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## Evaluation of Relative Diffusivity of Hydrogen-Methane System for Underground Hydrogen Storage in a Depleted Gas Reservoir Using a Novel Pore-Scale Reactive Transport Model

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The depleted gas reservoir is considered as one of attractive ways for underground hydrogen storage (UHS). However, due to the chemical reaction during UHS, the diffusion coefficient of the H<sub>2</sub>-CH<sub>4</sub> binary system is more difficult to evaluate. The objective of this paper is to establish a novel pore network model merging H<sub>2</sub> reactive transport to evaluate the relative diffusivity of the H<sub>2</sub>-CH<sub>4</sub> system for UHS in depleted gas reservoirs. Firstly, a stochastic pore network model was constructed based on the pore-throat diameter distribution of a depleted gas reservoir. Then, the concentration and rate functions were defined in the pore network model, in which the diffusion transport through porous media was expressed by the Fick's law. And a power-law chemical reaction equation for H<sub>2</sub>-rock was added as the source term. Finally, the curve of the relative diffusion coefficient vs. hydrogen concentration of the H<sub>2</sub>-CH<sub>4</sub> binary system was obtained by solving the governing equations, which could be used to determine the impacts of diffusion during UHS in depleted gas reservoirs. The results show that the diffusion coefficient of the H<sub>2</sub>-CH<sub>4</sub> system is related to H<sub>2</sub> concentration, porosity, pressure, etc. The H<sub>2</sub> diffusion coefficient is proportional to H<sub>2</sub> concentration and pore-throat size but inversely proportional to pressure. The diffusion coefficient under low pressure is about 20 times that under high pressure. Under the temperature of 40°C and the porosity of 0.247, the effective diffusion coefficient decreases from  $2.4 \times 10^{-7} \text{ m}^2/\text{s}$  to  $6.03 \times 10^{-8} \text{ m}^2/\text{s}$  when the pressure increases from 5MPa to 20MPa. Under the temperature of 40 °C and the pressure of 10MPa, the effective diffusion coefficient increases from  $3.7 \times 10^{-8} \text{ m}^2/\text{s}$  to  $1.21 \times 10^{-7} \text{ m}^2/\text{s}$  when the porosity increases from 0.2 to 0.32. Furthermore, under the temperature of 40°C, the porosity of 0.247 and the pressure of 10MPa, the H<sub>2</sub> effective diffusion coefficient is about  $5 \times 10^{-9} \text{ m}^2/\text{s}$  when the H<sub>2</sub> concentration is 0.4, while the effective diffusion coefficient increases to  $4 \times 10^{-8} \text{ m}^2/\text{s}$  when the H<sub>2</sub> concentration is 0.6. In addition, considering the CH<sub>4</sub> creation by the chemical reaction of H<sub>2</sub>, the H<sub>2</sub> effective diffusion coefficient decreased due to the decreasing of H<sub>2</sub> concentration and the increasing of CH<sub>4</sub> concentration.

A novel pore network model merging H<sub>2</sub> reactive transport was proposed in this paper to evaluate the relative diffusion coefficient of the H<sub>2</sub>-CH<sub>4</sub> system during UHS in depleted gas reservoirs. The methodology could provide a reference for UHS in depleted gas reservoirs.

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## **References**

## **Conference Proceedings**

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**Primary author:** ZHANG, Qiuyue

**Co-authors:** Mr CAO, Renyi; Mr JIA, Zhihao

**Presenter:** ZHANG, Qiuyue

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