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Membrane-less hybrid flow battery based on low-cost elements

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HIGHLIGHTS

- A novel organic-inorganic flow battery system using low-cost elements.
- For a membrane-less configuration the open-circuit voltage is 1.17–1.59
- The average coulombic efficiency is 71.8% over 20 cycles.
- Voltammetry and dissolution experiments identify the performance limitations.

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ABSTRACT

The capital cost of conventional redox flow batteries is relatively high (>USD$ 200/kWh) due to the use of expensive active materials and ion-exchange membranes. This paper presents a membrane-less hybrid organic-inorganic flow battery based on the low-cost elements zinc (<USD$ 3 Kg^{-1}) and *para*-benzoquinone (<USD$ 8 Kg^{-1}). Redox potential and voltammetric studies show that the open-circuit voltage of the battery is 1.17–1.59 V over a wide range of pH. Half-cell charge-discharge and dissolution experiments indicate that the negative electrode reaction is limiting due to the presence of chemical side reactions on the electrode surface. The positive electrode redox reactions are not affected and exhibit (half-cell) coulombic efficiencies of >92.7% with the use of carbon felt electrodes. In the presence of a fully oxidized active species close to its solubility limit, dissolution of the deposited anode is relatively slow (<2.37 g h^{-1} cm^{-2}) with an equivalent corrosion current density of <1.9 mA cm^{-2}. In a parallel plate flow configuration, the resulting battery was charge-discharge cycled at 30 mA cm^{-2} with average coulombic and energy efficiencies of *c.a.* 71.8 and *c.a.* 42.0% over 20 cycles, respectively.