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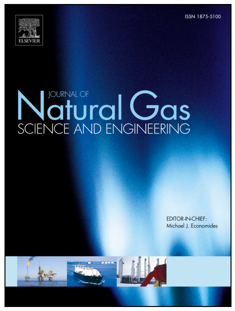


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# The Gas Effective Permeability of Porous Media with Klinkenberg Effect

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## Abstract

Gas transport properties in micro and nano-scale porous media are of significance for low-permeability reservoirs. Gas slippage and gas molecular diffusion in micro- and nano-pores take important effect on the gas permeability of porous media. Therefore, gas effective permeability of micro and nano-scale porous media over the entire Knudsen regime is presented by a fractal model. The analytical expression for gas effective permeability with Klinkenberg effect which is a function of structural parameter of porous media (porosity, fractal dimensions and pore diameter) and gas property (mean free path of gas molecule) was derived based on the microflow model and fractal capillary model. In order to further address the local flow field characteristics, numerical simulations are also performed on a fractal Sierpinski carpet. The fractal model is validated by comparison with available experimental results, and the effect of gas slippage on the gas permeability was discussed also. The present results indicate that gas effective permeability with slippage effect increases with the increase of fractal dimension for pore size distribution and decreases as the fractal dimension for tortuosity increases. And the gas slip factor increases with the decrease of pore size, it can be also increased by increased fractal dimension for pore size distribution under fixed maximum pore size and porosity. The current fractal model can characterize the multi-scale microstructures in porous media, and every parameter in the proposed gas effective permeability model has specific physical meaning.

**Keywords**: gas permeability, gas slippage, porous media, fractal, numerical simulation

***Remark: Changes in our revised manuscript are highlighted and marked in blue color.***