



SpectroInlets

Enabling real-time analysis

Introducing real-time gas analysis to battery research: The EC-MS Premium



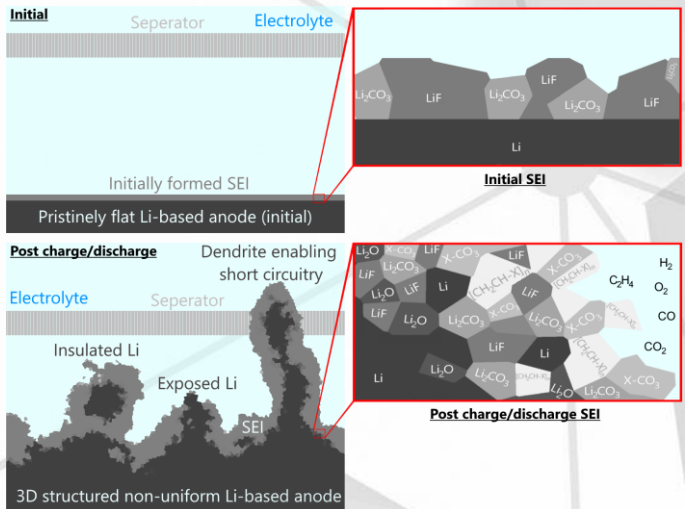
- ✓ Real-time and fully quantifiable
- ✓ Unprecedented sensitivity
- ✓ Transfer module for inert sample transfer from glovebox
- ✓ Temperature control of the cell (15-70 °C)
- ✓ Negligible electrolyte evaporation allowing long duration test
- ✓ Turnkey solution with integrated software



Challenges for Li-ion batteries

Li-ion batteries are currently challenged by:

- 1 Highly reactive Li** may spontaneously react with electrolytes, metals and H_2O/O_2 traces *etc.* lowering ion availability and conductivity, reducing battery efficiency and life-time.
- 2 Non-uniform SEI growth**, forming dendrites, may adversely *i)* insulate Li *ii)* expand SEI volume (lowering power density) *iii)* create a short circuit (a serious safety issue) through the separator material, see figure below.
- 3 Unstable SEI formation**, resulting in *i)* additional SEI growth accompanied by electrolyte decomposition and gas evolution *ii)* Li passivation and *iii)* increased resistances through a growing SEI.



SEI scheme; initial and after several charge/discharge cycles.

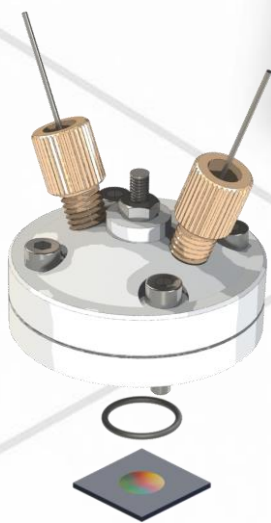
Gas evolution accompanies all processes mentioned in issues **1** to **3**. Hence, on-line gas analysis combined with electrochemical data acquisition may provide battery researchers with important information about SEI formation, electrolyte decomposition and the role of the H_2O/O_2 content in the battery. Thus, the EC-MS Premium can provide valuable insights for developing better and safer Li-ion or other types of batteries.



Real-time gas analysis

EC-MS Premium

The EC-MS Premium gives you the ability to determine the origin and the nature of the gas-evolution, enabling a better understanding of the Solid Electrolyte Interphase (SEI) formation and degradation of electrode and electrolytes. This accelerates the development of new and safer batteries with a shorter time to market. Combining electrochemistry (EC) with mass spectrometry (MS) provides a strong tool for analyzing electrochemical product formation in batteries.



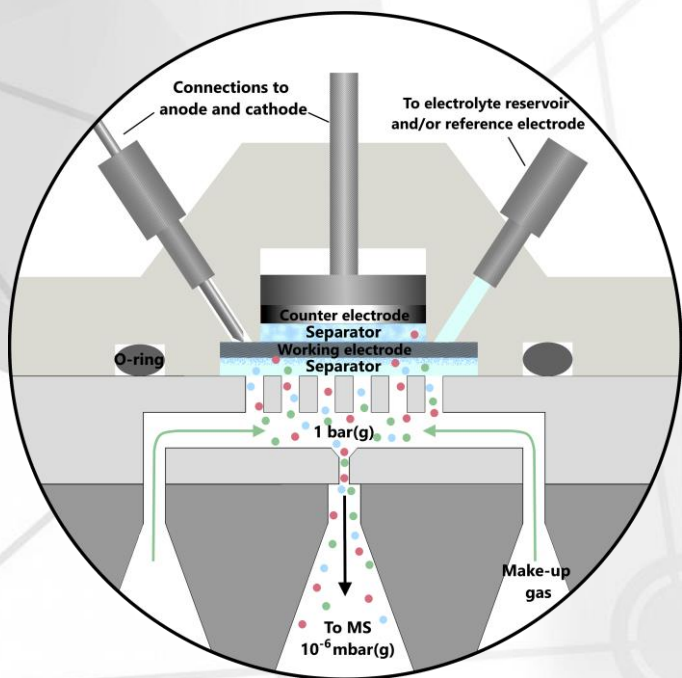
Through an optimized membrane chip with integrated microcapillary, Spectro Inlets offer a unique inlet coupling the ambient battery environment to the vacuum conditions of the MS. The hydrophobic membrane facilitates transport of volatiles to MS while inhibiting electrolyte evaporation.



Cell assembly



Working principle



Challenges of existing techniques

Introducing a pressure gauge into a battery cell

- × No information on gas nature
- × No quantification of evolved gas
- × Difficult installation

Post-mortem gas extraction *e.g.* using syringe

- × No real-time information
- × Difficult to quantify products
- × Requires external analysis of gas

Differential electrochemical mass spectrometry (DEMS)

- × Not compatible with volatile electrolytes
- × Loss of analyte to differential pumping
- × Not fully quantitative

Online electrochemical mass spectrometry (OEMS)

- × Significant electrolyte loss to evaporation
- × Ill-defined time response
- × No commercial solution

Our solution: EC-MS Premium

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About Spectro Inlets

We are a company founded in 2016 by a team of engineers from the Technical University of Denmark (DTU). Our core technology is a unique microchip inlet system enabling mass spectrometry of volatiles in liquids, which is the result of more than 10 years intense R&D work.

Based on the inlet system, we have developed a portfolio of state-of-the-art gas detection systems, including an industrial sensor for liquid gas analysis (LGA) and turnkey solutions for electrochemistry - mass spectrometry (EC-MS). Our latest product, the EC-MS Premium, enables battery researchers to gain unique insights into battery material properties, -limitations and -possibilities.

Contact us at sales@spectroinlets.com for further inquiries and to schedule a meeting with one of our electrochemistry experts or visit www.spectroinlets.com



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