FAST AND POTENTIALLY ON-LINE GAS CHROMATOGRAPHIC METHODS FOR THE MONITORING OF VOLATILE EMISSIONS OF LITHIUM ION BATTERIES

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The development of innovative energy storage for higher energy density, higher safety and lower environmental impact plays a key role in the adaptation of electric vehicles and the corresponding reduction of CO_2 emissions and fossil fuel dependence. To achieve this, larger lithium-ion batteries (LIBs) are developed, increasing the necessity of the risk assessment for unexpected chemical hazards, due to misuse or extreme operating conditions.

In this contribution, the application of different gas chromatographic approaches will be evaluated for the identification of volatile organic species and gases emitted from LIBs used under normal and abuse conditions. The proposed degradation mechanisms of the most commonly used LIBs' electrolytes will be discussed, summarizing the volatile compounds expected to emerge under thermal and/or electrochemical degradation. Targeting the highly volatile species, gas chromatography was selected and coupled to a mass spectrometer and the newly released barrier discharge ionization detector (BID), for the ex situ measurements of thermally degraded electrolyte mixtures. Selective investigation of compounds belonging to different volatility groups was performed by GC-MS and headspace GC-MS measurements using different GC column configurations. Critical evaluation of the identified compounds was performed, focusing on the formation paths of the detected degradation products.

In order to decrease the time requirements of the measurements and approach on-line measuring conditions the Vacuum Outlet (or Low Pressure) GC-MS was investigated for potential application in the field of LIB emissions, using standards of highly volatile compounds. A detailed study of all chromatographic parameters affecting this fast GC technique was performed, proving the applicability of the technique for certain ranges of analytes as well as its limitations.

An alternative experimental setup, based on the increased time resolution provided by FTIR was also applied. Focusing again on the possibilities for on-line monitoring of the volatile degradation species, in situ measurements of self-assembled and commercially available cells were performed using a FTIR-GC-MS system.

Utilizing the findings from both our in situ and ex situ investigations and the overall comparison of the aforementioned analytical approaches, future optimizations on the components of the batteries can be realized, contributing to the development of highly efficient, safe and environmentally friendly LIBs.

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