling performance (>99.5% capacity retention for 100 cycles) when linked with Li metal as the anode (with nonaqueous electrolyte and impermeable separator).^[1-5] The high performance for aqueous Li-I₂ battery is contributed to a suitable redox potential of ~3.5 V vs. Li⁺/Li in addition to high solubility, which offers a high energy density of ~0.33 kWh kg⁻¹. However, such a research direction to find ‘natural and elemental style’ of redox ions (e.g. vanadium ions, Zn-Br, I₃⁻/I⁻ etc.) have a limited scope to develop RFB performance due to their intrinsic and fixed redox potential and solubility. Here we present a new research approach to design redox-couple molecules, which allows us to feasibly tune redox potentials in non-aqueous electrolyte. We employed Co^{2+/3+} ion coordinated with various ligands as the redox molecules. The electron-withdrawing property of ligands and solvation with non-aqueous electrolyte modulate Co^{2+/3+} redox potentials. We will discuss stability of Co-based redox molecules in this presentation, which would guide design of promising redox-couple molecules in the future.

References

- [1] Zhao, Y.; Wang, L.; Byon, H. R. *Nature Communications* **2013**, *4*, 1896.
- [2] Zhao, Y.; Byon, H. R. *Adv. Energy Mater.* **2013**, *3*, 1630-1635.
- [3] Zhao, Y.; Hong, M.; Mercier, N. B.; Yu, G.; Choi, H. C.; Byon, H. R. *Nano Lett.* **2014**, *14*, 1085-1092.
- [4] Zhao, Y.; Mercier, N. B.; Byon, H. R. *ChemPlusChem* **2015**, *80*, 344-348.
- [5] Nikiforidis, G.; Tajima, K.; Byon, H. R. *ACS Energy Lett.* **2016**, in press

Keywords : Redox flow battery, electrochemical storage system, redox couple, cobalt, triiodide/iodide