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Effect of the Pore Structure on Diffusion Migration of Different Rank Coal Samples

Wangling
School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, Henan, 454003, China
Wangling82620@163.com

Extended Abstract

Existing experimental equipment was used to conduct high-temperature and -pressure diffusion tests on four coal samples with different low, middle, and high ranks. Then, the characteristics of the diffusion kinetics of coal samples under different temperatures and pressures are discussed by using the results. Meanwhile, a high-temperature and -pressure methane diffusion model was derived and established by combining with the molecular simulation of methane adsorption and diffusion. Finally, the mechanism of methane diffusion in coal samples is discussed by combining the pore structure and heterogeneity of coal samples. The results show that the adsorption capacity and isosteric heat of adsorption calculated by molecular simulation gradually decrease as the temperature increases. Comparing the methane self-diffusion coefficient and corrected diffusion coefficient with the transfer diffusion coefficient of coal samples at different temperatures, it can be seen that the values of three diffusion coefficients all increase with the increase of temperature. Under the same temperature and different pressures, the initial diffusion coefficient calculated by the new model gradually increases with the increase of pressure. With the increase of temperature, the attenuation coefficient by using new models first increases and then decreases under the conditions of 2, 6, and 12 MPa; it gradually decreases under the condition of 20 MPa. As the degree of coal rank increases, the diffusion coefficient, specific surface area, and fractal dimension all first decrease and then increase later. Then, the diffusion coefficient gradually increases with the increase of the fractal dimension, and there is a positive correlation between the two parameters. It shows that the more complex the pore structure of coal and the rougher the surface, the greater the impact on the methane diffusion coefficient.

The fractal dimensions obtained by high-pressure mercury intrusion and low-temperature liquid nitrogen tests all show a trend of first decreasing and then increasing as coal rank increases, and the variation of fractal dimension is consistent. Under the same temperature and different pressures, the initial diffusion coefficient in the new model gradually increases with the increase of pressure. With the increase of pressure, the attenuation coefficient gradually increases at 30°C and 70°C. Under the same pressure and different temperatures, the initial diffusion coefficients in the new model gradually increase with the increase of temperature. With the increase of temperature, the attenuation coefficient first increases and then decreases under the conditions of 2, 6 and 12. However, the value gradually decreases under the condition of 20MPa. As the coal rank, the methane diffusion coefficient, specific surface area, and fractal dimension all first decreasing and then increasing. The diffusion coefficient gradually increases with the increase of the fractal dimension, and those two parameters have a positive correlation. It shows that the more complex the pore structure of coal and the rougher the surface, the greater the impact on the methane diffusion coefficient.

References

[1] Tao, S.; Wang, Y.B.;, Tang, D.Z.; Xu, H.; Lv, Y.M.; He, W. Dynamic variation effects of coal permeability during the coalbed methane development process in the Qinshui Basin, China. Int. J. Coal Geol 2012, 93(1), 16-22.
[2] Tao, S.; Pan, Z.J.; Tang, S.L.; Chen, S.D. Current status and geological conditions for the applicability of CBM drilling technologies in China: A review. Int. J. Coal Geol 2019, 202:95-108.
[3] Cui, X.; Marc, Bustin. Volumetric strain associated with methane desorption and its impact on coalbed gas production from deep coal seams. AAPG Bulletin 2005, 89(9), 1181-1202.
[4] Zhang, X.G.; Ranjith, P.G.; Ranathunga, A. Haque Gas transportation and enhanced coalbed methane recovery processes in deep coal seams: a review Energy Fuels, 2016, 30 (11),8832-884
[5] Bhowmik, S.; Dutta, P. Adsorption rate characteristics of methane and CO2 in coal samples from Raniganj and Jharia coalfields of India. Int J Coal Geol, 2013, 113, 50-59

[6] Siemons, N.; Wolf, K.H.; Bruining, J. Interpretation of carbon dioxide diffusion behavior in coals Int. J. Coal. Geol., 2007, 72, 315-324
[7] Pan, Z., Connell L, D. Camilleri M, Connelly L. Effects of matrix moisture on gas diffusion and flow in coal. Fuel, 2010, 89(11), 3207-3217.
[8] Keshavarz, A.; Sakurovs, R.; Grigore, M.; Sayyafzadeh, M. Effect of maceral composition and coal rank on gas diffusion in Australian coals, Int J Coal Geol, 2017, 173, 65-75
[9] Busch, A.; Gensterblum, Y.; Krooss, B.M.; Littke, R.. Methane and carbon dioxide adsorption–diffusion experiments on coal: upscaling and modeling, Int J Coal Geol, 2004, 60 (2-4), 151-168
[10] Jamialahmadi, M..; Emadi, M and H. Müller-Steinhagen, 2006, Diffusion coefficients of methane in liquid hydrocarbons at high pressure and temperature. J. Pet. Sci. Eng., 2006, 53, 47-60.