SUPPORTING INFORMATION

A Gas Transport Model in Dual-Porosity Shale Rocks with Fractal Structures

[1]Jinze Xu, [1*]Keliu Wu, [2]Zhandong Li, [3]Yi Pan, [1]Ran Li, [1]Jing Li, [1]Zhangxin Chen

[1]Department of Chemical and Petroleum Engineering, University of Calgary, Calgary, Alberta, Canada T2N 1N4

[2]College of Petroleum Engineering Institute, Northeast Petroleum University, Daqing, Heilongjiang, China 163318

[3]College of Petroleum Engineering, Liaoning Shihua University, Fushun, Liaoning, China 113001

*Email: wukeliu19850109@163.com

Tel: +1-(403)966-3673

Calculation of Gas Properties

In SRK EOS, molar volume of real gas is calculated based on Equations (S1)-(S6) [1,2]:

$$V_m = -\frac{1}{3P}\left(B + \frac{3P\left(\chi^2 P + \chi RT - \alpha\kappa\right) + R^2T^2}{B} - RT\right) \tag{S1}$$

$$B = \sqrt[3]{\frac{g + \sqrt{g^2 - 4[3P(\chi^2 P + \chi RT - \alpha\kappa) + R^2T^2]^3}}{2}} \tag{S2}$$

$$g = -2R^3T^3 - 27\alpha\kappa\chi P^2 - 9RPT(\chi^2 P + \chi RT - \alpha\kappa) \tag{S3}$$

$$\alpha = [1 + (0.48508 + 1.55171\omega - 0.15613\omega^2)\left(1 - \sqrt{T_r}\right)]^2 \tag{S4}$$

$$\kappa = 0.42748\frac{R^2T_c^2}{P_c} \tag{S5}$$

$$\chi = 0.08664\frac{RT_c}{P_c} \tag{S6}$$

Density of molecular number can be calculated by (S7) [1,2]:

$$n = \frac{N_A}{V_m} \tag{S7}$$

Mean molecular speed is obtained based on Equation (S8) [1,2]:

$$\overline{v} = 2\sqrt{\frac{2RT}{\pi M}} \tag{S8}$$

Knudsen number can be expressed by Equation (S9) [1,2]:

$$Kn = \frac{\lambda}{d_h} \tag{S9}$$

Mean free path is calculated as Equation (S10) [1,2]:

$$\lambda = \frac{1}{\pi n d_m^2} \tag{S10}$$

Gas density is shown as Equation (S11) [1,2]:

$$\rho = \frac{Mn}{N_A} \tag{S11}$$

The viscosity is dependent as pressure and temperature, which is shown by Equation (S12)[3]:

$$\mu = \mu_0[1 + \frac{o_1}{{T_r}^5}\left(\frac{{P_r}^4}{{T_r}^{20} + {P_r}^4}\right) + o_2\left(\frac{P_r}{T_r}\right)^2 + o_3(\frac{P_r}{T_r})] \tag{S12}$$

The compressibility factor is based on Equation (S13)[1,2]:

$$Z = \frac{P}{nkT} \tag{S13}$$

Equation (S14) is the expression of gas coverage[4]:

$$\theta = \frac{P/Z}{P/Z + P_L} \tag{S14}$$

We can also obtain surface diffusion coefficient as follows[5]:

$$\mathfrak{D}_s = 8.29 \times 10^{-7} T^{0.5} \exp\left(-\frac{\Delta H^{0.8}}{RT}\right) \frac{2(1-\theta) + \Psi\theta(2-\theta) + [H(1-\Psi)](1-\Psi)\Psi\theta^2}{2\left(1-\theta+\frac{\Psi}{2}\right)^2} \tag{S15}$$

References

(1) Xu, J.; Wu, K.; Yang, S.; Cao, J.; Chen, Z.; Pan, Y.; Yan, B. Real Gas Transport in Tapered Noncircular Nanopores of Shale Rocks. *AIChE J.* **2017**, *63*, 3224-3242.

(2) Xu, J.; Wu, K.; Li, R.; Li, Z.; Li, J.; Xu, Q.; Chen Z. Real Gas Transport in Shale Matrix with Fractal Structures. *Fuel* **2018**, *219(1)*, 353-63.

(3) Jarrahian, A.; Heidaryan, E. A Simple Correlation to Estimate Natural Gas Viscosity. *J. Nat. Gas Sci. Eng.* **2014**, 20, 50–57.

(4) Wu, K.; Li, X.; Wang, C.; Yu, W.; Chen, Z. Model for Surface Diffusion of Adsorbed Gas in Nanopores of Shale Gas Reservoirs. *Ind. Eng. Chem. Res.* **2015**, *54*, 3225-3236.

(5) Civan, F.; Devegowda, D. Rigorous Modeling for Data Analysis towards Accurate Determination of Shale Gas-permeability by Multiple-repeated Pressure-pulse Transmission Tests on Crushed Samples. Presented at the SPE annual technical conference and exhibition, Amsterdam, October 2014; Paper SPE-170659-MS.