Experimental and Modelling Analysis of the Impact of Surfactant Adsorption on Coal Oxidation and Wettability

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# ABSTRACT

Surfactants are effective dust suppressants, enhancing dust reduction efficiency and improving coal dust wettability. This study aimed to investigate the effects of surfactants on the physical and chemical properties and wettability of coal at different coalification stages. The microstructural characteristics of surfactant-adsorbed coal, contact angle, industrial composition, and functional groups of oxidized coal, were measured. Stepwise regression and ridge regression prediction models were applied to analyze the experimental data and explore the relationship between these parameters and coal wettability. The results indicated that sophorolipid (SL) exhibited the lowest critical surface tension, reducing the contact angle of low-rank bituminous coal (YZ-LRBC) by 9.25°. SL significantly altered the particle size distribution of lignite (NM-LC) and YZ-LRBC, increasing the average pore size of coal samples and decreasing their specific surface area. Additionally, SL influenced the distribution of hydroxyl groups, aliphatic hydrocarbons, and aromatic structures. It was observed that the wettability of coal deteriorated after oxidation via surfactant adsorption at room temperature. However, the adsorption of SL and CDEA surfactants effectively mitigated the increase in the contact angle of oxidized coal, thereby preventing a severe decline in wettability. Coal dust wettability was found to result from the combined effects of multiple physical and chemical parameters. A stepwise regression equation revealed that specific surface area had a more significant impact on contact angle than particle size (D10). Considering coal oxidation, a coal wetting model was developed to quantify the influence of parameters on contact angle, with the order of importance as: FCad > Vad > P1 ≥ P4 ≥ Mad ≥ P3 ≥ P2. This study provides a theoretical foundation for designing dust suppressants that enhance coal wettability and reduce oxidation activity by targeting key parameters affecting wettability.