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The Inherent Tracer Fingerprint of Captured CO_2

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Inherent tracers, the isotopic and trace gas composition of captured CO_2 streams, are potentially powerful tracers for use in CCS technology [1,2]. Despite this potential, the inherent tracer fingerprint in captured CO_2 streams has yet to be robustly investigated and documented [3]. Here, we will present the first high quality systematic measurements of the carbon and oxygen isotopic and noble gas fingerprints measured in anthropogenic CO_2 captured from combustion power stations and fertiliser plants, using amine capture, oxyfuel and gasification processes, and derived from coal, biomass and natural gas feedstocks.

We will show that $\delta^{13}C$ values are mostly controlled by the feedstock composition, as expected. The majority of the CO_2 samples exhibit $\delta^{18}O$ values similar to atmospheric O_2 although captured CO_2 samples from biomass and gas feedstocks at one location in the UK are significantly higher. Our measured noble gas concentrations in captured CO_2 are generally as expected [2], typically being two orders of magnitude lower in concentration than in atmospheric air. Relative noble gas elemental abundances are variable and often show an opposite trend to that of a water in contact with the atmosphere.

Expected enrichments in radiogenic noble gases (^{4}He and ^{40}Ar) for fossil fuel derived CO_2 were not always observed due to dilution with atmospheric noble gases during the CO_2 generation and capture process. Many noble gas isotope ratios indicate that isotopic fractionation takes place during the CO_2 generation and capture processes, resulting in isotope ratios similar to fractionated air. We conclude that phase changes associated with CO_2 transport and sampling may induce noble gas elemental and isotopic fractionation, due to different noble gas solubilities between high (liquid or supercritical) and low (gaseous) density CO_2.

Data from the Australian CO_2CRC Otway test site show that $\delta^{13}C$ of CO_2 will change once injected into the storage reservoir, but that this change is small and can be quantitatively modelled in order to determine the proportion of CO_2 that has dissolved into the formation waters. Furthermore, noble gas data from the Otway storage reservoir post-injection, shows evidence of noble gas stripping of formation water and contamination with Kr and Xe related to an earlier injection experiment. Importantly, He data from SaskPower's Aquistore illustrates that injected CO_2 will inherit distinctive crustal radiogenic noble gas fingerprints from the subsurface once injected into an undisturbed geological storage reservoir, meaning this could be used to identify unplanned migration of the CO_2 to the surface and shallow subsurface [4].

References

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