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Hydrophobic regulation enhances the filtration and dehydration for coal preparation products, an experimental exploration

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Abstract: To enhance the filtration and dewatering performance while reducing the moisture content of coal preparation products, we conducted an investigation into the dehydration efficacy of various coal preparation products using different filter aids. The study involved examining the dehydration effects of both conventional filter aids and new filter aids on flotation cleaned coal and coarse fine slime at the Huaibei Linhuan coal preparation plant. Our findings revealed a significantly superior dehydration performance of the new filter aids compared to conventional hydrophobic ones. Subsequently, we explored the dehydration efficacy of a specific new filter aid, designated as 1239, on four types of coal samples sourced from the Huainan mining area. The results demonstrated that filter aid 1239 exhibited remarkable effectiveness on both flotation cleaned coal and coarse fine slime, with a discernible impact on coal slime as well. By modulating the hydrophobicity of particle surfaces, hydrophobic filter aids effectively facilitated the dehydration of coal preparation products. These findings bear substantial significance for improving the dewatering and transportation processes of coal preparation products.

Keywords: hydrophobic regulation, filtration and dehydration, flotation cleaned coal, coarse fine slime, filter aid

1. Introduction

Coal slurry is a residual product from the production and washing processes of coal (Wang et al., 2014; Marland et al., 2001). It forms when pulverized coal and its mineral components mix with water, resulting in slime water. Due to its inability to be discharged, coal slime contributes to significant environmental pollution and wastage of resources. China holds the title of both the largest consumer and producer of energy globally, with sustainable economic development intricately linked to energy demand (Dong et al., 2009; Li et al., 2020; Gui et al., 2013). Despite a declining proportion of coal consumption in recent years, the absolute total of coal consumed continues to rise annually (Höök et al., 2010; Liu et al., 2020; Zhou et al., 2018). Coal remains the primary fossil energy source in China (Alam et al., 2011; Wang et al., 2016). Presently, coal preparation plants predominantly rely on wet coal preparation methods like jigging, heavy medium separation, and flotation processes, all utilizing water or water-based heavy mediums for coal washing. Washing 1 ton of coal typically requires 2.5~4.5 cubic meters of water, representing a significant water demand (Zou et al., 2019; Li et al., 2020). Effective disposal of coal slime plays an important role in ensuring the normal production and overall economic benefits of coal preparation plants (Guan et al.,2021; Beier et al., 2009; Song et al., 2016; Zhang et al., 2017). Micro clay mineral particles within the slime exhibit strong surface hydration and high dispersion, presenting significant challenges to the effective separation of solids and liquids in coal slurry water. This has emerged as a critical obstacle hindering the clean coal production and utilization (Rahman et al., 2017; Besra et al., 2000; Zhao et al., 2020). Therefore, washing and processing coal are essential methods for achieving environmentally friendly utilization of this resource. Developing highly efficient coal preparation technology is a necessity for ensuring the sustainable growth of the coal industry in the new era (Han et al., 2023).

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In modern coal washing processes, driven by advancements in mechanized coal mining technology, the distribution of raw coal particles increasingly trends towards finer grains (Yang et al., 2018; Lai et al., 2020). This shift poses heightened demands on the separation and dehydration capabilities of coal preparation plants. Due to their small particle size, flotation agents' adsorption, coupled with the intrinsic properties of coal (Atousa et al., 2022; Mohammad et al., 2022; Sabah et al., 2004), the dehydration of flotation cleaned coal has become a major problem in coal preparation industry. The moisture content of cleaned coal directly impacts product quality. Specifically, for coking coal, increased moisture content prolongs coking time and reduces coke production (Crawford et al., 2001; Edraki et al., 2014; Zhang et al., 2018).

According to statistics, in most coal preparation plants in China, the content of < 0.5 mm slime can be as high as 25%~30% (Nguyen et al., 2021; Banerjee et al., 2020). In Chinese coal preparation production, heavy medium is generally used for sorting process, and the fine coal slime obtained by cyclone is typically directed into the flotation process to further recovery of the fine coal particles. The coal cleaned through flotation is typically dewatered using a pressurized filter or filter press (Zhao et al., 2020; Groppo et al., 1996), and the dehydrated slime product is mixed into the final cleaned coal product.

Presently, after dehydration, coal preparation plant through flotation treatment of cleaned coal, usually moisture content between 20% and 30% (Rao et al., 2015; Singh et al., 1998), significantly higher than the desired moisture content for final cleaned coal products. Moreover, as the percentage of fine coal slurry rises during raw coal selection, more slime enters the flotation system, elevating the percentage of coal processed through flotation in the end product. Consequently, this escalation in moisture content within the final cleaned coal product has substantial impacts on transportation costs and fuel calorific value (Fu et al., 2021; Yang et al., 2023; Bai et al., 2022; Tao et al., 2000). Thus, controlling the moisture content of cleaned coal has emerged as a pivotal quality control parameter in coking coal preparation plants (Alam et al., 2011; Qi et al., 2011).

For a considerable duration, fluctuations in the water content of cleaned coal have persisted across various aspects of heavy and medium coal cleaning processes, primarily influenced by changes in coal quality and the mechanization of mining and washing equipment. Notably, the presence of coarse fine slime and flotation cleaned coal tends to elevate the overall moisture content of cleaned coal products (Tao et al., 2000; Cai et al., 2019; Selomulya et al., 2006), with the moisture levels in these components directly impacting the moisture content of the entire cleaned coal output. Hence, reducing the total water content of cleaned coal is the key to solve the problem of dehydration about coarse and fine slime and flotation of cleaned coal (Shi et al., 2015; Chen et al., 2019).

Against the backdrop of initiatives like carbon peaking, carbon neutrality, and the ongoing advancement of ecological civilization construction, coal slime dehydration has emerged as a central concern within the coal carbon industry (Li et al., 2019). Consequently, enhancing the efficiency of coal slime dehydration holds significant practical importance for elevating the overall production process of coal preparation plants and realizing high efficiency and environmental protection production of coal preparation plant (Yao et al., 2022).

This study aims to carry out filtration aid dewatering test by using vacuum filter and high-speed centrifuge under laboratory conditions, and compare the water content of filter cake after centrifugation under various filter aid conditions. The objective is to evaluate the differences in dehydration effectiveness between conventional filter aids and new filter aids on various coal preparation products, ultimately determining the optimal type of filter aid and the appropriate dosage for achieving enhanced dewatering efficiency.

2. Materials and methods

2.1. Test sample

This study chosed representative flotation cleaned coal and coarse fine slime samples from the production site of Linhuan coal preparation plant from Huaibei, Anhui province in China, as well as the flotation cleaned coal, coarse fine slime, coal slime from Panyidong coal preparation plant, and coal slime from Zhangji coal preparation plant in Huainan, Anhui province in China, for research purposes. Upon sampling, each sample was placed into a sealed bag, labeled, and marked for easy identification.

After sampling, put the samples into a low temperature drying oven at no higher than 60℃ to remove the external water for the subsequent filtration dehydration test. In order to facilitate the distinction and description, the flotation cleaned coal and coarse fine slime in Linhuan coal preparation plant from Huaibei are labeled as FCC_L and CFS_L respectively. Similarly, the flotation cleaned coal, coarse fine slime, coal slime in Panyidong coal preparation plant and coal slime in Zhangji coal preparation plant from Huainan are labeled as FCC_P、CFS_P、CS_P and CS_Z respectively.

2.2. Test agent

Relevant studies have shown that cationic hydrophobic modifiers can adsorb on the surface of negatively charged particles due to electrostatic action, reduce the electronegativity of the surface of the particles and improve the surface hydrophobicity of the particles (He et al., 2023; Xia et al., 2019). Therefore, the hydrophobic modification agent commonly used in China was used in the experiment, namely dodecyl trimethyl ammonium chloride (DTAC), dodecylamine (DDA) and cetyl trimethyl ammonium chloride (CTAC). The new filter aids (1030, 1234, 1239, 1425, 1510) were sourced from BASF (China) Co. Ltd., Shanghai 200137, China, and are inherently hydrophobic. Each new filter aid consists of various agents in specific ratios, all of which are analytical reagents, thus lacking a specific molecular formula. Each type of filter aid was allocated to an aqueous solution with a mass concentration of 0.50 g/L, with the appropriate solution volume extracted for use in the experiments (Peng et al., 2017; Fan et al., 2015). The test water was deionized water.

2.3. Research method

2.3.1. Basic property test

2.3.1.1. X-ray diffraction analysis

The mineral components of raw coal, cleaned coal and coal slurry samples were analyzed by the XRD-6000 X-ray diffract meter manufactured by Shimadzu in Japan. The experiment conditions are shown below: the voltage of the Cu target K radiation X-ray tube was operated at 35 kV with an X-ray tube current of 30 mA. Scanning was conducted over an angle range of 5~80°. The scanning speed was maintained at a constant rate of 2°/minute, with sampling intervals set at 0.02°.

2.3.1.2. Infrared spectral analysis

The FTIR analysis of the samples was performed with the American Thermo Feld Nicolet iS50 infrared spectrometer. Dry sample particles (2 ± 0.01 mg) were mixed with 300 mg of KBr and ground in an agate mortar to a particle size of approximately -2 μm. Pressing the tablet under a pressure of 30~40 MPa. The scanning range is 4000~400 cm^{-1}, with a step size of 4 cm^{-1} and a scanning frequency of 64. Background values and air influence were deducted during sample analysis.

2.3.1.3. Contacting angle test analysis

The contact angle of the sample particles was determined using the American Kono SL200B contact angle instrument. Approximately 0.60 ± 0.01 g of dried sample particles were pressed into a thin sheet with a thickness of about 2 mm under a pressure of 20 MPa. The contact angle was measured in three different areas of the wafer, and the results were averaged.

2.3.2. Wet screening test and determination of total moisture content

According to GB/T 477-2008 "Coal Screening Test Method" (Coal screening test method, 2008), wet screening of six coal samples is performed. And according to GB/T 211-2007 "Method for determination of total moisture in coal" (Method for determination of total moisture in coal, 2007), the total moisture content of six coal samples was measured.

2.3.3. Suction filtration centrifugal dehydration method

The specific experimental steps are as follows.

2.3.3.1. Preparatory process

For each test, weigh the required filter paper and record its label. Weigh out 10 grams of the low-temperature dried sample and mix it with 100 mL of deionized water to achieve a pulp concentration of 100 g/L. Prepare each series of filter aid agents by configuring them into aqueous solutions with a mass concentration of 0.50 g/L and set them aside.

2.3.3.2. Suction filtration process

To begin, set up the vacuum filtration system according to the diagram in Fig. 1. Ensure proper connection of the vacuum filtration device. Select a circular filter paper of appropriate size for the Büchner funnel, wet it, and place it securely into the funnel to test its sealing performance. Control the pressure using a pressure control valve to $(4 \pm 0.1) \times 10^4$ Pa. Proceed with the first experimental group by conducting a blank test (without adding reagents). Stir the tested mineral sample thoroughly, then turn on the circulating water vacuum pump to transfer the slurry to the Büchner funnel. Simultaneously, start a stopwatch to monitor filtration progress until the surface water is fully drained, indicating the endpoint of filtration (Yang et al., 2022).

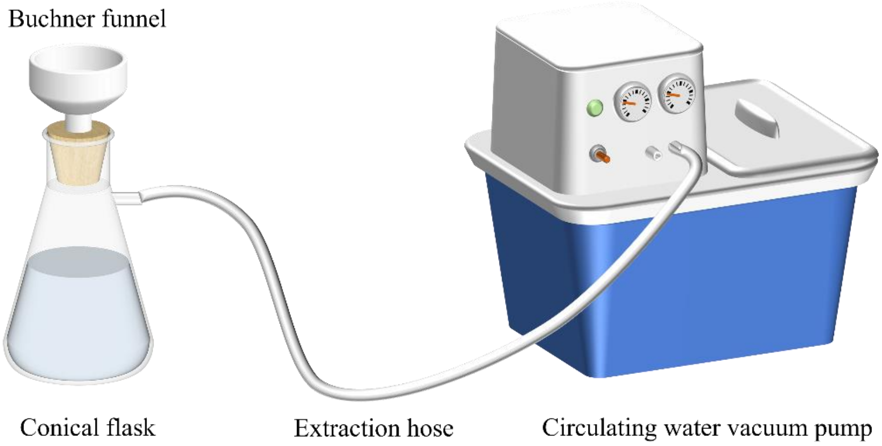

Fig. 1. Vacuum filtration test system

2.3.3.3. Centrifugal dehydration process

The TDL-4B low-speed table centrifuge from Shanghai, China, was used for centrifugal dehydration by modifying the centrifuge tube, as depicted in Fig. 2. Initially, place the sample (along with filter paper) after the filtration process into a customized centrifuge tube. The centrifuge is then set to operate at a speed of 3000 rpm for a duration of 5 minutes. Following completion of the centrifugal dehydration test, the sample is weighed and the results recorded.

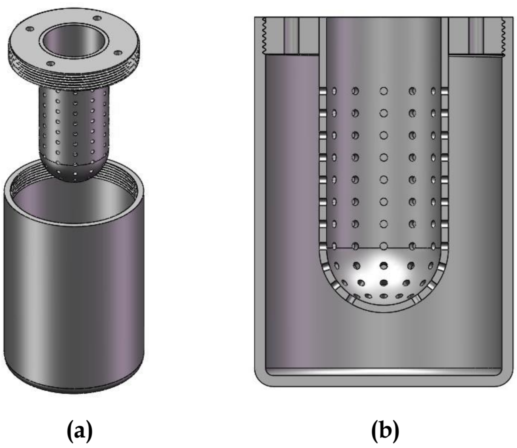

Fig. 2. Centrifugal tube (a: Overall diagram of centrifugal tube; b: Sectional diagram)

During the centrifugation process, the filter paper (along with the sample) is placed into the tubule, and the pores on the tube body are designed to allow water to seep out during the centrifugation process.

The filtration effect can be judged by the level of filter cake moisture, and the calculation formula is shown in Eq. (1).

$$M_t = \frac{M_{Total} - M_1 - M_2 - M_3}{M_{Total}} \quad (1)$$

where M_1 is coal sample mass, that is, 10g coal sample taken each time, M_2 is the mass of single filter paper, M_3 is the average water content of a single filter paper, M_{Total} is the weight of the sample after centrifugation.

3. Results and discussion

3.1. Basic property testing

3.1.1. Mineral composition analysis

X-ray diffraction analysis (XRD) was used to perform phase analysis on the FCC_L, CFS_L, as well as the FCC_P, CFS_P, CS_P, CS_Z. The mineral composition was examined, and the XRD patterns were depicted in Fig. 3.

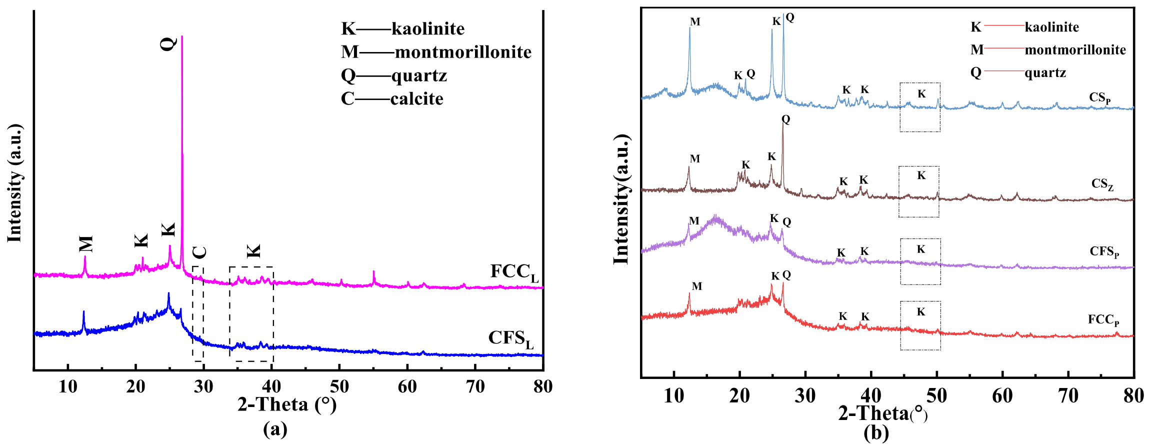

Fig. 3. XRD patterns of different samples

The XRD analysis results in Fig. 3 (a) illustrate that the main mineral components of the cleaned coal samples include montmorillonite, kaolinite, quartz, and calcite. The stronger diffraction peak of impurities in FCC_L compared to CFS_L indicates a higher content of high ash and fine mud in FCC_L.

The XRD analysis results depicted in Fig. 3 (b) reveal that the main components of the four coal samples include montmorillonite, kaolinite, and quartz. Among them, the diffraction peaks of impurities in FCC_P, CS_Z, and CS_P are significantly stronger than those in CFS_P, indicating that the high ash and fine mud content in FCC_P, CS_Z, and CS_P is more.

It can be seen from the above two figures that quartz and kaolinite have high diffraction peak intensities, indicating that these coal samples contain relatively more and purer quartz and kaolinite minerals. Research shows that quartz exhibits strong hydrophilicity, so the hydration film on the surface of quartz microfine particles is stronger, making it difficult for the particles to aggregate, reducing the filtration rate and increasing the moisture content of the filter cake. The clay mineral kaolinite has a high wetting heat value and will cover the surface of coal particles, causing the coal slurry to have increased water absorption and difficulty in water removal (Chen et al., 2024).

3.1.2. Surface functional group analysis of samples

Fourier transform infrared spectroscopy was employed to detect and analyze the surface functional groups present in coal samples obtained from the Linhuan coal preparation plant in Huaibei, as well as two coal preparation plants in Huainan. The results are illustrated in Fig. 4.

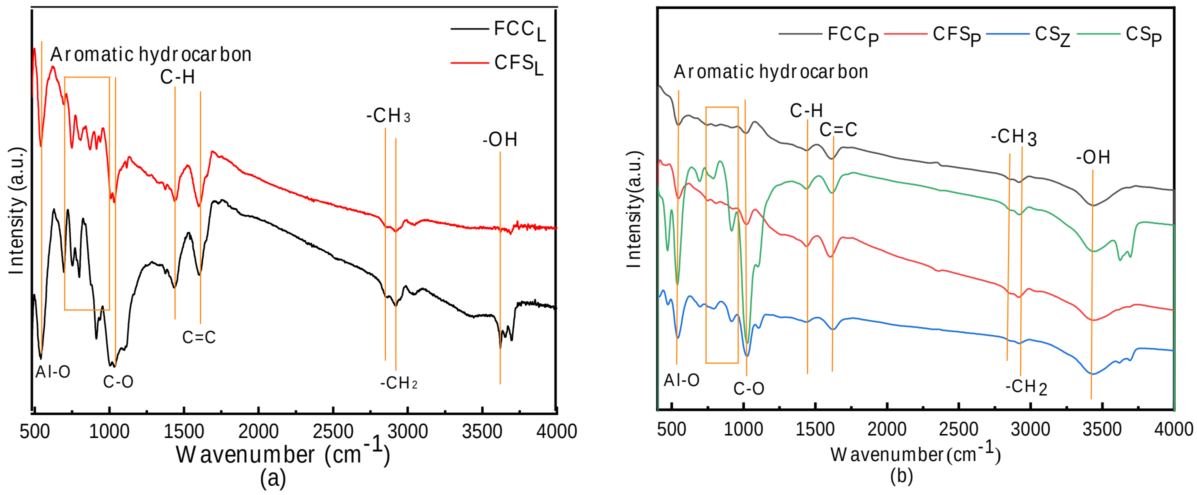

Fig. 4. FTIR spectra of different samples (a: Huaibei; b: Huainan)

The FTIR analysis results indicate the presence of various functional groups in the six types of coal samples, including aromatic hydrocarbons (700-1000 cm^{-1}) and C-O (1040 cm^{-1}) in coal, C-H (1430 cm^{-1}), C=C (1610 cm^{-1}), $-CH_3$ (2850 cm^{-1}), $-CH_2$ (2920 cm^{-1}), as well as Al-O (563 cm^{-1}) in impurity components. Further analysis reveals a notably higher content of Al-O and C-O bonds in FCC_L compared to CFS_L, indicating that the content of high ash and fine mud in FCC_L is higher, and the surface oxidation of coal is more severe. Similarly, the content of Al-O and C-O bonds in FCC_P, CS_Z, and CS_P markedly surpasses that found in CFS_P, indicating that the content of high ash and fine mud in FCC_P, CS_Z, and CS_P is higher. These findings indicate that the surface of the sample contains abundant oxygen functional groups.

3.1.3. Contact angle test

The contact angle of sample surface can reflect its hydrophilic or hydrophobic properties, which also reflect the degree of oxidation and hydrophilic mineral attachment on the coal surface to a certain extent. Contact angle tests were conducted on the FCC_L and CFS_L, and the results are shown in Fig. 5. Contact angle tests were conducted on FCC_P, CFS_P, CS_Z and CS_P, and the findings are depicted in Figure 6.

The contact angle test reveals variations in the surface contact angles of FCC_L and CFS_L due to differences in gangue content, fine mud occurrence, and oxidation degree. Specifically, the surface of FCC_L typically exhibits a small contact angle, and their hydrophilicity is the strongest. The surface of CFS_L typically exhibits a large contact angle, and its surface hydrophobicity is relatively strong. Due to surface oxidation and the existence of clay minerals on the surface of FCC_L, the hydrophobicity of its surface will be reduced, resulting in a smaller contact angle on the sample surface.

The contact angle results for FCC_P, CFS_P, CS_Z and CS_P are depicted in Fig. 6. The results demonstrate variations in the surface contact angles of FCC_P and CFS_P due to differences in oxygen-containing functional group, fine mud occurrence, and oxidation degree. Among them, CS_Z and CS_P exhibit relatively small surface contact angles, indicating strong hydrophilicity. In contrast, FCC_P and CFS_P show relatively large surface contact angles, reflective of stronger surface hydrophobicity.

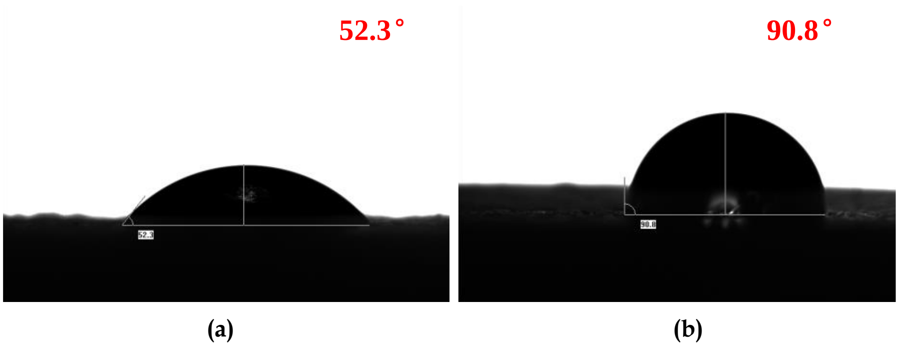

Fig. 5. Surface contact angle results. (a: FCC_L; b: CFS_L)

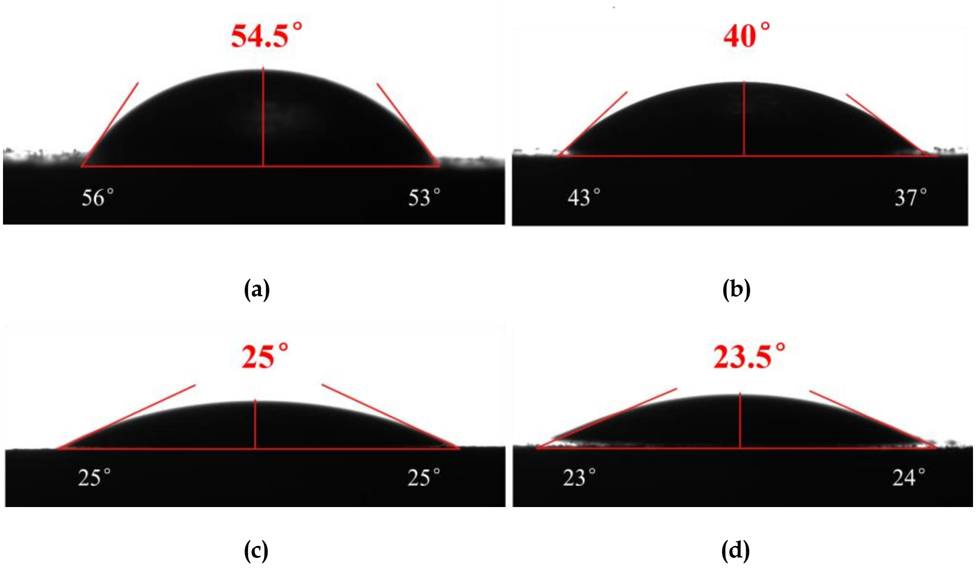

Fig. 6. Surface contact angle results. (a: FCC_P; b: CFS_P; c: CS_Z; d: CS_P)

3.2. Analysis of small screening and ash test results

The particle size composition of six coal samples of FCC_L, CFS_L, FCC_P, CFS_P, CS_P and CS_Z was analyzed by GB/T 477-2008 "Coal Screening Test Method". Each wet screened coal sample weighed 200g. Fig. 7 shows the corresponding specific gravity and ash content of coal samples of different particle size grades in the sample. The bar chart shows specific gravity, and the dot chart shows ash content.

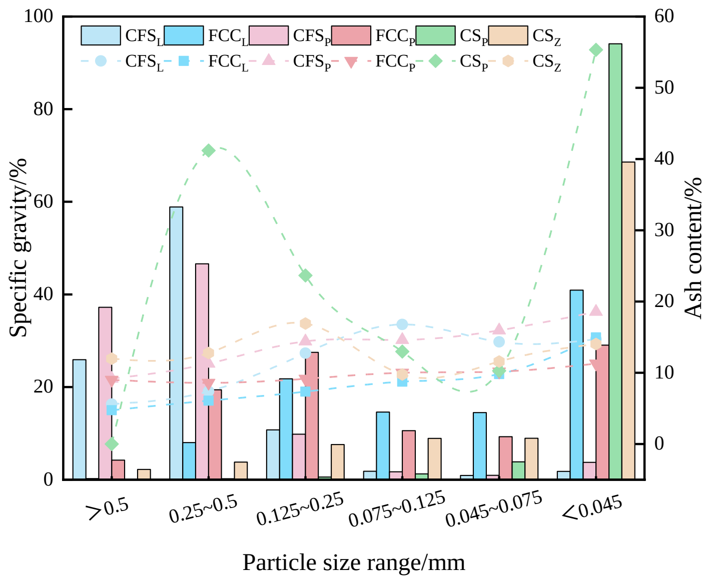

Fig. 7. Productivity and ash content of each sample at each particle size

From Fig. 7, after the CFS_L screening, the coal sample for particles sized between 0.25 and 0.5 mm exhibited the highest specific gravity at 58.89%, with an ash content of 7.39%. In addition, the ash content of 0.075 to 0.125 mm coal sample had the highest ash content at 16.79%. Following FCC_L screening, the coal sample with <0.045 mm particle size has the highest specific gravity (40.93%), along with the highest ash content at 14.97%.

After screening CFS_P, the coal sample for particle sized between 0.25 to 0.5 mm exhibited the highest specific gravity at 46.60%, with an ash content of 11.29%. In addition, the <0.045 mm coal sample had the highest ash content at 18.56%. Following FCC_P screening, the coal sample with a particle size of less than 0.045 mm exhibits the highest specific gravity (29.03%), along with the highest ash content at

11.29%. After the CS_Z screening, the coal sample with a particle size of less than 0.045 mm exhibits the highest specific gravity (68.59%) and ash content is 14.05%. In addition, 0.125 to 0.25 mm coal samples have the highest ash content (16.91%). Lastly, after CS_P screening, the <0.045 mm grain size coal sample exhibited the highest specific gravity at 94.12%, along with the highest ash content of 55.34%.

3.3. Analysis of total water results

GB/T 211-2007, "Method for determination of total moisture in coal" was used to measure the total moisture of six kinds of coal samples, namely, FCC_L、CFS_L、FCC_P、CFS_P、CS_P and CS_Z. The findings are presented in Table 1.

Table 1. Toal moisture results of all samples

Sample	FCC_L	CFS_L	FCC_P	CFS_P	CS_Z	CS_P
Total moisture (%)	18.62	11.89	30.47	23.27	27.82	35.98

Examining the moisture test results presented in Table 1 reveals that the total moisture of FCC_L is 18.62%, and the total moisture of CFS_L is 11.89%. Additionally, the total moisture content of FCC_P is 30.47%, CS_P is 35.98%, CFS_P is 23.27%, and CS_Z is 27.82%. In summary, among the six coal samples, FCC_P and CS_P exhibit the highest total moisture content, both exceeding 30%. The total moisture content of CFS_L is the lowest, which is 11.89%, indicating that the quality of CFS_L is higher.

3.4. Centrifugal-assisted filtration dehydration test

Using new filter aids and conventional filter aids, suction filtration centrifugal dewatering tests were conducted on the CFS_L and FCC_L, respectively. Examining the dosage of medication (50g/t, 100g/t, 150g/t, 200g/t and 250g/t). The findings are illustrated in Fig. 8. and Fig. 9. The moisture content of FCC_L is 18.62% and that of blank sample is 17.38%. The moisture content of CFS_L is 11.89%, and that of blank sample is 10.66%.

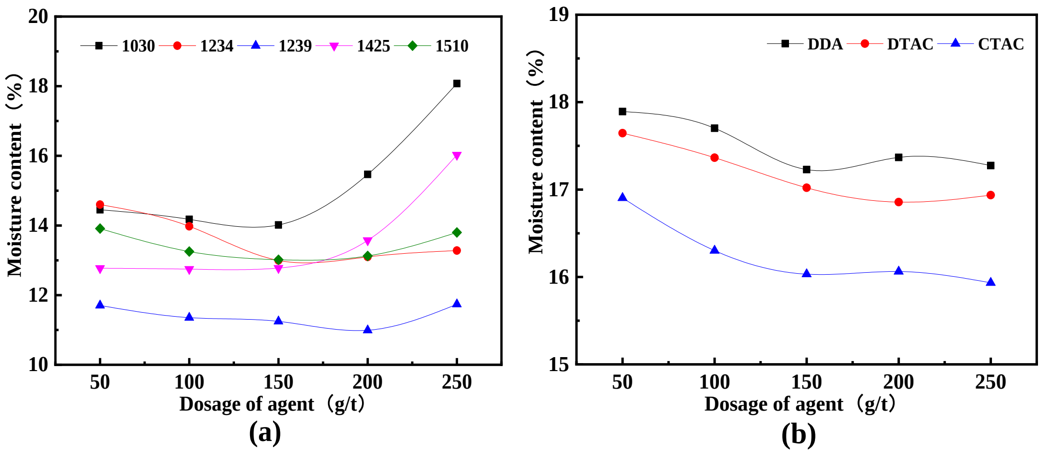

Fig. 8. Dehydration effect of FCC_L. (a: New filter aid; b: Conventional hydrophobic filter aid)

Figs. 8 and 9 illustrate that the five types of new filter aids have significant filtration and dehydration effects on both FCC_L and CFS_L, and the dehydration effect is significantly better than that of conventional filter aids. Within the experimental dosage range, the moisture content of the FCC_L is reduced by 0.60-7.0% after the action of five reagents (Compared to field FCC_L, the moisture content is 18.62%). After the action of five chemicals, the moisture content of the CFS_L decreased by 6.64-8.60% (Compared to 11.89% of the moisture content of the field CFS_L). Upon comparing the analysis, it indicates that the new filter aids demonstrate significantly better dehydration effects on CFS_L than on FCC_L. Notably, among the tested filter aids, 1239 exhibited the most effective dehydration performance, while 1030 showed the least effect, with the other three reagents falling between these two extremes.

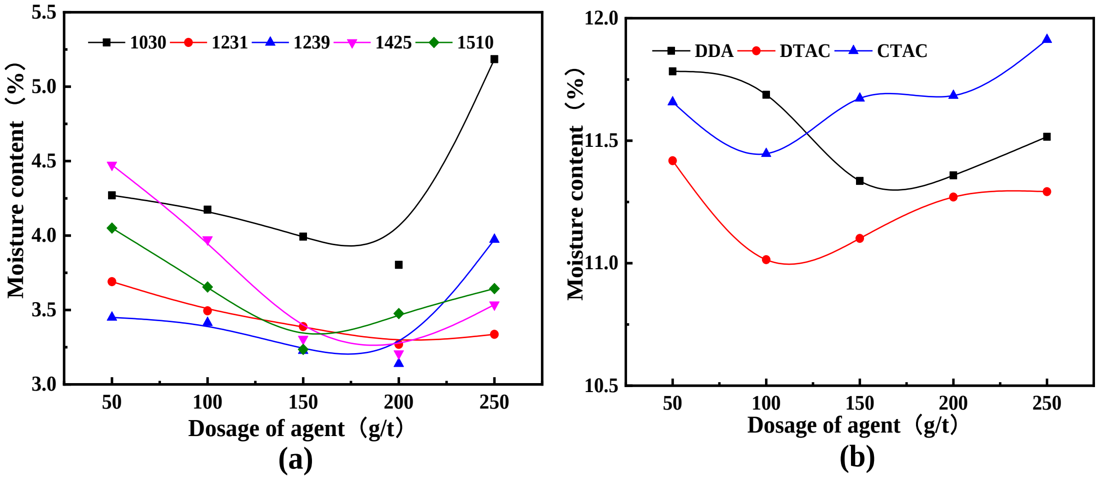

Fig. 9. Dehydration effect of CFS_L. (a: New filter aid; b: Conventional hydrophobic filter aid)

New filter aid 1239 was used to conduct suction filtration centrifugal dehydration tests on FCC_P, CFS_P, CS_P and CS_Z, respectively (With the dosage of 50g/t, 100g/t, 150g/t, 200g/t, and 250g/t). The findings are illustrated in Fig. 10.

As shown in Fig. 10, it is clear that new filter aid 1239 has a notable filtration and dehydration effect on both FCC_P and CFS_P, and exhibits some effect on CS_Z and CS_P. Among them, within the range of experimental reagent dosage, the effect of new filter aid 1239 reduces the deionized water moisture content of FCC_P by 0.09-1.12% (Relative to field FCC_P moisture content by 15.06%), the effect of new filter aid 1239 reduces the field water moisture content of FCC_P by 0.30-1.11% (Relative to field FCC_P moisture content by 15.17%), and the effect of new filter aid 1239 reduces the moisture content of CFS_P by 1.93-2.23% (Relative to field CFS_P moisture content by 10.36%). The moisture content of CS_Z was reduced by 0.26-1.96% (Relative to 26.67% of field CS_Z moisture) after treatment with filter aid 1239, while the effect on CS_P filtration was minimal. Comparative analysis reveals that new filter aid 1239 demonstrates a significantly superior dehydration effect on CFS_P compared to other coal samples.

Four distinct coal samples were subjected to contact angle measurements after dehydration, utilizing recycled clear water from the coal preparation plant in the Huainan mining area. The results are shown in Fig. 11. Shown in Fig. 11, the contact angle of coal samples treated with the new filter aid 1239 initially increases and then decreases. At an agent concentration of 200 g/t, the contact angle of CFS_P reaches its peak values of 67°. At 100 g/t concentration, the contact angle of FCC_P and CS_Z achieves maximum values of 51.5° and 36°, respectively. When the agent concentration is 150 g/t, the contact angle of CS_P reaches its highest point at 38.5°. Combined with the angle of contact of raw coal in Fig. 6. Above, it is

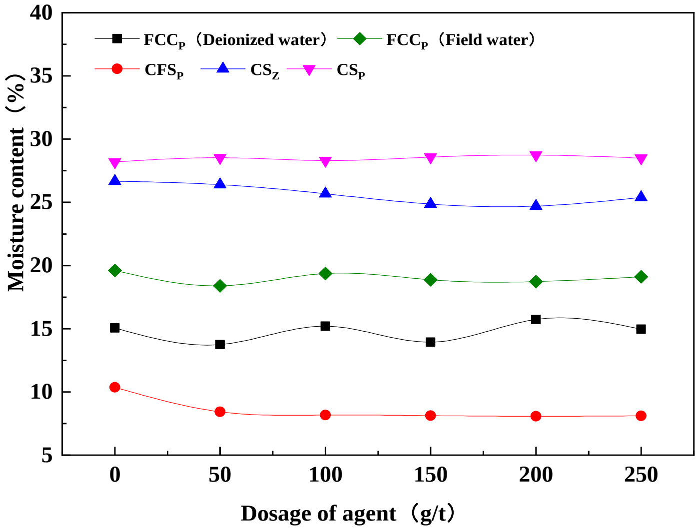

Fig. 10. Dehydration effect of new filter aid 1239 on different coal samples

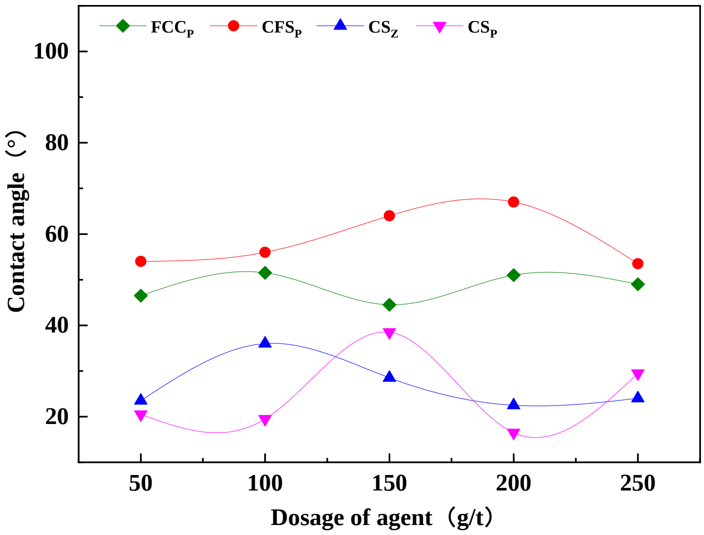

Fig. 11. Influence of new filter aid 1239 on the contact angle of different samples

evident that the influence of new filter aid 1239 on coal samples cannot be ignored, and the influence of varying concentrations of reagents on the hydrophilicity of coal samples is not exactly the same.

Both conventional and new filter aids can enhance the dehydration effect of coal preparation products to some extent by hydrophobic modification of the surface of the particles. However, new filter aids exhibit significantly stronger filtration and dewatering capabilities compared to conventional filter aids. The effectiveness of hydrophobic filter aids in dehydration is attributed to chemical molecules interacting with the coal surface, where polar groups adsorb onto areas of oxidation or clay occurrence. This exposure of hydrophobic groups on the surface of coal enhances overall hydrophobicity, thereby improving dehydration effectiveness (Zhao et al., 2013).

In practical applications, it is crucial to precisely control the amount of filter aid added, as excessive addition can hinder the dehydration of coal preparation products. When the amount of agent in the solution is too large, the particle surface may produce a double-layer adsorption phenomenon, weakening surface hydrophobicity, and potentially altering particle surface charges, leading to electrostatic repulsion that hinders filtration dehydration (Zou et al.,2019). Therefore, when selecting and using hydrophobic, it is important to identify the most appropriate type and quantity through testing to achieve the best dehydration effectiveness and economic benefits (Liu et al., 2020).

4. Conclusion

This study aimed to investigate the filtration efficacy of a novel filter aid by conducting filtration dehydration experiments on coal samples sourced from the Huaibei coal preparation plant, comparing conventional filter aids with the new filter aids. The experiments demonstrated that new filter aid 1239 had the best effect. Subsequently, filtration and dehydration experiments were carried out on four coal samples from two coal preparation plants in Huainan using the new filter aid 1239. The experiment revealed that new filter aid 1239 had a significantly better dehydration effect on coarse fine slime than on other coal samples.

(1) The basic properties of six coal samples are tested. The results reveal that the existence of clay minerals like kaolinite and montmorillonite, as well as hydrophilic minerals such as quartz, in flotation cleaned coal is one contributing factor to the elevated moisture content of cleaned coal products. The surface of slime particles is electronegative, resulting in large repulsive force between slime particles, which adversely affects filtration and dehydration. Therefore, using cationic filter aid to adjust the electrical properties of coal slime interface has a positive guiding significance for coal slime dehydration. It is consistent with the rule of others, which confirms the experiment. This is also verified by the subsequent experiments. (Zhang et al., 2020)

(2) The test of assisted filtration dewatering of coal samples from Linhuan coal preparation plant in Huaibei was conducted using conventional filter aids and new filter aids. The test results indicate

that the new filter aids demonstrate significantly better dehydration effects on FCC_L and CFS_L compared to conventional filter aids. Among the five new types of filter aids tested, the 1239 agent exhibited the most effective dehydration performance on both coal sample types. Reasonable addition of filter aid can effectively improve the filtration efficiency and reduce the water content of the product.

(3) The new filter aid 1239 was employed in filtration and dehydration experiments on four types of coal samples from two coal preparation plants in Huainan. The test results show that the new filter aid 1239 is effective in aiding dehydration. Comparing the dewatering effect of four coal samples, it can be seen that the dewatering effect of the new filter aid 1239 on CFS_P is obviously better than that of other coal samples.

(4) Coal particles will oxidize with air and water after exposure, resulting in enhanced surface hydrophilicity. After the use of hydrophobic modifier, the negative charge on the surface of coal particles increases and the surrounding cations are attracted, thus achieving electric neutralization. These agents are adsorbed on the surface of mineral particles, mainly by compressing the double electric layer and changing the surface hydrophobicity to weaken the thickness of the hydration film, improve the hydrophobicity, and then improve the dehydration effect (Chen et al., 2022).

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