UQ Gas and Energy Transition Research Centre

Impact of Gas Adsorption on Relative Permeability of Coal

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Abstract

CO_2 geo-sequestration in coal seams is a promising technique for mitigating the greenhouse effect. However, CO_2 adsorption-induced swelling in the coal matrix poses challenges in CO_2 injection by reducing coal seam permeability, significantly affecting the CO_2 injection efficiency. To better understand the impact of gas adsorption on gas-water two-phase flow behavior in coal seams, a suite of two-phase flow experiments was conducted with both adsorbed and non-adsorbed gases. The relative permeability curves for helium-water, nitrogen-water, and CO_2 -water systems were obtained.

The results indicate that gas adsorption induces coal matrix swelling, leading to lower relative permeability in adsorbed gas-water systems (nitrogen and CO_2) compared to non-adsorbed gas (helium). Finally, quantitative relationships for estimating the relative permeability of nitrogen-water and CO_2 -water systems were developed, providing four coefficients relative to the helium-water system. These coefficients offer a new approach to predict CO_2 -water two-phase flow behavior in coal and provide valuable insights for assessing CO_2 injectivity in CO_2 geo-sequestration.

Experimental Procedure

The absolute permeability was measured using water under a confining stress with 2 MPa before the two-phase flow tests. Then, the relative permeability of different gas-water systems were measured using steady-state method.

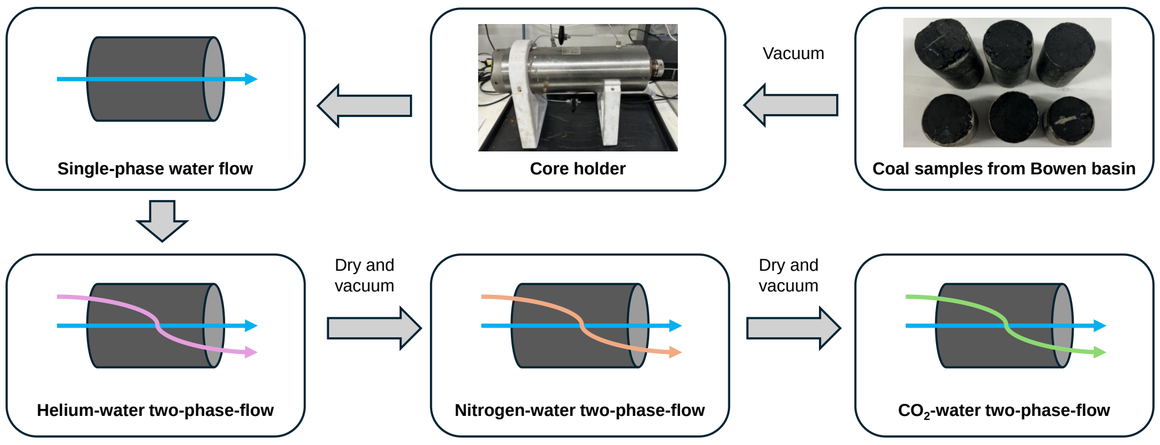


Figure 1: Experimental procedure flowchart.

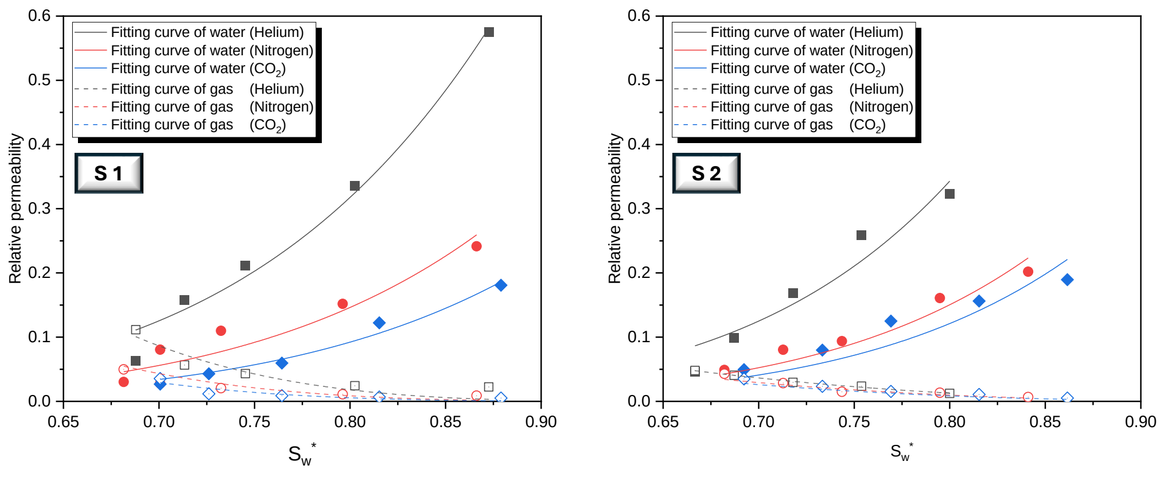
Relative Permeability Results

1. Relative permeability model

$$k_{rw} = a(S_w^*)^b \quad (1)$$

$$k_{rg} = m(1 - S_w^*)^n \quad (2)$$

where constants a, b, m and n are the coefficients depending on coal properties and gas-water two-phase flow systems.



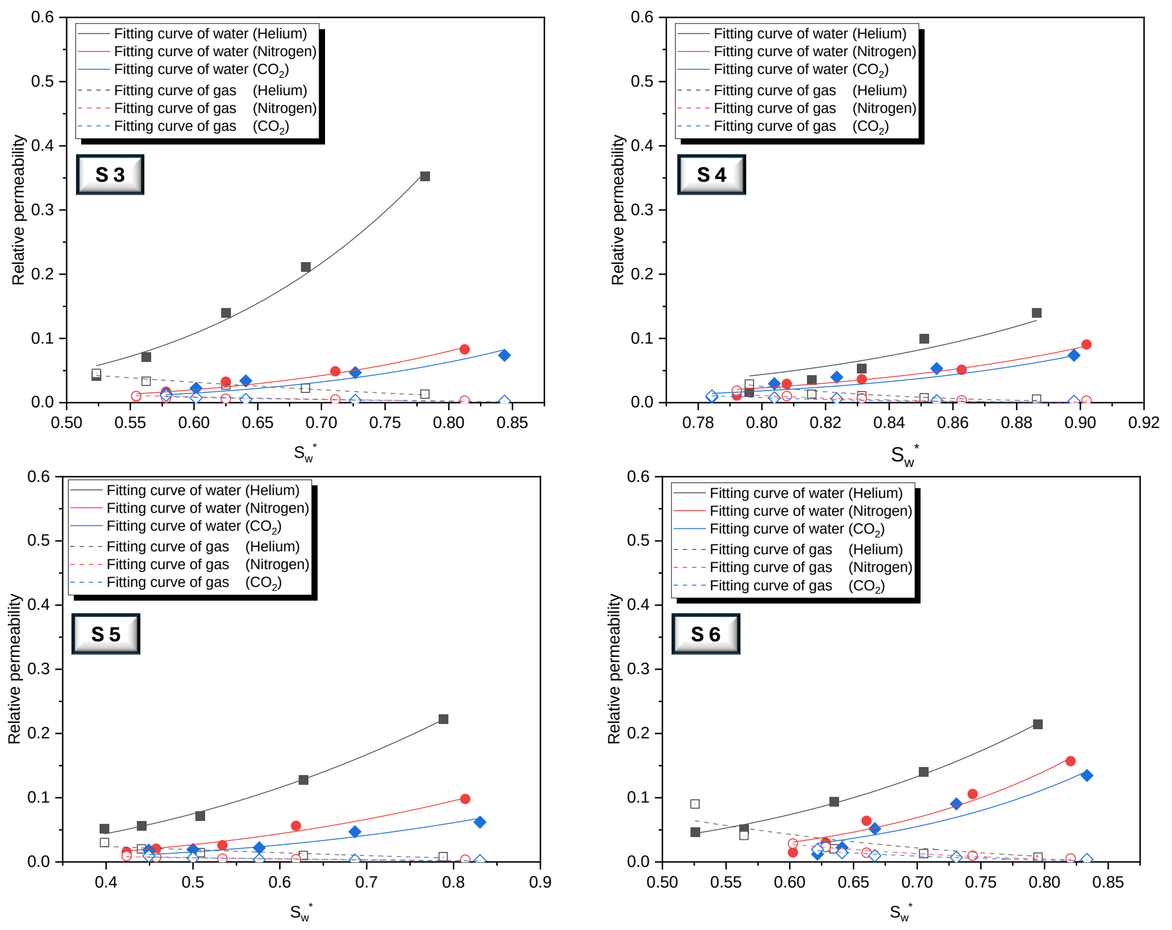


Figure 2: Relative permeability under different gas-water two-phase flow systems.

2. Quantitative correlation between the non-adsorbed and adsorbed gases

$$k_{rw\_N_2} = \alpha \times k_{rw\_He} \quad (3)$$

$$k_{rw\_CO_2} = \beta \times k_{rw\_He} \quad (4)$$

$$k_{rg\_N_2} = \gamma \times k_{rg\_He} \quad (5)$$

$$k_{rg\_CO_2} = \delta \times k_{rg\_He} \quad (6)$$

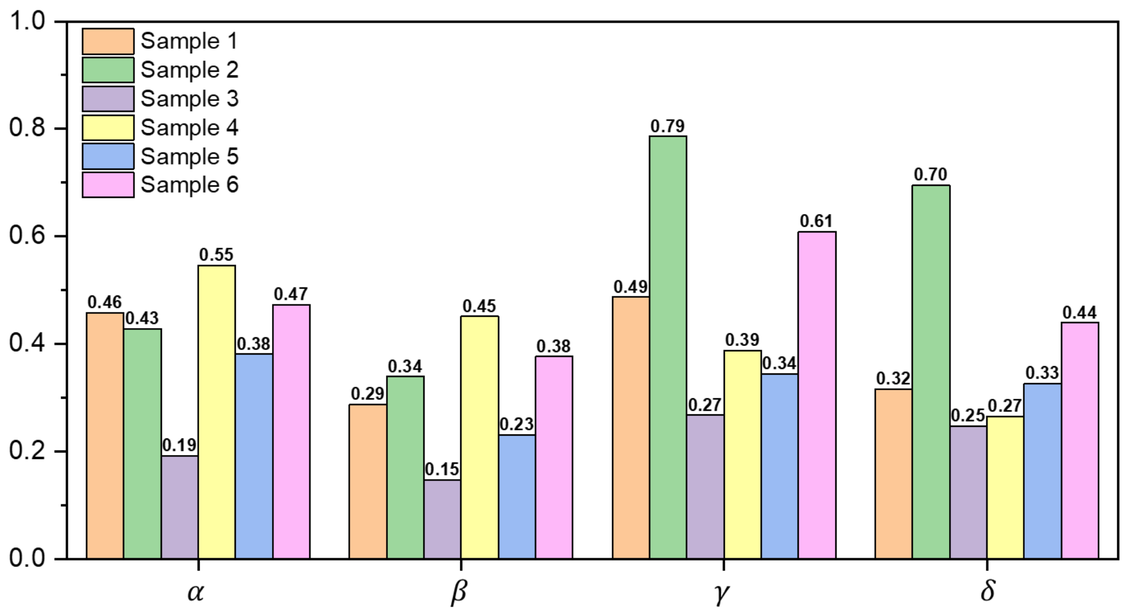


Figure 3: Values of four constants for each coal sample.

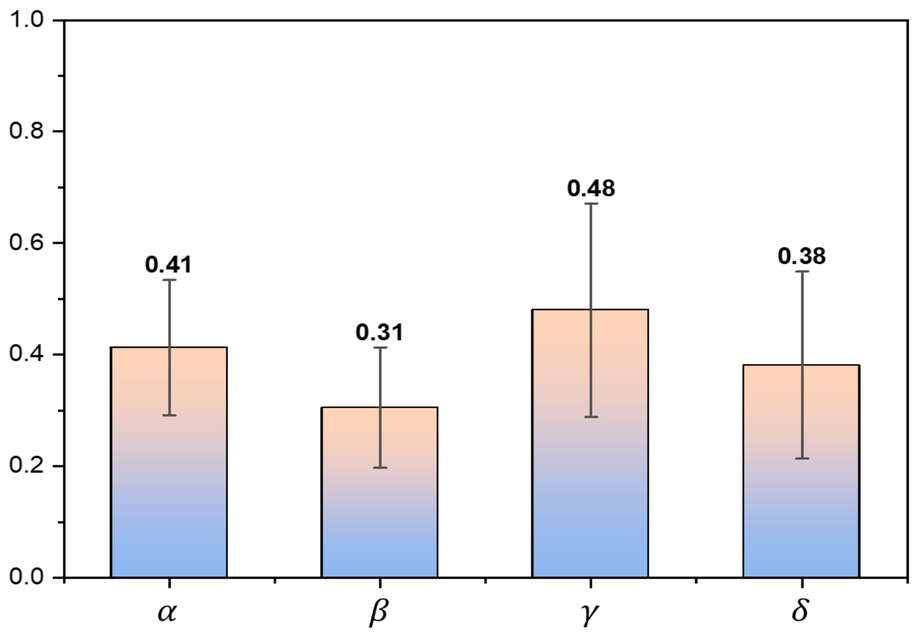


Figure 4: Average values of all tested coal samples.

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