

## P03

# First steps towards field integration of benchtop NMR spectroscopy for online monitoring and process control

**Simon Kern<sup>1</sup>, Patrick Gräber<sup>1,3</sup>, Nicolai Zientek<sup>1,2</sup>, Michael Maiwald<sup>1</sup>**

<sup>1</sup>*Bundesanstalt für Materialforschung und -prüfung (BAM)  
Richard-Willstätter-Str. 11, D-12489 Berlin, Germany*

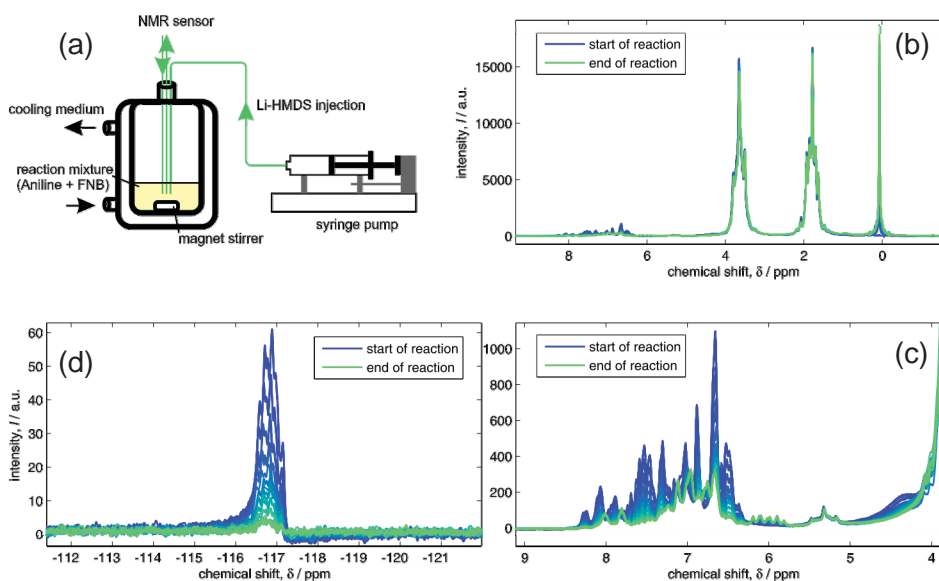
<sup>2</sup>*Technische Universität Berlin, Department of Chemical Engineering  
Straße des 17. Juni 136, MA 5-7, 10623 Berlin, Germany*

<sup>3</sup>*Humboldt-Universität zu Berlin, Institut für Chemie  
Brook-Taylor-Str. 2, D-12489 Berlin, Germany*

Online monitoring and process control requires fast and noninvasive analytical methods, which are able to monitor the concentration of reactants in multicomponent mixtures with parts-per-million resolution. Online NMR spectroscopy can meet these demands when flow probes are directly coupled to reactors, since this method features a high linearity between absolute signal area and sample concentration, which makes it an absolute analytical comparison method being independent on the matrix. Due to improved magnet design and field shimming strategies portable and robust instruments have been introduced to the market by several manufacturers during the last few years. First studies with this technology showed promising results to monitor chemical reaction in the laboratory [1, 2].

Within the project CONSENS [3], the continuous production of high-value products in small production scale is advanced by introducing benchtop NMR spectroscopy. CONSENS is a research and innovation project on integrated control and sensing for sustainable operation of flexible intensified processes.

This poster will present the first steps of the process integration of a benchtop NMR instrument for a lithiation process [4] and outlines further fields of activity and potential challenges. Hereby, the following issues are going to be addressed: explosion-proof housing for the spectrometer, automation of signal processing (data pre-treatment, evaluation and communication to the control system), flow cells and measuring conditions. Furthermore, first online spectra of the lithiation reaction in batch mode were acquired in lab scale. The reaction was performed in a 25 mL glass reactor with thermal jackets for temperature control of the reaction mixture (Fig. 1a). The Li-HMDS was dosed stepwise by using a glass syringe. First spectra in the proton and fluorine domain were recorded online using a flowrate of 3.5 mL min<sup>-1</sup> and a simple 5 mm polytetrafluoroethylene tube (PTFE) as a flow cell (Fig. 1b,1c, and 1d).



**Fig. 1:** Laboratory setup of first lithiation reactions (a) and online spectra acquired with a benchtop NMR spectrometer: complete  $^1\text{H}$  spectra with dominant solvent signals (b) aromatic region (c),  $^{19}\text{F}$  spectra along the reaction path (d).

#### Literature

- [1] F. Dalitz, M. Cudaj, M. Maiwald, and G. Guthausen, 'Process and Reaction Monitoring by Low-Field NMR Spectroscopy', *Prog. Nucl. Magn. Reson. Spectrosc.*, 60 (2012), 52–70.
- [2] N. Zientek, C. Laurain, K. Meyer, M. Kraume, G. Guthausen, and M. Maiwald, 'Simultaneous F-H Medium Resolution NMR Spectroscopy for Online Reaction Monitoring', *J. Magn. Reson.*, 249C (2014), 53–62.
- [3] [www.consens-spire.eu](http://www.consens-spire.eu)
- [4] P. Zhang et al., *Bioorganic & Medicinal Chemistry Letters* 18 (2008), 6067–6070.