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Study on the Thermal-Seepage-Chemical Coupling Mechanism during the Oxidation and Spontaneous Combustion of Gas-Containing Coal

As a primary component of the global energy mix, coal remains crucial for energy security worldwide. With the gradual increase of coal seam mining depth and strength, the coal seam environment is becoming more and more complex and changeable, and the risk of coal spontaneous combustion and gas compound disaster in goaf is intensified. The goaf serves as a critical "ignition source" for gas combustion, explosions, and related disasters. The thermal effect of coal is a key indicator for assessing its spontaneous combustion propensity. The physicochemical properties of gas-containing coal and the migration behavior of gas molecules significantly influence the spontaneous combustion process. This study combines theoretical research with experimental analysis, employing Differential Scanning Calorimetry (DSC), Fourier Transform Infrared Spectroscopy (FTIR), and Mercury Intrusion Porosimetry (MIP) to systematically investigate the heat release patterns during the oxidation of gas-containing coal under varying coal qualities and gas pressures.

The distribution of functional groups and pore fractal characteristics of coal after oxidation under different pressures were analyzed. A fractal network model of dual (adsorption-seepage) pores and fractures in coal, accounting for gas occurrence and migration, was established. The mechanism by which gas desorption and migration influence heat and mass transfer during coal spontaneous combustion was elucidated. The thermal effects and gas evolution rules during the process were revealed. The impact of the physicochemical properties of gas-containing coal on the spontaneous combustion process was clarified. Quantitative relationships between coal particle size and heat release were explored. Furthermore, the influences of gas phase transformation and migration on the oxidation and spontaneous combustion processes under different gas pressures were investigated.

By comprehensively analyzing the distributions and evolution of heat release characteristics, gas evolution behavior, pore structure, and functional group features during gas-containing coal oxidation, this study clarifies the cross-coupling attributes between thermal effects, the seepage field, and chemical reactions. The findings provide a theoretical foundation for a deeper understanding of the spontaneous combustion mechanism of gas-containing coal and the prevention of associated hazards.

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Biography

Zhang Tan is a doctoral student in China Jiliang University. He has published more than 3 papers in reputed journals and has been an expert reviewer.

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