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A battery made from cellulose

Paperweight

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A lightweight battery that could be used to identify and track objects

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The raw material

MANY an engineer has dreamed of making a battery as light, thin and flexible as paper. Such a device would dramatically trim the weight and dimensions of whatever it powered. Now Albert Mihranyan of Uppsala University in Sweden and his colleagues have built a battery that is, in essence, made of paper. It is lightweight and slim, and although still unsuitable for everyday use, could be employed to trace products supplied to shops or baggage passing through airports.

Batteries work by electrochemistry. Each contains two electrodes (an anode and a cathode) immersed in an electrolyte. A lithium-ion battery, the sort that powers mobile phones and laptop computers, typically has an anode made of carbon, a cathode made of lithium cobalt oxide and an electrolyte of a lithium salt in an organic solvent. When the battery is being charged, electrons are pumped into the cathode. That forces lithium ions to move away from it and into the anode. When the battery is being used, drawing the current pulls the lithium ions out of the anode and back to the cathode.

The device developed by Dr Mihranyan and his colleagues, which they describe in NanoLetters, is based on cellulose—the material from which paper is made. This is not any old cellulose, though. It is extracted not from trees or cotton, as the cellulose used in paper is, but from algae. Dr Mihranyan used algal cellulose because its fibres are wispier. That gives it a greater surface area and thus allows it to store more electric charge.

Cellulose does not, however, conduct electricity, so Dr Mihranyan needed to coat it with a substance that does. He chose a polymer called a polypyrrole which, soaked into the algal cellulose, produced a combination that conducted electricity well. He then fashioned the anode and cathode of his battery from the stuff. For the electrolyte, he used filter paper soaked in brine.

The battery thus consisted of this brine-soaked filter paper sandwiched between two cellulose electrodes that were, in turn, held between two glass slides. Platinum strips attached to the electrodes provided electrical contacts to the outside world. The electrical energy itself was stored and released by chemical changes in the polypyrrole. This molecule can exist in two forms, known technically as "oxidised" and "reduced", and a current will flow between the two when they are part of a circuit. The result was a one-volt battery that could be charged in seconds—and charged and discharged 100 times without serious loss of performance.

Dr Mihranyan is now seeking to commercialise the technology. Although algal batteries cannot replace lithium-ion ones, because they are only about a third as efficient, they could be used for niche applications. That might include luggage tags containing small radios that broadcast their location to baggage handlers. "Smart" packaging materials such as cereal boxes that include electronic displays are another possibility.

In addition, other researchers have recently made paper-based transistors. Dr Mihranyan's battery could power electronics based on these. That would represent a neat reversal of the idea that technology will lead inevitably to the paperless office.