

Thermal Runaway Volatile Detection

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INTRODUCTION

Batteries are a true marvel of scientific innovation, that tremendously revolutionizes modern lives. They help the working of smartphones and other technologies from tethering the clutches of endless power cables. One such revolutionary player in the battery realm is the Lithium-ion battery (LIB), the primary energy source for powering portable electronic devices. The term “thermal runaway” was associated with LIBs referring to a chain exothermic reaction unfolding within the battery. This phenomenon results in a rapid surge of temperature around 752 degrees Fahrenheit / 400 degrees Celsius and pressure within the battery, leading to gassing, explosions, and fires that are challenging to extinguish.

The Hazards of Thermal Runaway

During the thermal runaway, Lithium-ion batteries will release high temperatures followed by venting and rupturing of cell casing or in-cell explosion, potentially causing harm to nearby equipment or individuals. The combustion of leaked gasses produced includes not only flammable components but also highly toxic substances, such as phosphoryl fluoride (POF₃) and hydrogen fluoride. The chain reaction can spread through neighboring cells within a module, amplifying the dangers across the entire battery.

Causes of Thermal Runaway

Electrical, mechanical, and thermal abuses are the fundamental causes of thermal runaway. Electrical abuse results from internal and external short circuits, overcharging, or over-discharging. Mechanical abuse occurs due to external forces like collisions, causing internal short circuits. Thermal abuse occurs when external heating of batteries leads to a critical accumulation of heat, triggering thermal runaway.

Challenges in Detection

Once thermal runaway initiates, its termination is possible only after the complete combustion of the reactants in the battery, making early detection crucial. Contemporary battery management systems face challenges in detecting small changes in the battery temperature, discharge current, and voltage, highlighting the need for advanced sensing technologies.

Thermal runaway in Lithium-ion batteries is a key concern for the developers of equipment like e-bikes, electric vehicles, mobile phones, and laptops. The risks associated with lithium-ion batteries have been highlighted by several high-profile incidents.

Historical Incidents and Current Challenges

In the years 2006 and 2007, millions of mobile phones and laptops faced recalls due to safety issues regarding their lithium-ion batteries. Moreover, a Boeing 787 aircraft was temporarily grounded in the year 2013, due to an electric issue emerging from the lithium-ion battery that existed inside the auxiliary power unit of the aircraft. About 2.5 million mobile phones experienced a recall due to complaints of overheating and exploding batteries in 2016.

After an extensive investigation, it was revealed that the overheating and explosions in batteries were due to insufficient insulation material and design flaws, particularly the lack of space for safe electrode accommodation. Recently in London, there has been a 60% increase in e-bike fires when compared to the year 2022. As there is an increase in cases over time, there is a growing demand for advanced sensing technologies to detect faulty Li-ion batteries, during both production and operation.

SENSORS

The most viable solution to thermal runaway is employing gas sensors to detect early signs. This is crucial since thermal runaway leads to the production of gaseous substances by electrochemical reactions. Notably, O₂, H₂, CO₂, C₂H₄, C₂H₅F, C₄H₁₀, POF₃, and PF₅ gases were detected during the heating process within lithium batteries. Concerning the significant variations in gas content, gas type, and gas change rate, extensive monitoring can be carried out during the early stages of thermal runaway. A targeted sensor with a corresponding threshold for detection needs to be developed for effective implementation.

The Role of Voltrac - VOC Sensors

The development of Voltrac sensors emerges as a practical solution for detecting the early warning signs of thermal runaways. These sensors can identify specific gasses produced during electrochemical reactions inside lithium batteries, offering a reliable means of monitoring.

Applications of Voltrac - VOC Sensors

- **Early Warning Systems** - Voltrac sensors provide early warnings by detecting flammable gasses even at low concentrations, enabling timely preventive measures to mitigate hazards.

- **Monitoring Battery Storage Facilities** - Continuous monitoring of flammable compound leakage in large battery storage facilities aids in the early detection of thermal runaway, preventing potential hazards.
- **Electric Vehicles (EVs)** - Voltrac sensors in EVs allow continuous monitoring of flammable gasses emitted during thermal runaway, facilitating automatic detachment from power sources to prevent overheating. A sensitive VOC sensor embedded in the EV will not only avert a potential hazard but also enhance the life of the battery pack as a whole by providing valuable insights into its management.
- **Battery Management Systems (BMS)** - Integration of Voltrac sensors into BMS enhances safety by enabling rapid responses to abnormal conditions, including disconnecting power sources, triggering cooling systems, and reducing charging or discharging rates.
- **Quality Control in Battery Production** - Voltrac sensing throughout the manufacturing process helps identify faults or impurities, ensuring that only safe batteries enter the market.

CONCLUSION

The implementation of Voltrac sensors represents a crucial step toward enhancing the safety of lithium-ion batteries. By providing early warnings and real-time monitoring, these sensors play a pivotal role in preventing and mitigating the hazards associated with thermal runaway. As technology evolves, the integration of VOC sensors becomes imperative for a safer and more reliable future in battery-powered applications.