

"Bending the rules"

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Devising a flexible battery with a solid electrolyte has been the goal of researchers for many years. Donald Sadoway and his collaborators at MIT have developed Slimcell – a bendy, polymer-based battery that could be manufactured on large scales. But is it solid stuff? Luke Hutson reports.

'There had to be something we could contribute,' says Donald Sadoway, a materials chemistry professor from MIT. 'I reasoned the plateau in battery progress was largely contained by inadequate materials. If we could address this by using materials that had been previously ignored, we might make a quantum leap in performance.' The result is what Sadoway calls the Slimcell. A 100% solid state battery consisting of a multilayered sandwich – the outer packaging, the current collector for the anode, the anode, the polymer electrolyte, then the cathode, cathode current collector and finally the exterior packaging.

Sadoway credits his collaborator Professor Anne Mayes, also from MIT, as being the brains behind the electrolyte. Entangled strands of methacrylate, or Perspex, form its solid backbone, while two varieties of solubilising side groups provide the electrical properties. Sadoway describes these side groups as 'bristles' on the backbone strands.

'In essence we have separated length scales for electrical and mechanical behavior,' says Sadoway. The longer length scales of tens of nanometres give the electrolyte its bulk rigidity. The side groups on the other hand have length scales of the order of 3-4nm, and because they are only eight units long are barely polymers, says Sadoway. 'These side groups have liquid-like properties,' he says, 'and so lithium dissolves in them.' In doing so the copolymer – so-called because it is a combination of polymers – becomes a conductor of lithium ions.

According to Sadoway, the polymer can be synthesised by routes that are common in industry for making cheap, bulk industrial grade polymers. 'We're not relying on some finicky unstable synthetic route,' he says. 'With this polymer, we are able to get a thin film with integrity.' His team have produced prototypes that have an output of 300Wh/kg – standard lithium batteries in mobile phones or laptops typically have a specification of 125Wh/kg.

Sadoway and his group started researching into new materials for batteries about 10 years ago. Ralph Wise, a product marketing manager and battery chemistry scientist with the lithium battery manufacturer Ultralife, agrees that there has been a long search for a polymer electrolyte. 'Flexible lithium metal batteries with solid highly conductive polymer electrolytes have been the holy grail of rechargeable battery technology for the last 15 years,' says Wise. One of the stumbling blocks to the realisation of the technology, says Wise, is the conductivity of the solid electrolyte – the solid phase is generally several orders of magnitude less conductive than liquid electrolytes.

Another obstacle is the interface between the polymer and the lithium, says Wise. 'Some interesting work has been done by another group here in the US called Polyplus, which shows promise. The idea is to insulate the surface of the electrode with a glass phase material that isolates the lithium metal and provides a more stable interface. Specific energies of 1000Wh/kg have been claimed as well as good cycle life.'

But Wise is unsure about applications for the bendy batteries. Batteries that are bendable are also subject to the laws of electrochemistry, says Wise, limiting the speed to which they can be charged and discharged. 'The optimum surface geometry of any electrochemical system is two flat parallel plates, due to the geometry of the current and voltage fields of the battery,' continues Wise. Once you start adding odd geometries to these electrode surfaces, says Wise, the current density of the battery can 'pile up' in certain locations. Non-uniform current densities can lead to metallic plating and irreversible capacity losses at relatively high rates, such as those required in an electric car.

These are problems for Sadoway to think about. He does not plan to form a spin-off company in the near future. It takes an entrepreneur to take the technology forward he says, and he likes his life as an academic. 'I'm having too much fun teaching and mentoring my students - I'm not about to give up the day job.'