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research highlights

AQUEOUS BATTERIES

Versatile quinones

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Aqueous rechargeable batteries use water-based electrolytes and offer safety advantages over lithium-ion batteries that feature flammable organic electrolytes. However, the operating voltage window of water is small (only 1.23 V). This is why the energy density of aqueous batteries is much lower than non-aqueous ones. In addition, outside this voltage window, undesired hydrogen and oxygen evolution occurs. The redox potential of electrodes should therefore avoid the potential range of water electrolysis to avoid gas evolution, which limits the choice for electrode materials. Furthermore, the existing anode materials often have too high solubility towards aqueous electrolytes, leading to poor cycle life as well as loss of capacity. Antonio Facchetti, Yan Yao and colleagues from the United States have now developed several quinones (oxidized derivatives of aromatic compounds) as anodes for high-performance aqueous batteries. These quinones are shown to operate well, especially in cycling, under different chemical and thermal environments.

The researchers selected the quinones by considering whether they have an appropriate redox potential, a high capacity and a low solubility in water, before demonstrating various battery applications. For acidic batteries, they paired a quinone (pyrene-4,5,9,10-tetraone) with PbO_2 (the cathode for commercial lead-acid batteries), and showed that the combination significantly outperforms the lead acid in cycling stability. For alkaline batteries, poly(anthraquinonyl sulfide) was chosen to pair with $Ni(OH)_2$/NiOOH (a common cathode for commercial Ni-based alkaline batteries). This battery not only shows prolonged cycling stability, but also performs well at low temperatures, which is in contrast to the drastic capacity reduction at low temperatures for commercial Ni-based alkaline batteries. A pH-neutral battery with a polymerized version of pyrene-4,5,9,10-tetraone as the anode and $LiMnO_2$ (a common cathode for Li-ion batteries) as the cathode also showed exceptional capacity retention, even in the presence of oxygen where current aqueous battery anodes would quickly decay.

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