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High-performance non-aqueous hybrid lithium-organic redox flow batteries

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Recently redox flow battery has attracted considerable attention as a promising stationary energy storage technology to stabilize the power grid and tackle the intermittency of the renewable energies. The cell architecture of flow battery allows the energy capacity to be determined by the electrolyte volume while the power rating by the stack size, thus separating the power and the energy. This feature gives flow battery excellent scalability and modularity for scale-up, and exceptional design flexibility to meet the power-to-energy ratio requirement in different applications.

A number of redox flow chemistries have been proposed and studied in both aqueous and nonaqueous environments. Aqueous flow batteries have a relatively long history of research and development, but generally suffer from low energy density. This is primarily because of the narrow electrochemically stable voltage window of aqueous systems (usually < 1.8V), beyond which water electrolysis side reactions will inevitably take place. On the contrary, non-aqueous electrolytes can provide wider voltage window of >2V. Expansion of the cell voltage is the primary motivation of the current pursuit of nonaqueous flow batteries in an attempt to develop high energy density flow systems. Most nonaqueous flow batteries are based on organic electroactive materials taking advantage of their structural diversity that offers tremendous redox candidates.

Here we report a nonaqueous hybrid lithium-organic flow battery that uses lithium metal - based anode and an organic catholyte material. The organic redox compound shows a high solubility in the supporting organic electrolyte, which, together with a cell voltage as high as 3.5V, results in a high theoretical energy density of the flow system. The flow cell tests demonstrated great cell efficiencies and remarkable cycling stability that exceed those of most other non-aqueous flow batteries. Effective protection of the lithium anode employed in these lithium-organic RFB systems will be discussed.

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