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DISPATCH · AQUEOUS IODINE BATTERIES · 2 MIN

Halogen-free water-based electrolytes support four-electron iodine battery chemistry

A 2026 Nature study from UCL and Oxford stabilises reactive iodine with a three-part electrolyte recipe instead of corrosive halogen-rich electrolytes, in zinc and aluminium cells.

14 November 2026 · based on a paper in Nature



Photo: Paul Calvo

Batteries that use water as the liquid between their electrodes are attractive because water does not burn, but they have struggled to store as much energy as their flammable, solvent-based rivals. One way to close the gap is to make each iodine atom in a metal–iodine battery work harder, cycling it through what chemists call four-electron conversion. A study published in Nature in 2026 by researchers at University College London and the University of Oxford describes a way to do this without the harsh ingredients that have usually been required.

The obstacle is a reactive, positively charged form of iodine that appears during the deeper reaction. For the reaction to be reversible in water, this form has to be stabilised. According to the authors, earlier work did this by using highly concentrated electrolytes, the conducting liquid, containing other halogens, which bind to the iodine. Those electrolytes are corrosive.

The team instead builds the electrolyte from three kinds of ingredient, each assigned a job. The first is a polar anion, a negatively charged ion with an uneven charge distribution. The authors report that these ions create a region at the electrode interface that is short of water and rich in anions. The second is a kosmotropic anion, a type of ion that strongly orders the water molecules around it. Here its role is to manage how water interacts with the third ingredient, a nucleophile, meaning a molecule that readily donates electrons to a positively charged partner.

The nucleophile is what actually protects the iodine. Two nucleophile molecules sandwich each positively charged iodine through halogen bonds, a weak attraction between a halogen atom and an electron-rich neighbour. By regulating how water interacts with the nucleophile, the kosmotropic anions make more of it available for this task, the authors say. The approach therefore replaces interhalogen binding, the conventional route, with an arrangement that works in a halogen-free electrolyte.

The authors report testing the framework with a range of different nucleophiles and in two battery types, zinc–iodine and aluminium–iodine cells, which suggests the idea is not tied to a single nucleophile or metal. They describe it as a mechanistic shift in how multi-electron iodine chemistry can be run in water.

The abstract, which is all that was available for this report, gives no figures for capacity, energy density, cycle life or how the cells compare with halogen-based electrolytes, so it is not possible to say here how close these batteries come to practical use. It also does not state which specific salts and nucleophiles were used, or under what test conditions the cells were run.

PAPER	*Non-halogen aqueous electrolytes for four-electron iodine conversion*
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