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Online Mass Spectrometry for Ultra-Sensitive Detection of CO_2 Impurities: Meeting Updated Northern Lights Specifications

Armin Wisthaler[a,b,*], Felix Piel[b], and Tomas Mikoviny[a]

[a]*Advanced Monitoring Solutions AS, Oslo, Norway*
[b]*University of Oslo, Department of Chemistry, P.O. Box 1033 Blindern, 0351 Oslo, Norway*

Abstract

In 2024, the CO_2 transport and storage company Northern Lights JV DA ("Northern Lights") released updated CO_2 specifications, defining maximum permissible concentrations for a broad range of impurities in transported liquid CO_2. These revisions were introduced in response to emerging insights into the formation of corrosive acids resulting from cross-reacting impurities, as well as concerns related to material degradation and the occurrence of liquid or solid phase dropouts. The objective of the update is to ensure the continued integrity, operability, and safety of Northern Lights' CO_2 transport infrastructure.

The revised specifications cover a diverse set of contaminants, including inorganic species (e.g., NO_x, SO_x, H_2O, H_2S, NH_4) and a variety of organic compounds such as aliphatic and aromatic hydrocarbons, as well as functionalized organics including alcohols, glycols, aldehydes, amines, and nitriles. Comprehensive analysis of these compounds presents significant challenges, both due to the requirement for sub-ppm detection limits and the wide variability in their physicochemical properties. This complexity is further exacerbated by the logistical and economic difficulties associated with deploying multiple analytical sensors in industrial environments. Furthermore, many of the targeted compounds lack commercially available sensors that have been validated for real-time use under field conditions, limiting the reliability and applicability of conventional monitoring approaches.

In our earlier research (*Wisthaler et al., 2022*), we demonstrated that online mass spectrometry (MS) can reliably detect both organic and inorganic impurities in gaseous CO_2 at parts-per-billion (ppb) levels, although that work was limited to a narrower set of analytes. Building on those results, our current efforts aim to extend the detection capability to the full range of impurity classes specified by Northern Lights. Notably, our initial findings confirm that glycols – particularly difficult to quantify due to their low volatility and polarity – can be accurately measured in CO_2 at ppb concentrations using online MS. In this presentation, we will describe the recent enhancements made to our MS methodology that enable high-sensitivity detection across a broader array of contaminants, and outline the technical advancements that support robust and comprehensive monitoring of both organic and inorganic species in CO_2.

Reference: Wisthaler, A., Mikoviny, T. and Languille, B., Ultra-Sensitive Detection of Impurities In CO_2 (August 30, 2022). Proceedings of the 16th Greenhouse Gas Control Technologies Conference (GHGT-16) 23-24 Oct 2022, Available at SSRN: https://ssrn.com/abstract=4294576

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* Corresponding author.
E-mail address: info@adms.no