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Visualisation of [11C]CO2 storage in coal with positron emission tomography imaging

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CO2 geo-sequestration is a practical approach to achieve net-zero carbon target. Coal has become an optimal geological storage option due to its large adsorptive capability for CO2. However, one of the main challenges for successful CO2 geo-sequestration is the reduced injectivity that are caused by adsorption-induced swelling of coal matrix. In addition, its complex and heterogenous internal pore and fracture structure make the processes of gases adsorbing, desorbing, and transporting more complicated compared with conventional rocks. This work aims to gain insights about the gas transport behaviours in coal by developing a novel experimental framework with Positron Emission Tomography (PET) imaging technology to directly visualise gas flow multiphysics in coal.

PET imaging has demonstrated its capability in providing real-time visualisation of fluids flow in geological materials. However, it has not been used for the study of CO2 injection and storage in coal for the application of CO2 geo-sequestration. To observe the processes directly, [11C] CO2 is the most optimal radiotracer, which is rarely used due to its short half-life (20.4 min) and handling safety issues as a gaseous tracer. In this work, a novel laboratory protocol is developed to use gaseous [11C] CO2 as the radiolabelled tracer to visualise and quantify dynamic processes of gas spreading, adsorption, diffusion, and advection flow in coal under in-situ conditions. The experimental setup integrates core flooding setup with PET scanning. Coal samples are pretreated to mimic different injection conditions, including coal seam gas reservoirs in early production stage, gas depleted stage and CO2 storage stage. Due to high temporal resolution of PET imaging, time-lapse CO2 gas concentration map of each test is acquired by converting the PET intensity values to gas concentrations. Impacting factors on storage capacity and efficiency are also studied, including permeability, gas adsorption, gas exchange, and initial storage conditions.

This work introduces a new laboratory protocol and analysing framework to quantify sub-core scale multiphysics CO2 flow in coal, which provides a foundation for future across-scale theoretical and experimental study of multiphase and multicomponent flow behaviours in coal for the application of CO2 geo-sequestration.

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References

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