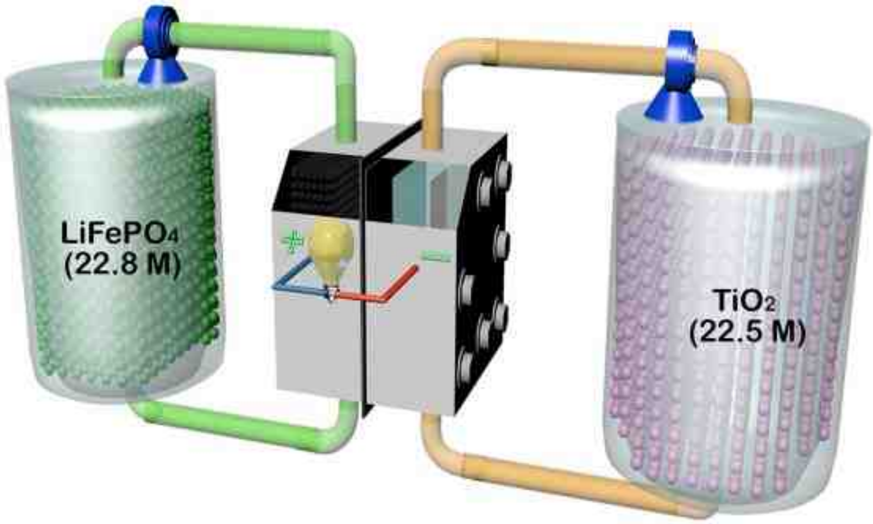

C. Jia et al., Science Advances (2015)

A new flow battery that uses lithium ion technology is able to hold more energy in a given volume than those already on the market.

New type of ‘flow battery’ can store 10 times the energy of the next best device

By
[Robert F. Service](#)
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Industrial-scale batteries, known as flow batteries, could one day usher in widespread use of renewable energy—but only if the devices can store large amounts of energy cheaply and feed it to the grid when the sun isn't shining and the winds are calm. That's something conventional flow batteries can't do. Now, researchers report that they've created a novel type of flow battery that uses lithium ion technology—the sort used to power laptops—to store about 10 times as much energy as the most common flow batteries on the market. With a few improvements, the new batteries could make a major impact on the way we store and deliver energy.

Flow batteries aren't much different from the rechargeables we're all used to, aside from their massive size. In conventional rechargeables, electrical charges are stored in an electrode called an anode. When discharged, electrons are pulled off the anode, fed through an external circuit where they do work, and returned to a second electrode called a cathode. Liquid electrolytes between the electrodes ferry ions through the battery to balance the charges. The batteries can be recharged by plugging them in, which forces the charges—and the ions—to flow in reverse.

But in flow batteries, the charges are stored in liquid electrolytes that sit in external tanks. The charge-carrying electrolytes are then pumped through an electrode assembly, known as a stack, containing two electrodes separated by an ion-conducting membrane. This setup allows large volumes of the electrolytes to be stored in the tanks. Because those tanks have no size limit, the storage capacity of a flow battery can be scaled up as needed. That makes them ideal for storing large amounts of power for the grid.

Today, the most advanced flow batteries are known as vanadium redox batteries (VRBs), which store charges in electrolytes that contain vanadium ions dissolved in a water-based solution. Vanadium's advantage is that its ions are stable and can be cycled through the battery over and over without undergoing unwanted side reactions. But vanadium is costly, and VRBs have a relatively low energy density. This means that the external tanks must be quite large to hold enough power to be useful.

Lithium ion batteries have a far higher energy density than VRBs. But it's been difficult to incorporate their technology into flow batteries. For starters, the membrane that separates the two electrodes in a flow battery must allow for the quick passage of lithium ions to balance the charges during charging and discharging. Current lithium conducting membranes are either effective but brittle, or flexible but inefficient.

To address this problem, researchers led by Qing Wang, a materials scientist at the National University of Singapore, came up with a bit of a hybrid solution. They kept the overall flow battery architecture, with charge-storing tanks separated by a central electrode stack. But inside the external tanks they placed solid—as opposed to liquid—lithium storage materials, one containing a common lithium ion battery cathode material called lithium iron phosphate ($LiFePo_4$), the other containing titanium dioxide (TiO_2), which is sometimes used as a lithium ion battery anode. They then used charge-carrying liquids, called redox mediators, to ferry electrical charges from the solids to the stack and back again. The solid storage materials are porous enough to allow the liquid redox mediators to bubble through and grab both electrons and lithium ions and ferry them to the membrane.

The researchers also modified the conventional flexible membrane material, called Nafion, combining it with another polymer that better allowed lithium ions to pass through. The approach worked. As they report today in Science Advances, [the novel lithium-based flow cells are able to store 10 times more energy by volume](#) in the tanks compared with VRBs.

It’s “very innovative” work, says Michael Aziz, a flow battery expert at Harvard University. But he adds that even though the novel battery has a high energy density, the rate at which it delivers that power is 10,000 times slower than conventional flow batteries, far too lowslow for most applications. Wang and his colleagues acknowledge the limitation, but they say they should be able to improve the delivery rate with further improvements to the membrane and the charge-ferrying redox mediators. If they can, the new lithium flow batteries could give a much-needed jolt torenewable power storage.

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