Fast Gas Chromatography with development of a negative-thermal gradient GC for the study of volatile products formed in lithium-ion batteries

Bernhard Klampfl[1], S. Wöhrer[1], J. Kahr[2], E. Rosenberg[1]

bernhard.klampfl@tuwien.ac.at

[1]Vienna University of Technology, Institute of Chemical Technologies and Analytics, Vienna, Austria
[2]AIT Austrian Institute of Technology GmbH, Center for Low-Emission Transport, Electric Drive Technologies, Vienna, Austria

---

Improvements to the longevity, energy-density, cost-efficiency and charging times are crucial aspects for the viability of lithium-ion batteries. Research on LIBs aims at optimizing electrolyte composition and establishing a deeper understanding of their degradation and stabilization mechanisms. To investigate the degradation and aging mechanisms of the electrolyte in-situ, a real-time- (operando) method is required. Highly time-resolved analysis of the gas species that are formed during the use of LIBs is crucial to understand the dynamics of the process. To achieve this, a GC/MS system equipped with a fast-measuring system to enable short injection intervals is employed. The long cycle times of conventional temperature programmed gas chromatography prompted us to look for a different approach.

Directly heated short columns allowing for rapid heating rates (> 1400 K min^{-1}) appeared to be a suitable solution. Negative thermal gradients were investigated for their suitability to improve separation efficiency. For this purpose, different setups were designed and tested on their ability to enable fast separations.

We report here two experimental setups capable of producing spatially resolved temperature gradients along a GC column. The systems achieved rapid changes in the shape of their gradients and enabled fast separations of analytes with high volatility range. It was shown that base-line separated measurements of a C_8-C_{20} n-alkane standard could be realised in less than 30 seconds for both systems. Both systems require little resources in comparison to conventional gas chromatography in terms of electricity and carrier gas consumption. These aspects make this technology a viable asset for more sustainable analytical processes.

- Fast negative-thermal gradient GC
- Short separation cycles for in-situ and on-line analysis
- Sustainable gas chromatography

Acknowledgements
Financial support of this work in the frame of the FFG (Austrian Research Promotion Agency) Project “OPERION” (proj. no. 879613) is gratefully acknowledged.