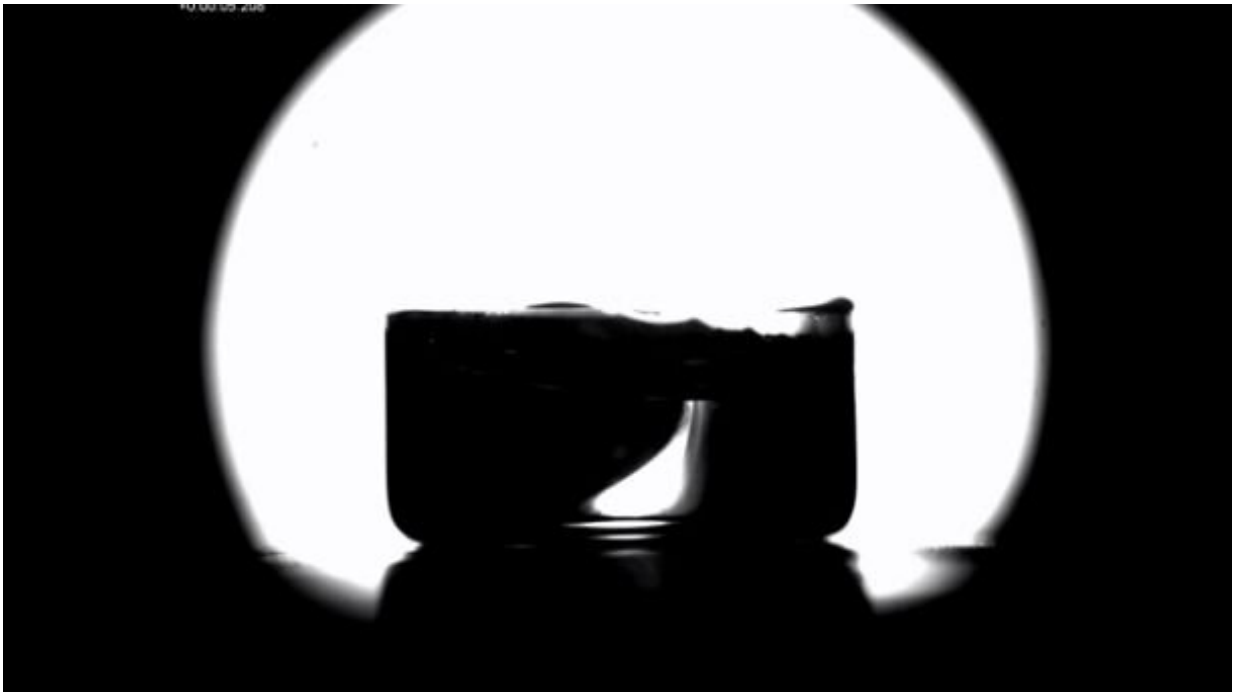
Powering a solution: Professor takes charge at improving lithium ion batteries safety

June 19 2019



As cutting edge as electric vehicles are, they're still vulnerable to an Achilles heel—the very source that gives them power.

One of the common types of batteries used in electric vehicles, lithium ion batteries—or Li-ion batteries—is susceptible to catching on fire or exploding as a result of a crash or other major impact exerted onto the

vehicle. The impact results in the internal short-circuit of electrodes. The small fire can spread throughout the battery and to other parts of the car through "thermal runaway."

"Although significant efforts have been applied to the thermal management of the battery cells, battery fires and explosions in recent electrical car accidents pose significant concerns in public," said Yu Zhu, Ph.D., associate professor of polymer science at The University of Akron (UA). "In most cases, the battery ignited when it was not operated under normal use, such as through a large external impact, or crash."

Zhu and his team of graduate students in UA's College of Polymer Science and Polymer Engineering are working to improve the safety of Li-ion batteries by creating a shear-thickening electrolyte—a substance that can become thicker under impact, set between the battery's anode and cathode that will be impact-resistant, thus not causing a fire or an explosion upon any collision. Under normal conditions, the novel electrolyte remains soft.

The group's research, led by Zhu's Ph.D. student Kewei Liu, was recently published in the *Journal of Power Sources*: "A shear thickening fluid based impact resistant electrolyte for safe Li-ion batteries."

"In Li-ion batteries for use in electric vehicles, the cathode and anode are separated by a very soft membrane and a liquid electrolyte," said Zhu. "Simply replacing a liquid electrolyte with its solid counterpart is still a challenging task because both electrodes are porous and they need liquid to fill pores and make contact. Our idea is you can still use a liquid-like electrolyte under a normal situation, but with a liquid that can improve its own mechanical strengths under impact. So, we developed a shear-thickening electrolyte."

Think of it as a starch and water mixture. You can put you hand into it

and slowly stir the starch and water while feeling very little resistance. However, if you increase your stir rate, you will dramatically feel much more resistance. In fact, a bowling ball can bounce off the surface of a cornstarch and water mixture, which behaves like a solid during the impact.

A liquid with such properties is called a dilatant, a type of non-Newtonian fluid. If an electrolyte is also a dilatant, it will prevent the battery from short-circuiting under external impact. However, forming a shear-thickening electrolyte is much more difficult than mixing cornstarch and water, because the composition of the electrolyte is complicated consisting of different ions, solvents, and various additives.

"In our preliminary research," Zhu said, "we demonstrated that a modified low-cost glass fiber filler can produce the shear-thickening electrolyte we're looking for, which is compatible with commercial Li-ion batteries and shows improved impact resistance."

Videos from Zhu's group demonstrate the bullet with different speed impacting the regular liquid electrolyte and shear-thickening electrolyte. The shear-thickening electrolyte absorbed the kinetic energy and slowed down the moving bullet significantly.

"Compared to a conventional liquid electrolyte, the shear-thickening electrolyte will not significantly reduce the performance of Li-ion batteries," Zhu said. "During an impact, the shear-thickening electrolyte will immediately behave like a solid and generate larger force to resist external impact because of the shear-thickening effect. This solution is complementary to external thermal management system of the battery pack, which often falls short in response to the abrupt impact"

Zhu said the research on improving of Li-ion batteries is relatively new, especially for the use in electric vehicles. He added that shear-thickening

electrolytes can have other niche uses, such as in bulletproof energy storage devices.

More information: Kewei Liu et al, A shear thickening fluid based impact resistant electrolyte for safe Li-ion batteries, *Journal of Power Sources* (2019). DOI: 10.1016/J.JPOWSOUR.2019.03.056

Provided by University of Akron