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Editorial: Advanced diagnosis and early warning strategies on degradation and safety of lithium-ion batteries

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Editorial on the Research Topic
Advanced diagnosis and early warning strategies on degradation and safety of lithium-ion batteries

1 Introduction

Lithium-ion batteries (LIBs) have attracted attention for use in a wide range of applications, from portable electronics to electric vehicles and renewable energy storage, due to their high energy density, long cycle life, and relatively low self-discharge rates. However, despite their numerous advantages, LIBs face significant challenges related to degradation and safety, which can compromise performance and reliability. The degradation mechanisms of LIBs are complex processes driven by various factors including chemical, mechanical, and thermal stresses. These factors would result in capacity fading, increased internal resistance, and, in severe cases, fatal failure.

Therefore, taking early warning measures before a fatal accident occurs is crucial, suggesting that an on-board device should continuously monitor the condition of the battery in operation and Research Topic warning messages based on the severity of any faults. Implementing such an early warning system enhances the safety and reliability of the lithium-ion battery, allowing potential risks that may arise during operation to be detected and addressed in advance.

This Research Topic aims to not only elucidate complex degradation phenomena but also develop effective mitigation strategies for LIBs. Additionally, the Research Topic also aims to develop innovative diagnostic tools that can accurately monitor and predict battery health in real-time to ensure the continued advancement and widespread utilization of LIBs. This Research Topic includes three original research articles and one review article that showcase novel findings on lithium-ion battery degradation phenomena, mitigation strategies, early warning systems, and diagnostic methods. The articles are categorized under two main themes: mechanisms of degradation and mitigation strategies, and early warning systems and diagnostic methods.

1.1 Mechanisms of degradation and mitigation strategies

Understanding complex mechanisms behind degradation phenomena of LIBs is essential for developing effective mitigation strategies. The degradation of battery cells involves complex processes such as gas generation, swelling, electrolyte decomposition, lithium dendrite formation, active material dissolution, and separator breakdown.

Gao et al. investigate the side reactions during fast charging, particularly focusing on lithium plating and solid electrolyte interface (SEI) film growth. Their findings highlight that lithium plating significantly contributes to capacity attenuation in the early stages, while SEI film growth dominates in later stages. This study provides critical insights into improving charge/discharge strategies for LIBs.

Yang et al. discuss various materials used in battery thermal management systems. The review covers liquid coolants, phase change materials, and innovations in enhancing cooling efficiency and thermal performance. By summarizing these advancements, the review inspires new designs and improvements in battery safety and performance through advanced intelligent methods.

Tian et al. use quantum chemical calculations to model electrolyte decomposition. Their research reveals the role of dielectric constants and solvation effects in enhancing electrolyte stability, thereby providing a theoretical basis for understanding thermal runaway events. This study underscores the importance of chemical modeling in developing safer battery systems.

1.2 Early warning systems and diagnostic methods

The development of early warning systems and diagnostic methods is crucial for preventing accidents related to lithium-ion battery failures. Innovative sensor technologies and diagnostic algorithms play a pivotal role in monitoring battery health and issuing timely alerts.

Wang et al. explore the use of ultrasound-based methods for assessing the state of health of LIBs. The study employs machine learning algorithms to process ultrasonic signals, demonstrating the effectiveness of this approach in accurately predicting battery degradation. This research highlights the potential of combining ultrasonic diagnostics with computational models for precise battery health evaluation.

2 Conclusion

This Research Topic brings together pioneering research on the degradation mechanisms, mitigation strategies, and early warning systems for lithium-ion batteries. Advancing understanding and capabilities in these areas enhances the safety and reliability of lithium-ion batteries, ultimately contributing to a more sustainable and secure use for various systems, including portable electronics, electric vehicles, and energy storage systems.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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