

Novel material and manufacturing requirements of the proton battery

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Recent experimental and theoretical research at RMIT University on the novel 'proton battery' system will be reported. Key requirements of this system in terms of carbon-based materials for electrochemical hydrogen storage, and associated manufacturing, will be identified. Essentially a proton battery is a reversible PEM fuel cell with an integrated solid-state electrode for storing hydrogen in atomic, rather than molecular gaseous, form. It is thus a hybrid between a hydrogen-fuel-cell and battery-based system, combining advantages of both system types. In principle a proton battery can have a roundtrip energy efficiency comparable to a lithium ion battery. Experimental results published earlier this year showed that a small proton battery (active area 5.5 cm²) with a porous activated carbon electrode made from phenolic resin and 10 wt% PTFE binder was able to store in electrolysis (charge) mode very nearly 1 wt% hydrogen, and release on discharge 0.8 wt% in fuel cell (electricity supply) mode. This gravimetric energy density, with a far from optimal system, is already comparable with lithium ion batteries and ambient-temperature commercial metal hydrides for hydrogen storage. Layered graphene and carbon nitride materials with controllable interlayer spacing are now being examined as the negatively-polarised storage electrodes for atomic hydrogen in a proton battery that produces protons (as hydronium) on the counter electrode by water splitting. *Ab initio* molecular dynamic simulations are being conducted to improve fundamental understanding of hydronium-graphene reactions. Future prospects of the proton battery concept will be discussed.



An experimental proton battery with active electrode area of 5.5 cm²