Fire-inhibiting, nonflammable gel polymer electrolyte for lithium-ion batteries

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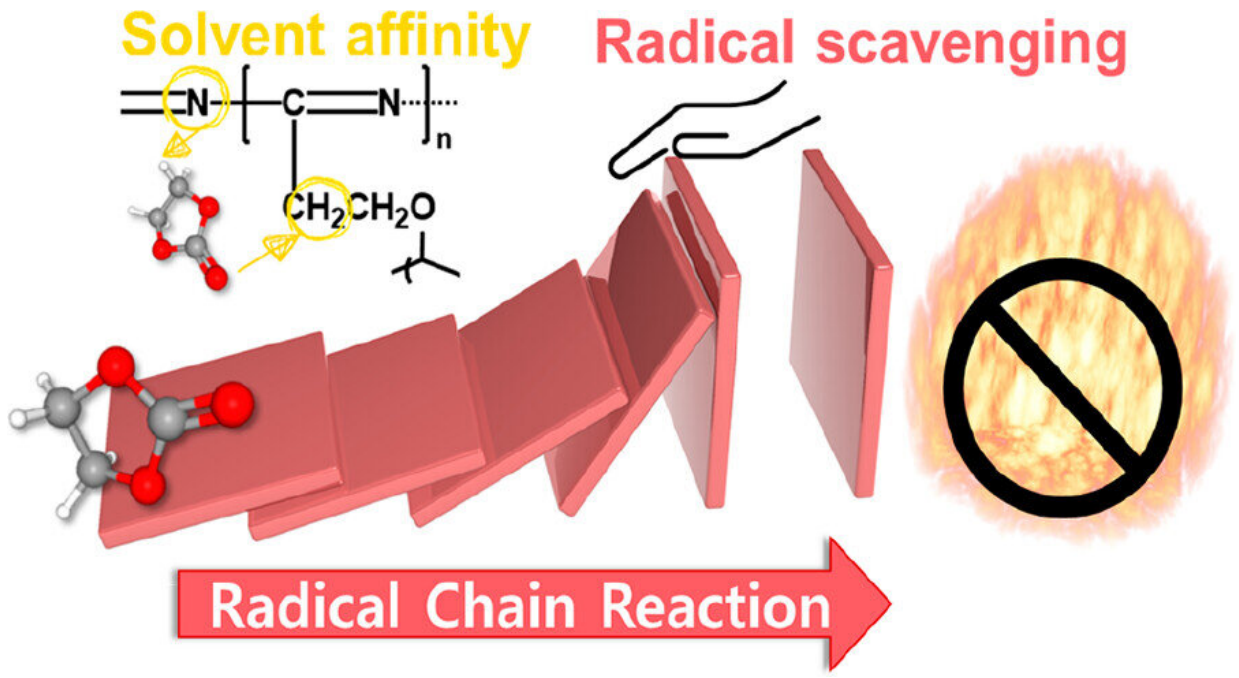


Schematic image depicting the principles of operation of non-flammable gel electrolytes. Credit: Ulsan National Institute of Science and Technology

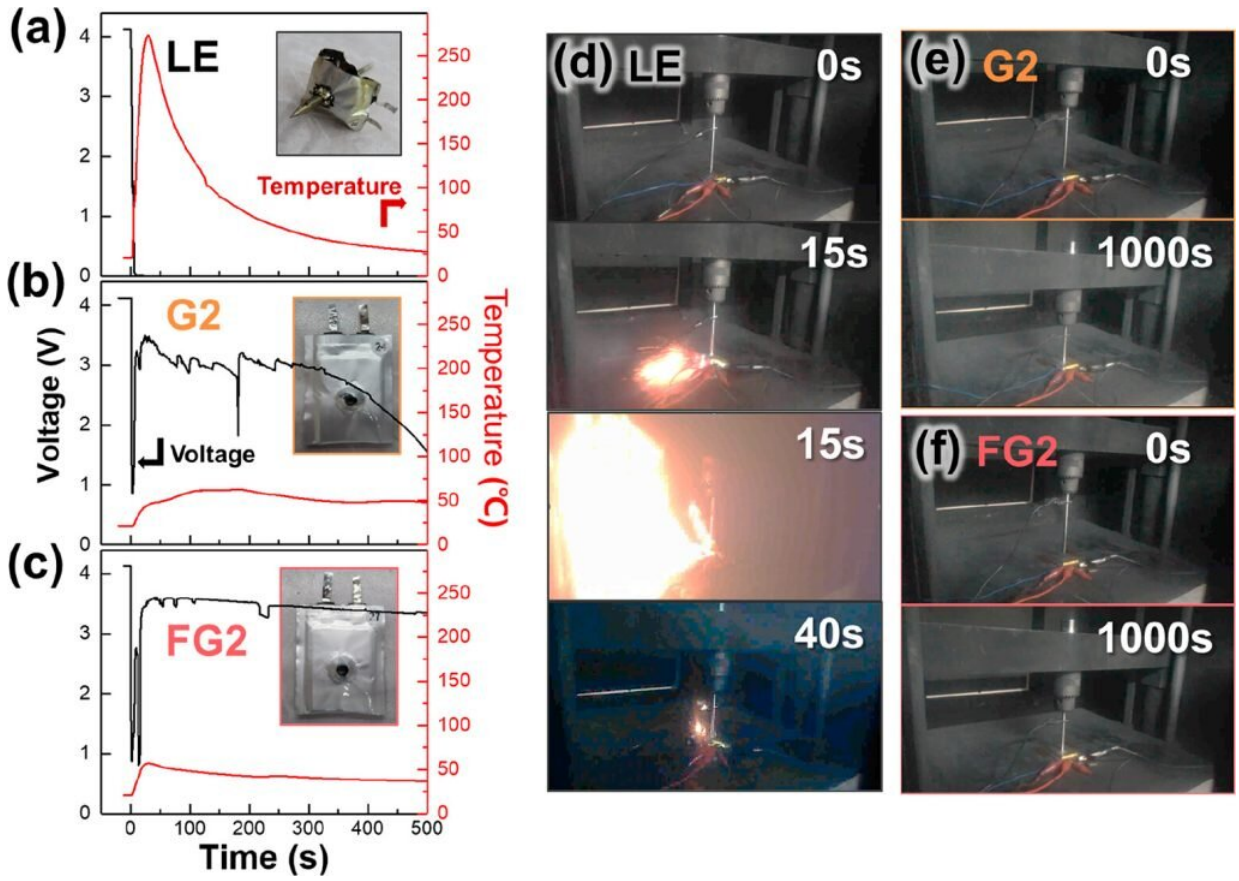
A collaborative research team has achieved a milestone in battery technology. Their achievement in developing a non-flammable gel polymer electrolyte (GPE) is set to revolutionize the safety of lithium-ion batteries (LIBs) by mitigating the risks of thermal runaway and fire incidents.

The research was led by Professor Hyun-Kon Song in the School of Energy and Chemical Engineering at UNIST, Dr. Seo-Hyun Jung from Research Center for Advanced Specialty Chemicals at Korea Research Institute of Chemical Technology (KRICT), and Dr. Tae-Hee Kim from the Ulsan Advanced Energy Technology R&D Center at Korea Institute of Energy Research (KIER). The results have been published in *ACS Energy Letters*.

In the past, the potential flammability of LIBs has raised significant concerns, especially in electric vehicles, where fire hazards pose a serious threat to underground parking lots. Addressing this critical issue, the research team has successfully developed a groundbreaking non-flammable polymer semi-solid electrolyte, offering a promising solution to mitigate battery fires.

Conventionally, non-flammable electrolytes have heavily relied on the incorporation of flame retardant additives or solvents with exceptionally high boiling points. However, these methods often resulted in a considerable decrease in ion conductivity, compromising the overall performance of the electrolyte.

In their breakthrough research, the team introduced a trace amount of polymer, creating a semi-solid electrolyte. This novel approach dramatically increased the lithium ion conductivity by 33% compared to existing liquid electrolytes. Moreover, the pouch-type batteries incorporating this non-flammable semi-solid electrolyte exhibited a remarkable 110% improvement in life characteristics, effectively preventing unnecessary electrolyte reactions during the formation and operation of the solid-electrolyte interphase (SEI) layer.



Nail penetration of 650 mAh pouch cells of NCM811||graphite. (a to c) Voltage and temperature profiles (d to f). Credit: Ulsan National Institute of Science and Technology

The key advantage of this innovative electrolyte lies in its exceptional performance and non-combustibility. By suppressing radical chain reactions with fuel compounds during the combustion process, the polymer semi-solid electrolyte effectively inhibits the occurrence of battery fires. The research team demonstrated the excellence of the developed polymer by quantitatively analyzing its ability to stabilize and suppress radicals.

Jihong Jeong (School of Energy and Chemical Engineering, UNIST)

said, "The interaction between the polymerized material inside the battery and volatile solvents allows us to effectively suppress radical chain reactions. Through electrochemical quantification, this breakthrough will greatly contribute to understanding the mechanism of non-flammable electrolytes."

Co-first author Mideum Kim, a master student in the School of Energy and Chemical Engineering at UNIST and the Korea Research Institute of Chemical Technology (KRICT), further confirmed the exceptional safety of the battery itself through various experiments. The team's comprehensive approach included applying the non-flammable semi-solid electrolyte to pouch-type batteries, ensuring the evaluation of electrolyte non-combustibility extended to practical battery applications.

"The research team's multidisciplinary composition, involving electrochemistry from UNIST, polymer synthesis from the KRICT Research Center for Advanced Specialty Chemicals, and battery safety testing by the Ulsan Advanced Energy Technology R&D Center at Korea Institute of Energy Research (KIER), has been instrumental in achieving this breakthrough," stated Professor Song. "The use of non-flammable semi-solid electrolytes, which can be directly incorporated into existing battery assembly processes, will accelerate the future commercialization of safer batteries."

More information: Jihong Jeong et al, Fire-Inhibiting Nonflammable Gel Polymer Electrolyte for Lithium-Ion Batteries, *ACS Energy Letters* (2023). DOI: 10.1021/acsenergylett.3c01128

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