PUBLISHED: 8 MARCH 2017 | VOLUME: 2 | ARTICLE NUMBER: 17042

research highlights

BATTERIES

Shuttling hydronium ions

Angew. Chem. Int. Ed. http://doi.org/bz4n (2017)

Driven by increasing demand in the automotive industry and in grid-scale storage applications, an intensive effort to develop post-lithium-ion batteries is currently under way. Although many promising candidates such as lithium–sulphur and lithium–oxygen batteries have emerged, research interest has also expanded to batteries with charge carriers other than the lithium ion. Xiulei Ji and colleagues in the USA now report a battery based on the reversible storage of hydronium ions — the species that form from the water molecule in acid — which represents a new addition to the rechargeable battery family.

The researchers set up a three-electrode cell, with a negative electrode of crystalline 3,4,9,10-perylenetetracarboxylic dianhydride (PTCDA), a known solid organic electrode for lithium-ion batteries, and a sulfuric acid electrolyte. Using cyclic voltammetry and X-ray diffraction, they demonstrate the reversible redox reaction of PTCDA. With the aid of first-principles calculations, they also identify significant expansion and contraction in certain lattice planes of PTCDA, which is ascribed to intercalation of the relatively large hydronium ions. The researchers further suggest that when hydronium ions are intercalated into the electrode, they reside in the interstitial space between the stacked PTCDA molecules and are stabilized by adjacent carbonyl groups. The battery displays reasonable performance: PTCDA has a specific capacity of up to 85 mAh g^{-1}, but this falls below 60 mAh g^{-1} during 120 galvanostatic cycles. The cycling stability is likely to be affected by the partial dissolution of PTCDA into the acidic electrolyte.

Changjun Zhang