Monitoring real time, in-line variations of noble gas concentrations during CO₂ capture and injection operations by means of a portable mass spectrometer (miniRUEDI): establishing background data for future leakage detection

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Abstract

In the ICO2P project [1] we apply cutting-edge technology in developing an innovative and cost-effective monitoring scheme for CO₂ capture and storage operations. The aim is to monitor CO₂ storage projects and natural basin flow processes for the Norwegian offshore setting by recording noble gas fractionation and isotopes to learn their evolution in time and space. This approach will allow for source-specific identification of fluids; differentiating injected (anthropogenic) CO₂ from natural (methanogenic/biogenic) CO₂ rich gases at potential leakage points. The first step is to establish a basis for fluid source identification by recording temporal variance of noble gas composition in the CO₂ product. Studies so far typically include only a few, single point samples, and there is a clear need for better background data on gas compositions. In ICO2P, we are using a portable instrument; the miniRUEDI [2] mass spectrometer, to investigate real time variability of the noble gas content in CO₂ gas streams at operating CCS facilities.

The first study was performed at the Technology Centre Mongstad (TCM) in Norway, a large-scale test facility for CO₂ capture operations. An open scientific test campaign for post-combustion capture processes, using amine-based temperature swing absorption (TSA), was run during summer 2017 [3]. The combined cycle gas turbine based combined heat and power plant is fed by reservoir gas from different fields in the North Sea mixed with a smaller fraction of refinery gases (still combustible gases). Flue gas is fed into the TCM plant, cooled, run through the absorber, before CO₂ is stripped-off and vented to safe location in a dedicated vent stack. Combustion of different hydrocarbon sources (e.g. gas versus coal) was simulated by varying the CO₂ content through recycling in the line. A miniRUEDI [2] mass spectrometer was connected to the outgoing CO₂ product stream from the capture process, downstream the overhead condenser of the CO₂ stripper. This stream is water saturated, and the slip stream to the instrument was passed to a dryer to avoid the risk of condensation in the instrument. A pressure reduction cell was mounted between the sample point and the instruments membrane inlet. The instrument was mounted in less than an hour, and ran continuously during a 5-day test period, measuring noble gases He, Ar, Kr, Ne, as well as CO₂, N₂, O₂ every 10 to 15 minutes in the CO₂ product stream out. In this way, a unique, semi-continuous data series of noble gas content was established. The test was successful, and operational changes (e.g. recycling in the production line) are detected in the He and Ar data. Similarly, we observed fluctuations related to
flue gas (in) and CO$_2$ product (out) variability. Another test-run at TCM and analysis of single samples for full isotopic fractionation analysis at the noble gas lab at Eawag is underway.

The miniRUEDI [2] allows for frequent and accurate measurements of noble gas abundance, which may shed light on absolute variability in live gas streams and guide follow-up sampling for isotopic analysis in the lab. This is a new approach that will provide knowledge of the uniqueness of noble gas fingerprints in the product stream from hydrocarbon production, CO$_2$ capture operations and in the injection line for CO$_2$ storage. Mapping of the background noble gas abundance before injection is of utmost importance to characterize the natural gas composition and spatial distributions prior to CO$_2$ injection. This will improve the understanding of CO$_2$ trapping mechanisms and oil/water/gas partitioning in reservoirs, and form the grounds for comparison of fluid sources needed in leakage detection schemes at CO$_2$ storage sites.

References:

