Magnetically controlled battery could store energy for power grids

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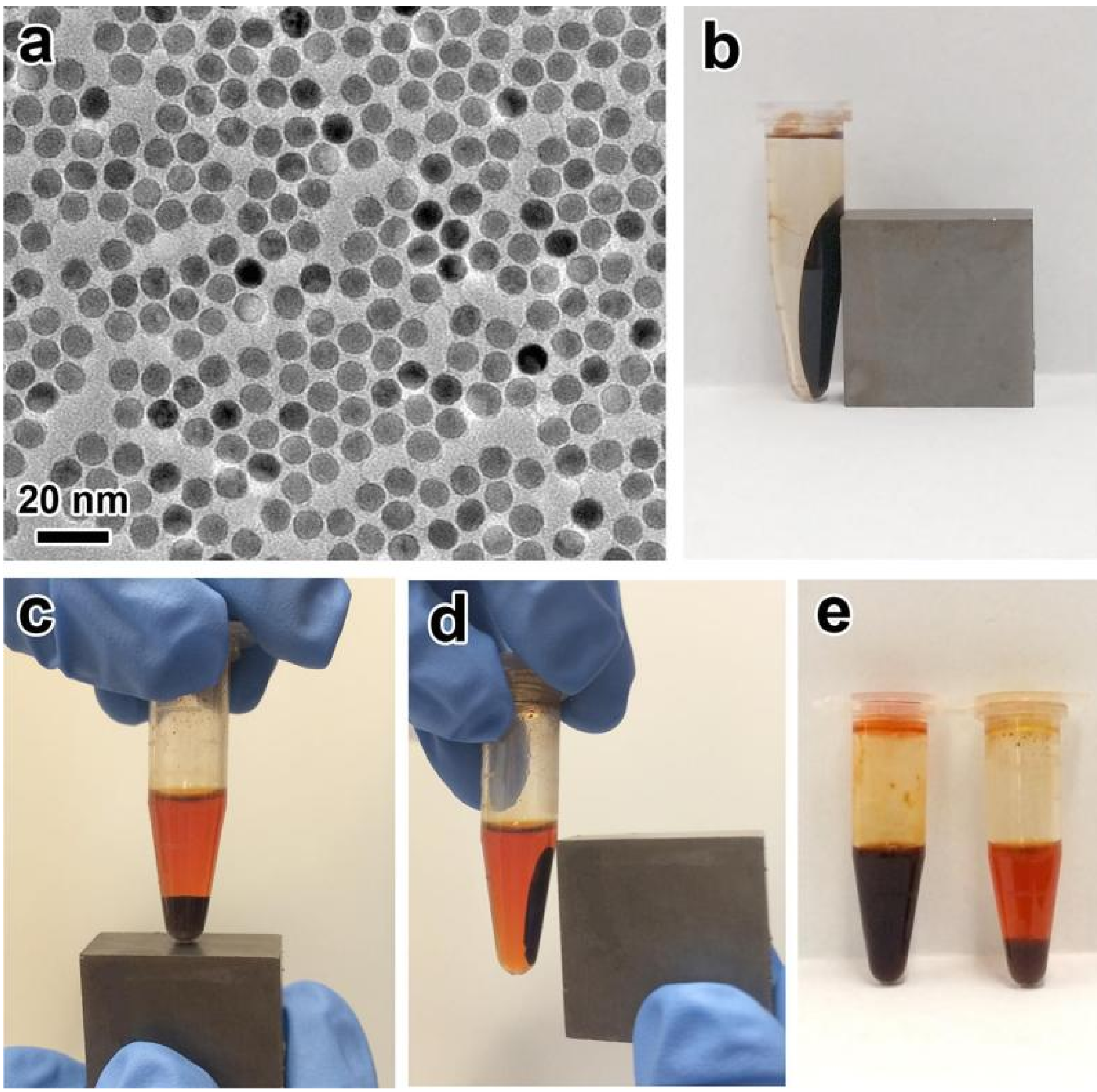

Images of the magnetic fluid containing superparamagnetic nanoparticles that move with an applied magnetic field. (e) shows the color difference between a pure polysulfide solution without magnetic nanoparticles (left) and a biphasic magnetic polysulfide solution (right) with a high and low concentration of polysulfide. Credit: Li, et al. ©2015 American Chemical Society

(Phys.org)—Scientists have built a battery containing a magnetic fluid that can be moved in any direction by applying a magnetic field. The magnetically controlled battery concept could be especially useful for flow batteries, where it could eliminate the need for the pumps that are typically required for moving the electrolyte from an external storage tank to the inside of a power stack to provide electricity. Flow batteries are being actively researched as large-scale energy storage devices for power grids, where they could store energy captured by intermittent alternative energy sources such as wind and solar.

The researchers, led by Yi Cui, Professor at Stanford University, have published a paper on the new magnetically controlled battery in a recent issue of *Nano Letters*.

"The greatest significance of our work lies in the innovative idea of using a magnetic field to control and enhance the mass and electron transport in a battery system," lead author Weiyang Li, previously at Stanford University and now at Dartmouth College, told *Phys.org*.

The key to the new battery design is the composition of the catholyte (the part of the electrolyte near the cathode), which contains lithium polysulfide mixed with magnetic iron oxide nanoparticles. By applying a magnetic field, the researchers could pull the nanoparticle colloids in a desired direction, and due to strong binding between the iron oxide nanoparticles and the lithium polysulfide, the lithium polysulfide could be pulled along with the magnetic particles. This creates a biphasic magnetic solution, with a high concentration of polysulfide on one side of the container and a low concentration on the other.

Magnetically moving the electrochemically active materials in the electrolyte in this way would be very useful for flow batteries because the goal in these batteries is to move the active molecules so that they are in close contact with a current collector. This allows a greater number of the active materials to be used, resulting in a higher energy density for the battery.

Tests showed that the new magnetic fluid containing the iron oxide nanoparticles leads to improvements in several areas compared to an electrolyte without the nanoparticles, including a higher capacity (350 mAh/g vs. 126 mAh/g), which corresponds to a high volumetric energy density of 66 Wh/L, as well as better capacity retention and efficiency. The researchers attribute these improvements to the magnetic field's ability to transport more polysulfide molecules and to minimize the undesirable "shuttle effect"—which occurs when the polysulfide molecules shuttle to the anode—because the magnetic nanoparticles can anchor the polysulfide molecules at the cathode.

In the future, if the magnetic-field-control concept could replace the need for pumps in flow batteries, it would eliminate parasitic pumping losses, which in turn could significantly increase the efficiency and lower the cost of these energy storage systems.

"Our idea can be potentially applied to a wide range of flow battery systems, not only confined to the lithium polysulfide battery in our paper," Cui said. "We are planning to extend our idea to other energy storage systems for electric grids, portable electronics, and transportation, as well."

More information: Weiyang Li, et al. "Magnetic Field-Controlled Lithium Polysulfide Semiliquid Battery with Ferrofluidic Properties." *Nano Letters*. DOI: 10.1021/acs.nanolett.5b02818