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The Analysis of Swelling Lithium-Ion Battery with a Residual Gas Analyzer

RGA provides valuable data for optimizing battery safety, performance, and longevity

This application note aims to demonstrate the use of a Residual Gas Analyzer (RGA) in identifying and quantifying the gases produced by Li-ion battery swelling. By analyzing these gases, researchers and engineers can gain valuable insights into the battery's chemical processes, identify potential failure modes, and optimize electrolyte formulations for enhanced battery performance and safety.

Introduction

Lithium-ion (Li-ion) batteries have several key advantages including high energy densities, flexible design, light weight, fast charging, and long lifespan. These advantages have made Li-ion batteries the preferred choice for a wide array of devices, from consumer electronics to electric vehicles and renewable energy storage systems. Lithium-ion (Li-ion) batteries can swell (also known as "gassing") due to several factors, primarily related to chemical reactions within the battery. Swelling is a serious issue because it can indicate a failure in the battery's safety mechanisms. Swollen batteries should not be used, as they can lead to further degradation, overheating, or even dangerous situations such as fires or explosions.

Analyzing gases in swelling lithium-ion batteries can be crucial for understanding the causes and consequences of battery swelling, especially for safety and performance assessments.

A Residual Gas Analyzer (RGA) operates by measuring the partial pressure of different gases in a vacuum or low-pressure environment. The analyzer detects and identifies the types of gases present, such as permanent gases (e.g., CO_2, CO, H_2) and light hydrocarbons (e.g., methane, ethane), through a combination of mass spectrometry

Experimental

A swelling Li-ion battery was carefully prepared for testing. The exterior surface was wiped down with IPA to remove grease and moisture. About 1 cm square of brown silicone rubber gasket was cut and adhered to the surface of the sample. The sample was then punctured with the needle through the silicone gasket. The needle needs to avoid touching the jelly roll. The gas analysis was conducted using a QMS 300 amu gas analyzer with the following parameters as shown in Table 1.

Inlet type	PEEK capillary
Flow rate	1 to 10 mL/min
Pressure	10mbar to 1 bar
Operating temp	25 °C
Mass Spectrometer	Quadrupole
Detectors	Faraday cup & electron multiplier
Operating pressure	5×10–6 mbar
Range	0 to 150 atomic mass units

Table 1: Analytical parameters of the QMS 300 amu gas analyzer

Results and Discussion

Table 2 presents the results of the gas analysis for the swollen battery. Various amounts of hydrogen, hydrocarbons, carbon dioxide, and carbon monoxide were detected. The low carbon dioxide (CO_2) to carbon monoxide (CO) ratio suggests significant oxidation at the anode and reduction at the cathode, which may be caused by over-discharging.

Conclusion

A Residual Gas Analyzer (RGA) is an essential tool for understanding the chemical processes that occur within lithium-ion batteries during swelling. By analyzing the composition of gases produced during battery degradation, RGA provides valuable data for optimizing battery safety, performance, and longevity. This method is a powerful tool for researchers, engineers, and manufacturers seeking to improve the safety and efficiency of Li-ion batteries for a wide range of applications.

Contact us today to learn how we can help you with your next project.

Propylene Carbonate	0.000%
Ethylene Carbonate	0.000%
Dimethyl Carbonate	0.780%
Diethyl Carbonate	0.001%
Ethylmethyl Carbonate	0.000%
Methyl Carbamate	0.000%
Battery Gases	**Abundance**
Hydrogen	1.76%
Carbon Dioxide	62.43%
Carbon Monoxide	14.70%
Water Vapor	1.32%
C1-C4 Hydrocarbons	6.24%
Oxidized Organics	3.59%
Fluorocarbons	0.05%
HF	0.03%
Solvents	0.78%
Net Fraction Battery Gases	90.90%
Sample pressure (Atm)	1.09
[Fraction of air in sample]	9.10%
Ratio (CO_2/CO)	4.25

Table 2: Gas analytical results

References

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