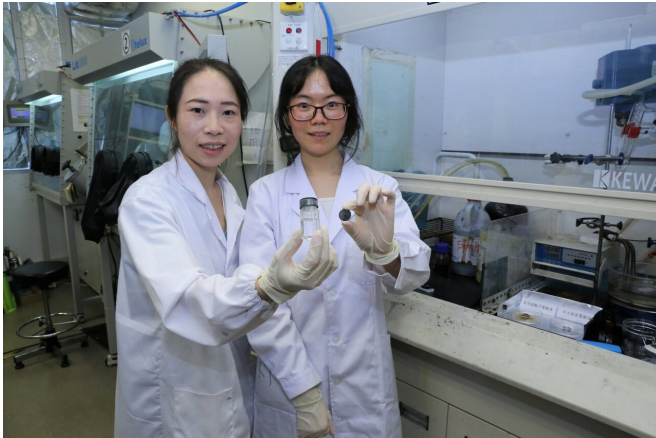


Battery electrolyte made with skin cream ingredients enables stable and non-flammable aqueous Li-ion batteries

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Prof. Yichun Lu (left) and Ph.D. candidate Jing Xie present molecular crowding electrolyte and battery prototype. Credit: The Chinese University of Hong Kong (CUHK)

A research team led by Prof. Yi-Chun LU from the Faculty of Engineering at The Chinese University of Hong Kong (CUHK) has taken a critical step forward in improving high-energy batteries by introducing a novel electrolyte to the aqueous lithium-ion (Li-ion) battery. This electrolyte is commonly used in skin cream. It is inexpensive, inflammable, less toxic and is eco-friendly, yet can create stable voltage for common usage. The breakthrough was recently published in *Nature Materials*.

The transformation of the Li-ion battery: from flammable organic to aqueous

In electronic devices and gadgets such as cell phones and laptops which have improved our daily lives on many levels, you can always find a Li-ion battery. As a result of the rechargeable characteristics and stable energy output, they have

become the heart of these electronics. Despite years of research, Li-ion batteries still heavily rely on toxic and flammable organic electrolytes to produce power, and the serious safety hazards remain unsolved. The Samsung smartphone explosions and batteries on fire in a novel Boeing plane are just a few examples. These incidents have indicated that the safety of Li-ion batteries is not yet assured.

In contrast, aqueous Li-ion batteries are non-flammable and because of their water-based electrolyte, they do not pose any significant risks of explosion. However, aqueous Li-ion batteries have been suffering from low energy-density issues due to the low battery cell voltage limited by water stability. Electrolysis will occur and break down water into hydrogen and oxygen when the voltage is over 1.23 volts, destabilising the battery operation and voltage output. Existing approaches to increase the cell voltage of aqueous batteries often involve the use of a large amount of expensive and toxic Li-ion salts to stabilise [water molecules](#), which raises the issues of cost, toxicity and environmental sustainability.

Skin cream ingredient helps stabilise aqueous electrolyte

Building on their previous research on aqueous Li-ion batteries, Prof. LU's team introduced "molecular crowding" into a novel aqueous electrolyte to replace Li-ion salts as the main stabilisation agent.

"Molecular crowding" is a common phenomenon in living cells, describing the fact that the properties of solution molecules can be substantially modified when macromolecules (proteins, complex sugars, polysaccharides and so on) or small hydrophilic molecules (metabolites, osmolytes) reach a certain concentration level. As a consequence of crowded

environments, the activity of the water solvent is reduced owing to the changes in the water's hydrogen-bonding structuring.

Prof. LU's team chose to use poly(ethylene glycol) or PEG to replicate "molecular crowding" in the electrolyte. PEG is a water soluble polymer that can be easily incorporated into aqueous batteries. It is also the basis of many skin creams and personal lubricants and is even used in toothpastes and as an anti-foaming agent in food and drinks.

Using this novel stabilisation agent, a LiMn_2O_4 cathode and a $\text{Li}_4\text{Ti}_5\text{O}_{12}$ anode, the team successfully expanded the aqueous electrolyte stability window to 3.2 volts and demonstrated stable battery operation for delivering a high energy density of 75-100Wh per kg over 300 cycles using this new electrolyte; the operational voltage can be further improved to over 4.0 volts with gel coating. The common side reactions in aqueous Li-ion batteries (hydrogen / oxygen evolution reactions) are virtually eliminated. A flammability test was conducted to prove the fireproof characteristics of the novel electrolyte, significantly improving the safety of Li-ion batteries.

Prof. LU said, "This electrolyte enables the use of many electrode materials that cannot be used in the conventional aqueous electrolytes. More importantly, this research finding provides a new platform for designing an aqueous [electrolyte](#) with large-voltage window and high stability for safe, low-cost and eco-friendly energy storage."

More information: Jing Xie et al. Molecular crowding electrolytes for high-voltage aqueous batteries, *Nature Materials* (2020). [DOI: 10.1038/s41563-020-0667-y](#)

Provided by The Chinese University of Hong Kong

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