Gellified Cells: A Next-Generation Battery Approach – Abuse Testing, Safety, and Performance Assessment

ADVANCED BATTERY POWER
14.–16. April 2026 P2-033

Technische Hochschule Ingolstadt

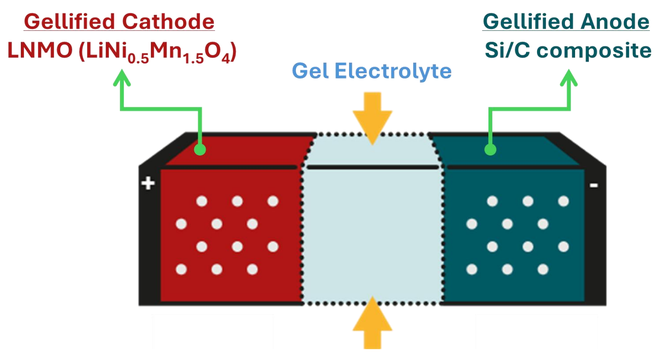
Bidheyak Subedi, Yash Kotak, Hans-Georg Schweiger
CARISSMA Institute for Electric, Connected and Safe Mobility (C-ECOS),
Technische Hochschule Ingolstadt, 85049 Ingolstadt, Germany

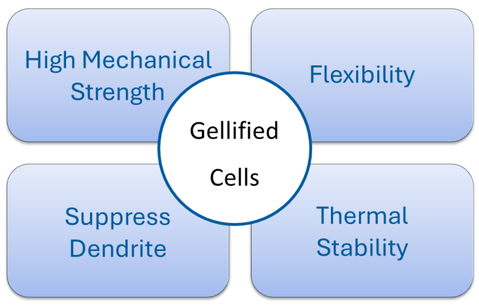
NEXTCELL

Introduction

The advancement of lithium-ion battery (LIB) technology progressively demands innovations that increase energy density and reduce cost without compromising safety, mechanical resilience, and reliability. This requires innovation in both battery materials and design. NextCell, an EU project, focuses on developing a gellified cell concept to provide a new 3b-LIB generation [1]. The innovation in this new cell is at the material level: gellification of the electrode and separator, and the use of a high-voltage gel electrolyte. According to the literature, the tests on material level and small gellified cells indicated that the gel structure slowed down the thermal runaway (TR) mechanism [2],[3]. However, testing of cells of bigger capacity under severe conditions remains limited. Henceforth, in this project, the plan is to design and manufacture a prototype of gellified LIBs and subject them to a variety of abuse tests.

Gellified Cell Components

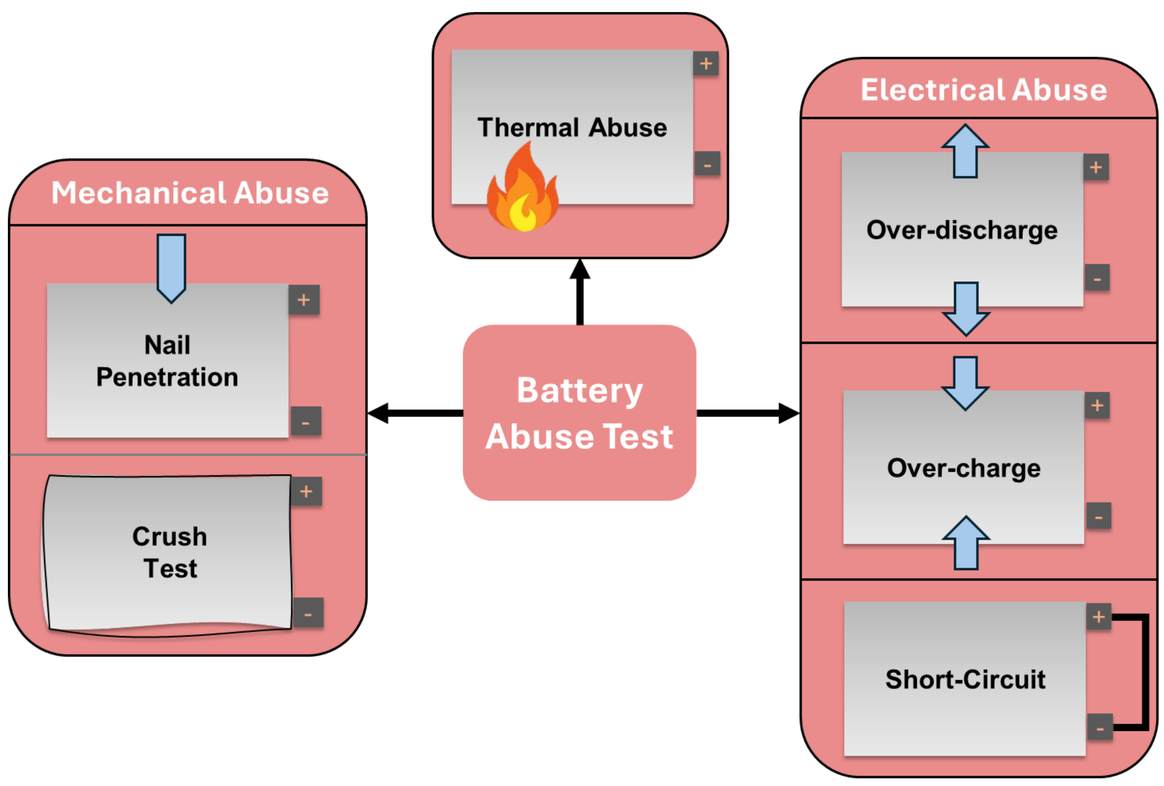




Features of Gellified Cell

- Low-boiling-point components are trapped inside the polymer matrix, leading to improved thermal robustness and safer operation
- Gellification strengthens electrode structure and boosts mechanical stability and flexibility [4]
- Potentially improved safety under abuse

Proposed Tests



- Abuse tests are planned on 0.5, 3, and 4 Ah pouch cells
- The test would be coupled with FTIR to find out the composition of vented gases
- Testing is based on FreedomCAR and IEC 62600-2 standards
- Post-mortem analysis of abused cells is planned
- Cell behavior during abuse tests would be classified based on EUCAR hazard rating (0-7), as in Figure 2
- The lower the hazard index (↓), the safer (↑) the cells are

Expected Results

- Evolution of temperature and voltage during different abuse tests

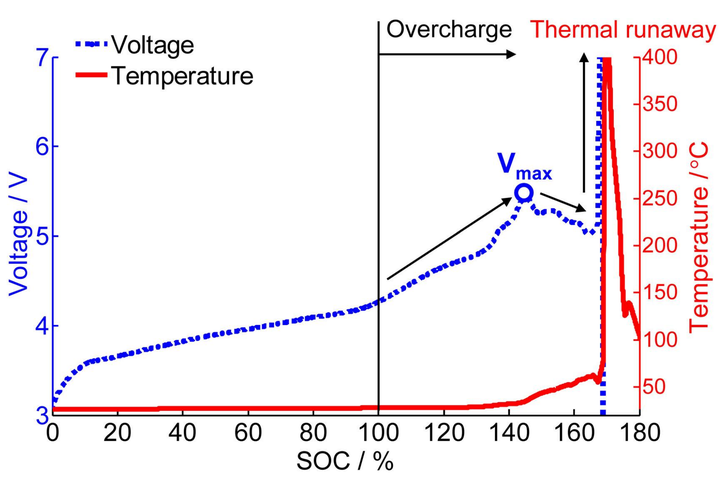


Figure 1: Evolution of voltage and temperature during overcharging [6]

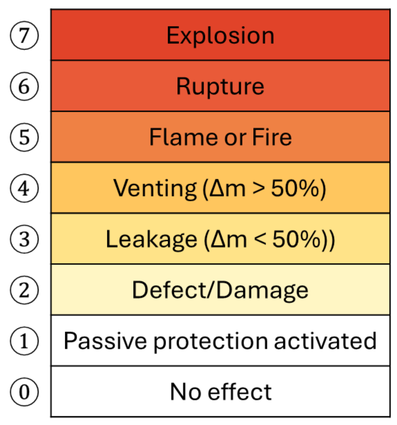


Figure 2: EUCAR hazard rating [5]

- Thermal runaway characteristics: A delayed onset of TR with a higher TR temperature → Extended safety window
- Liquid electrolyte (LE) based LIB, it is common to see jet fire/ rupture/ explosion [6]. Corresponding to hazard level (5-7)
- Safety index: A lower hazard level is expected → Improving overall safety

Possible Implication of Results

- Replacement of traditional LIB with LE by state-of-the-art gellified cells
- Implementation of the gellified-cell concept in high-energy density cells
- Extended safety window → Extending the time to evacuate the vehicle during TR

Acknowledgment

Authors kindly acknowledge the NEXTCELL project, which has received funding from the European Union's Horizon Europe Research and Innovation Actions under Grant Agreement No. 101069910.

References

[1] Soares et al., Increasing environmental performance of battery technologies, WASTES 2025
[2] Wang et al., Noncombustible gel polymer electrolyte inspired by bio-radical chemistry for high-voltage.., J. Colloid Interface Sci., 2024
[3] Du et al., 3D hierarchical fireproof gel polymer electrolyte towards high-performance and comprehensive safety LIB, Chem. Eng. J., 2023
[4] Yang et al., Biopolymer-based gel electrolytes for electrochemical energy storage: Advances and prospects, Prog. Mater. Sci., 144 (2024)
[5] EUCAR, Battery requirements (BEV/FCEV), hazard levels, 2019
[6] Feng et al., Thermal runaway mechanism of Li-ion batteries, Energy Storage Mater., 2018

M. Sc. Bidheyak Subedi
Research Assistant at C-ECOS
Technische Hochschule Ingolstadt
85049 Ingolstadt
E-Mail: bidheyak.subedi@carissma.eu

CARISSMA
Institute of Electric, Connected and Secure Mobility