

## Electronic Supplementary Information

### **Ion Transfer Battery: Storing Energy by Transferring Ions across Liquid-Liquid Interfaces**

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## Chemicals

All chemicals were used as received without further purification. All aqueous solutions were prepared with ultra-pure water (Millipore Milli-Q, 18.2 M $\Omega$ ·cm). Bis(triphenylphosphoranylidene)ammonium chloride (BACl, 98%), LiCl, >99%, LiOH·H<sub>2</sub>O, tetrahexylammonium perchlorate (THxAClO<sub>4</sub>) and 1,2-dichloroethane (DCE) were purchased from Fluka. Lithium tetrakis(pentafluorophenyl)borate ethyl etherate (LiTB) was purchased from Boulder Scientific. Decamethylferrocene (DMFc, 99%) were provided by Alfa Aesar and  $\alpha,\alpha,\alpha$ -trifluorotoluene (TFT, 99%+) was purchased from Acros. DMFcTB was synthesized as described previously,<sup>1</sup> followed by recrystallization.

## Electrochemical experiments

Cyclic voltammograms (CVs) were recorded under both ambient aerobic conditions and anaerobic conditions using a PGSTAT101 (Metrohm, the Netherlands) potentiostat. Three electrode experiments were performed with droplet-modified carbon paste electrodes (radius 2.5 mm) with Ag/AgCl/(3 M KCl) reference and a platinum counter electrode. A droplet of 5  $\mu$ L of the organic solution was deposited onto the surface of the working electrode, which was immersed into the aqueous solution. In order to avoid the oxidation of DMFc by oxygen, the electrolytes were prepared with concentrations corresponding to the discharged battery, (DMFc can readily reduce oxygen in the presence of LiTB<sup>2,3</sup>). Additionally, 100 mM of LiOH was added into the aqueous solution to make oxygen reduction thermodynamically more unfavorable.

The electrochemical performance of the battery was tested in a static H-cell configuration under anaerobic conditions, with porous reticulated vitreous carbon electrodes (or GC electrodes, 3 mm diameter) on both sides, in a two-electrode set-up, with both DCE and TFT as the organic phases, under vigorous stirring. The cell composition and the reactions upon discharge for the ion transfer battery are depicted in Figure 1 of the main text. The ohmic resistance was calculated with a current step measurement, where a current step from 0 to 100  $\mu$ A was taken at the time of 10 ms after each charge and discharge cycle. As the purpose of the paper is to present the proof of concept of this liquid system, all experiments were corrected for the *IR* drop to describe the theoretical maximum performance of the system. Voltammograms

obtained under stirring were smoothed by Percentile Filter method with OriginPro 2015 (Fig. 3B), or by 5-point average (Fig. 3A).

## References

- 1 H. Deng, P. Peljo, D. Momotenko, F. Cortés-Salazar, T. J. Stockmann, K. Kontturi, M. Opallo and H. H. Girault, *J. Electroanal. Chem.*, 2014, **732**, 101–109.
- 2 H. Deng, P. Peljo, T. J. Stockmann, L. Qiao, T. Vainikka, K. Kontturi, M. Opallo and H. H. Girault, *Chem. Commun.*, 2014, **50**, 5554–7.
- 3 H. Deng, T. J. Stockmann, P. Peljo, M. Opallo and H. H. Girault, *J. Electroanal. Chem.*, 2014, **731**, 28–35.