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All iron aqueous redox flow batteries using organometallic complexes consisting of iron and 3-[bis (2-hydroxyethyl)amino]-2-hydroxypropanesulfonic acid ligand and ferrocyanide as redox couple

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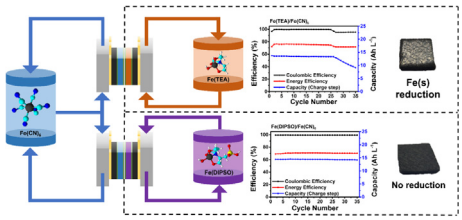
HIGHLIGHTS

- Fe(DIPSO) consisting of Fe and DIPSO ligand is suggested as negative active species.
- Fe(DIPSO) and $Fe(CN)_6$ are selected as redox couple for RFB.
- Fe(DIPSO) has a strong resistance against the reduction to Fe(s).
- Cell voltage of the redox couple is 1.37 V.
- RFB using new redox couple has 14.4 $Ah{\cdot}L^{-1}$ (capacity) and 93.2 $mW{\cdot}cm^{-2}$ (power density).

GRAPHICAL ABSTRACT



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ABSTRACT

The Organometallic complex consisting of iron and 3-[bis (2-hydroxyethyl) amino]-2-hydroxypropanesulfonic acid (DIPSO) ligand (Fe(DIPSO)) is newly suggested as negative active species for redox flow battery (RFB), while ferrocyanide ($Fe(CN)_6$) is used as positive active species. When the two active species are used, cell voltage of the RFB reaches 1.37 V. In a comparison of Fe(DIPSO) and Fe-triethanolamine (Fe(TEA)), redox potential of the two complex is similar as −1.05 V (vs. Ag/AgCl), but the Fe(DIPSO) does not suffer from the reduction to metallic iron (Fe(s)) that is the general problem of iron based organometallic materials, meaning that Fe(DIPSO) has a strong resistance against the reduction to Fe(s) and this can induce obvious enhancements in the performance and stability of RFB using the complex. Actually, when RFB using 0.5 M Fe(DIPSO) and $Fe(CN)_6$ is operated at 80 mA cm^{-2}, its discharge capacity is 14.4 Ah L^{-1}, power density is 93.2 mW cm^{-2} and energy efficiency is 70% and even after 100 cycle, while the capacity preserves well with the decay rate of 0.12% per cycle. In contrast, in the RFB using 0.5 M Fe(TEA) and $Fe(CN)_6$, although initial discharge capacity is 13.4 Ah L^{-1}, decay rate is very high as 0.96% per cycle with a rapid decrease of columbic efficiency from 99.5 to 95.4% for the initial 25 cycle. This is due to the conversion of ferrous/ferric core to Fe(s) occurring at Fe(TEA) during cycle. Based on that, it is revealed that the RFB using 0.5 M Fe(DIPSO) and $Fe(CN)_6$ shows excellent performance and stability demonstrated as high power and energy densities.

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