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Fractal nanopore structure of anthracite and CO2 adsorption-induced alteration: A synchrotron radiation SAXS study

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Abstract:
Coal is a porous medium material with a highly developed pore network inside. Nanopores dominate gas adsorption and transport behavior in geological reservoirs. The fractal nanopore structure of anthracite from the Qinshui Basin were characterized using synchrotron radiation small angle X-ray scattering (SAXS). Based on the fractal theory of SAXS, the fractal characteristics of nanopores were obtained by analyzing the scattering data. The results indicate that the nanopores at 10~70 nm exhibit surface fractal characteristics, with irregular self-similar surfaces. The fractal nanopore structure of different sizes can be obtained by dividing the logarithmic curve into different regions. The pores at 10~20 nm, 20~30 nm, and 30~40 nm exhibit surface fractal characteristics, with the greatest contribution to the surface fractal characteristics of the overall pores (10~70 nm). However, the pores at 40~50 nm, 50~60 nm, and 60~70 nm exhibit pore fractal characteristics, reflecting the self-similar pore structure of the nanopores. Compared to the initial state, the surface fractal dimension of pores at 10~70 nm with CO2 adsorption gradually decreases. There is a negative correlation between surface fractal characteristics and adsorption pressure. From the initial state to 3 MPa adsorption, the fractal dimensions of pores at 10~20 nm, 30~40 nm, and 60~70 nm decreased by 5.597%, 2.397%, and 8.214%, respectively. CO2 adsorption weakens the fractal characteristics most significantly. The fractal dimensions of pores at 20~30 nm and 50~60 nm exhibit fluctuations under different adsorption pressures. CO2 adsorption has a relatively small impact on the fractal nanopore structure. Specifically, the pores at 40~50 nm with CO2 adsorption have the maximum fractal dimension (up to 2.97) and remain constant. It is difficult to alter the self-similarity of pore structure between 40~50 nm for CO2 adsorption.
Key words: Coal; Nanopore; CO2 adsorption; SAXS; Fractal

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