Chemists create gel to prevent leaks and boost lithium-ion battery life

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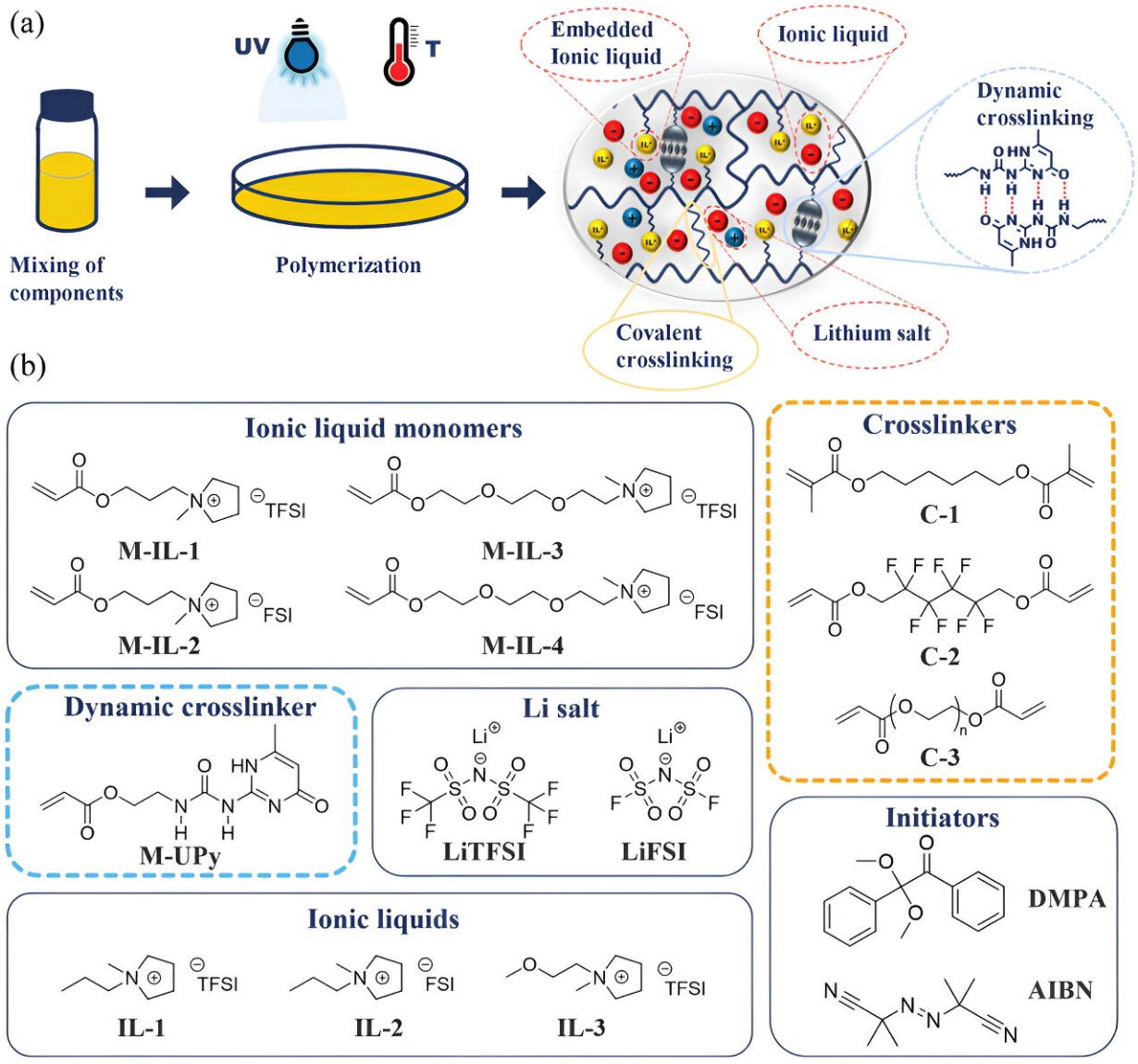


a) Schematical representation of gel electrolyte preparation and highlighted

characteristic features, b) chemical structures of gel components. Credit: *Advanced Functional Materials* (2024). DOI: 10.1002/adfm.202403487

A new type of gel, developed by chemists at the Martin Luther University Halle-Wittenberg (MLU), could help to make lithium-ion batteries safer and more powerful. The gel is designed to prevent the highly flammable electrolyte fluid from leaking.

Initial lab studies show that it also improves the performance and service life of the batteries. The researchers have published their work in the journal *Advanced Functional Materials*.

Lithium-ion batteries are real powerhouses. "They charge faster than conventional rechargeable batteries and can therefore be used in almost all areas of life," says Professor Wolfgang Binder, head of the Macromolecular Chemistry Research Group at MLU.

"However, the electrolytes, which transport the ions that conduct the current between the electrodes, are highly flammable. This can cause the battery to catch fire or explode if it is damaged."

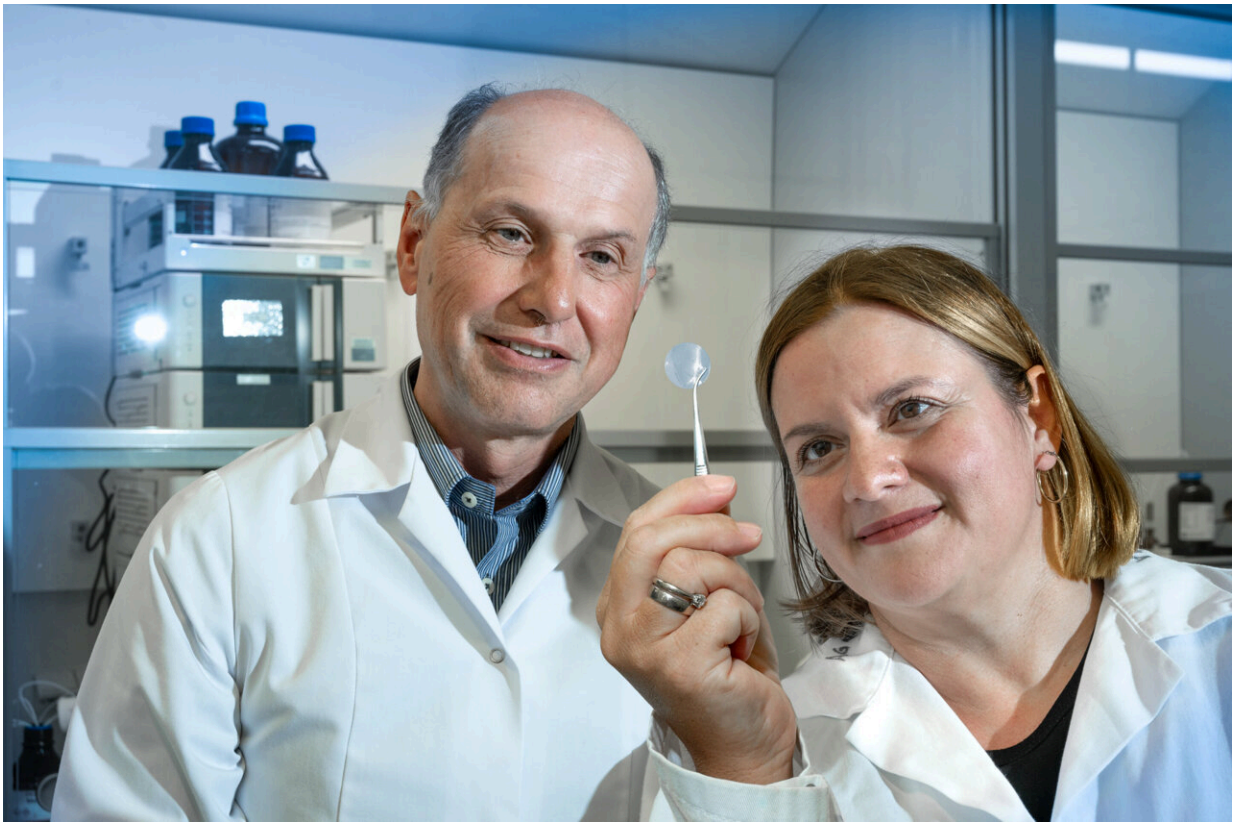
The researchers at MLU are working on improving the safety of lithium-ion batteries. "We have developed a polymer that can be filled into the battery cell. The electrolyte is bound to this substance, however the ions can continue to circulate freely between the electrodes," explains Dr. Anja Marinow, a chemist at MLU.

"The filling has a gel-like consistency and combines the high conductivity of liquids with the thermal stability and robustness of polymers."

Gel batteries with traditional electrolytes are essentially nothing new; they are used as starter batteries in motorbikes, for example. However, in combination with lithium ions, they represent uncharted technological territory.

This is largely due to one particular challenge. "In conventional lithium-ion batteries, the liquid electrolytes create a stabilizing layer on the electrodes when the battery is first charged. This is crucial for the performance and service life of the battery," explains Marinow.

"However, we needed a fundamentally new design when it came to gel electrolytes." The researchers have solved this problem by integrating an ionic scaffolding into the polymer's molecular chains.



Dr Anja Marinow and Professor Dr Wolfgang Binder present the gel filling they have developed for lithium-ion batteries. This should make the batteries safer and more efficient. Credit: Uni Halle / Heiko Rebsch

Initial test runs in the laboratory show that the approach could increase battery safety and even improve service life and performance. "Around 3.6 volts is considered a critical value for the stability of the electrolytes in conventional lithium-ion cells," says Binder. "Our gel electrolytes even remain stable at over 5 volts."

Sustainability is also a priority: the gels are designed so that they can be recycled relatively easily if there is a defect or at the end of the battery's life. However, extensive long-term studies still need to be conducted before the new lithium gel batteries can be produced on an industrial scale.

The research work was carried out as part of the "BAT4EVER" project. Universities, research centers and industrial partners from Germany, Belgium, Luxembourg, Italy, Spain and Turkey were involved in the project.

The plan is to continue the research and expand on it, particularly in the area of sustainability, as part of the "European Center for Just Transition Research and Impact-Driven Transfer (JTC)." The center, which is currently being established at MLU, will develop research-based solutions that support structural change in Saxony-Anhalt, for example in the area of the circular economy or social innovation.

More information: Zviadi Katcharava et al, Designing Conductive Pyrrolidinium-Based Dual Network Gel Electrolytes: Tailoring Performance with Dynamic and Covalent Crosslinking, *Advanced*

Functional Materials (2024). DOI: 10.1002/adfm.202403487