Development of Temperature Sensitive Paint for Energy Storage System (ESS) Safety

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Introduction

Existing issue

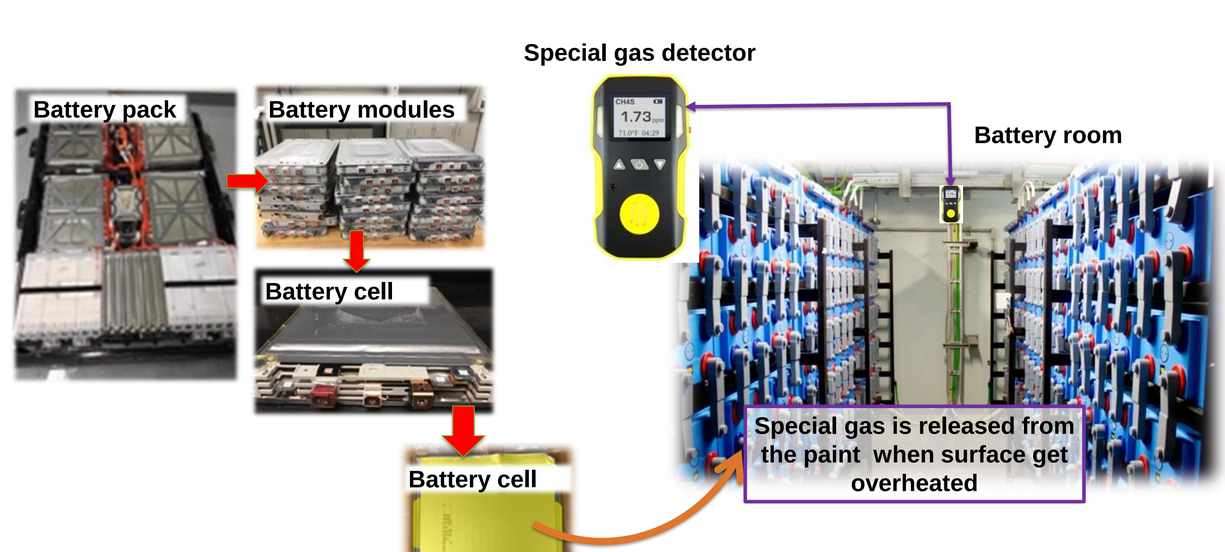
- Safety and reliability are the primary concerns of the energy storage systems (ESS).
- Thermal runaway is the most reported safety issue of Li-ion batteries in ESS.
- It is challenging to monitor the temperature of every single cell in a bank of hundreds and thousands of batteries.
- Battery failure usually starts from a hot spot at a single cell, it presented an impossible task to use temperature sensors effectively.
- The batteries may continue to overheat without flames leading to a thermal runaway event slowly over time.
- ESS needs a large-area temperature monitoring system.

Potential solution

- A temperature-sensitive paint: The low-cost paint can be applied to every cell and cover all surfaces for an ESS.

Our approach

- Entrap/attach molecules (e.g., thiols) in larger molecules designed to release the gas when a specific threshold temperature is passed.
- A special gas detector placed nearby or coupled to the ventilation system will sound an alarm if the designated molecule is detected.

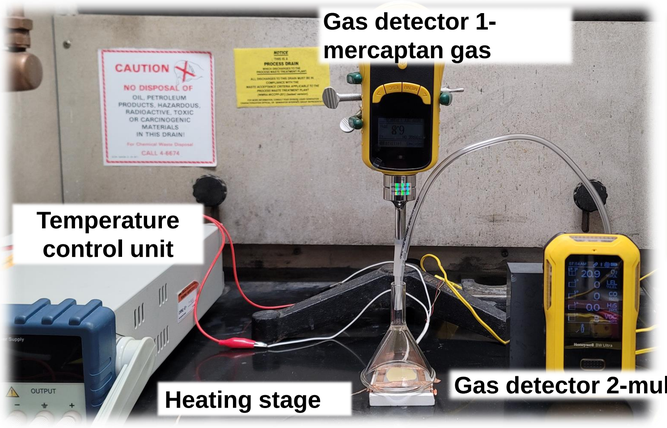


Methods

Thermal-sensitive compound synthesis and characterization

Copper thiol compound-1

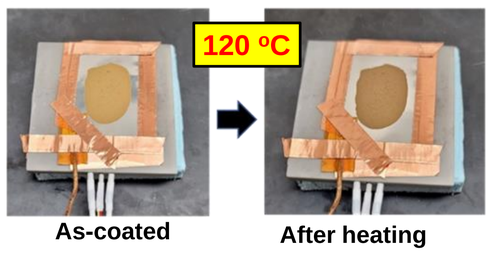
Thermal runaway event simulation



- **The thermal sensitive compound coated battery pouch foil was place on the heating stage**
- **Released gases were detected as function of time and temperature using several sensors**

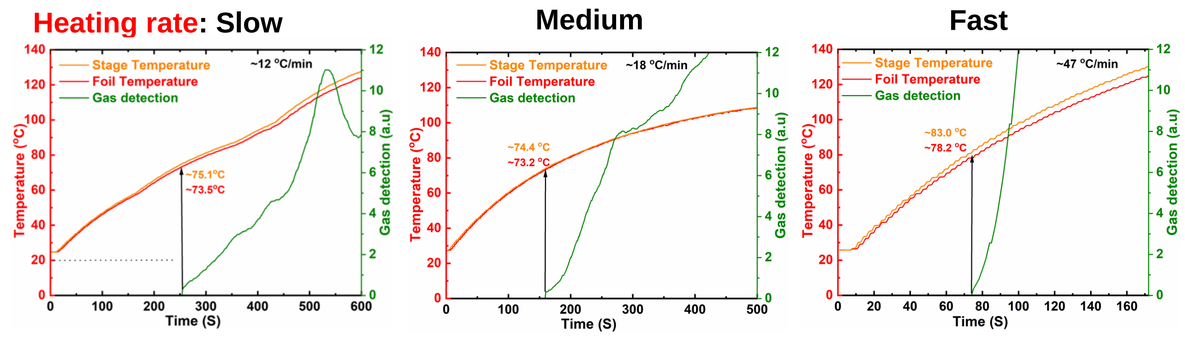
Results

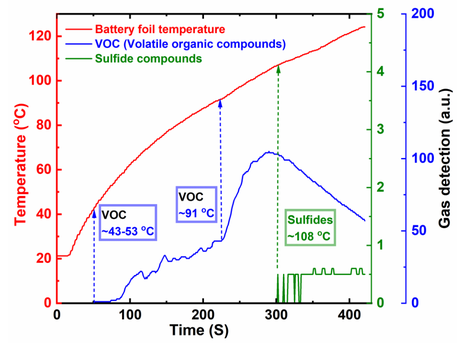
Copper-thiol compound-1



Onset gas release temperature :
Mercaptan detector: 73-78 °C

At different heating rates:
- gas release rate increases.
- gas release quantities increase.
- gas release onset temperature increases.

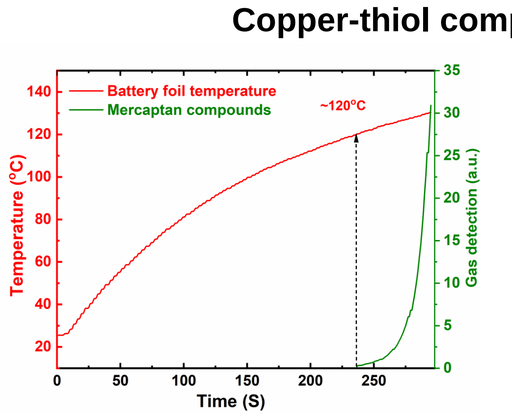


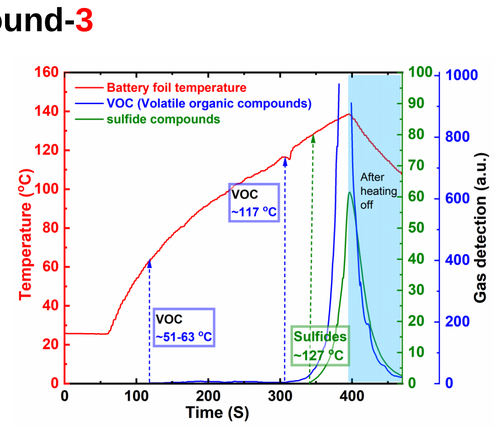


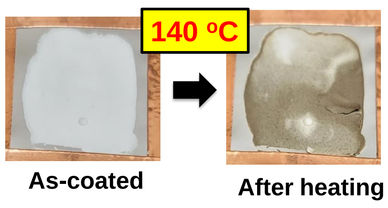
Sensor-dependent onset gas release temperature

Mercaptan : 73-78 °C
VOC : 53, 91 °C
Sulfide : 115-120 °C

Copper-thiol compound-3







Onset gas release temperature :
Mercaptan : 120-125 °C
VOC : 117°C
Sulfide : 125-127 °C

The onset of gas release temperature is tunable..!

Copper-thiol compound	Onset gas released temperature (°C)
Compound - 1	72-75
Compound - 2	84-96
Compound - 3	120-127
Compound - 4	152-163
Compound - 5	172-174

Conclusions

- Copper-thiolate compound thermally decomposes to release volatile compounds (VOC and sulfur-containing) when critical temperature is reached.
- Critical thiol release temperature can be tuned by changing the chemistry of the compounds
- Gas detection depend on the type of gas release and detector/ sensor used

Acknowledgements

- This work was supported by the U.S. Department of Energy, Office of Electricity, Energy Storage System Safety & Reliability Program and ORNL DRD SEED money program.

References

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- Temperature sensitive coatings, U.S. Patent Application No.18/119,373, March 9, 2023

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