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Flotation behavior of different size fractions of fresh and oxidized coals

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ABSTRACT

XPS was used to indicate the difference in surface properties between fresh and oxidized coals. XPS results showed that fresh coal had much more C – C and C – H groups than oxidized coal. In contrast, oxidized coal had much more C – O, C═O and O═C – O groups than fresh coal. Oxidized coal had higher ash content than fresh coal and oxidized coal surface had more ash minerals than fresh coal surface. The contact angle of fresh coal was much higher than that of oxidized coal, and hence oxidized coal was more hydrophilic than fresh coal. Flotation behavior of different size fractions of fresh and oxidized coals at different collector dosages were investigated in an experimental flotation cell. Flotation results showed that combustible matter recovery of oxidized coal was much lower than that of fresh coal. Combustible matter recovery decreased with the increase of particle size. Oxidation processes had much more negative effect on the flotation of coarser coals than the flotation of finer coals. The flotation behavior of oxidized coal may be enhanced by the increasing of collector dosage. Furthermore, a lower hydrophobic property makes larger oxidized coals (especially for the coal size more than 0.125 mm) more difficult to float. Reducing coal particle size should be suitable for oxidized coal flotation.

1. Introduction

Coal oxidation processes usually change both the surface properties and structures of coal [1–3]. FTIR, XPS and EPR have been widely used to indicate the changes in surface properties of coals before and after oxidation processes. The oxidation processes can increase the content of oxygen containing functional groups on coal surface [4–6]. Besides, the surface topography of coal surface can be changed by oxidation processes [7]. Therefore, oxidized coal is difficult to float with common oily collectors [8–14]. It is necessary to seek some useful methods for enhancing the flotation behavior of oxidized coal. Grinding and surface attrition were considered to be useful since these methods could remove the oxidized layer from oxidized coal surface [15,16]. Ultrasound pretreatment could also remove the oxidized layer and had more positive effect on the improvement in floatability of oxidized coal than high-intensity conditioning pretreatment [17]. Premixing oxidized coal pulp in a flotation cell before flotation could increase the combustible matter recovery during the flotation of oxidized Amasra coal [18]. Microwave pretreatment could improve the floatability of Taixi oxidized by reducing the moisture content of coal samples [19].

Besides these pretreatments, some efficient collectors and promoters were also used to enhance the flotation of oxidized coal. Both ionic and non-ionic surfactants could change the surface characteristics of oxidized coal. Oxidized coal could be well floated by the new collectors or surfactants. Blending of hydrocarbons and non-hydrocarbon collectors, such as copolymers, long chain amines and fatty acid amides could improve the floatability of oxidized coal [8–10,20]. Biodiesel and oxidized diesel oil were also found to be advantageous in the flotation of Taixi oxidized coal [21,22].

Even though the flotation of oxidized coal could be partly enhanced or improved by the above-mentioned methods, the flotation behavior of different size fractions of oxidized coal was little investigated. Very little attention has been paid to the comparison of flotation behavior of different size fractions of fresh and oxidized coals. In this investigation, we attempted to find out the effect of particle size on the flotation behavior of oxidized coal. A comparison of flotation behavior of different size fractions of fresh and oxidized coals was made in order to give a useful concept of oxidized coal flotation.

2. Experimental method and procedure

2.1. Materials

Fresh bituminous coal samples were obtained from Shanxi Province of China. Coal samples were dry-ground in a laboratory mill to pass 0.5 mm sieve. Then, coal samples were classified into two parts. One was stored in a pocket by nitrogen protection. The other was oxidized on a roof for natural weathering processes. Fresh coal samples were broken down due to the sun, wind and water and became oxidized coal after 6 months.

Fig. 1 illustrates particle size and ash content distributions of fresh and oxidized coals. It indicates that oxidized coal size is finer than

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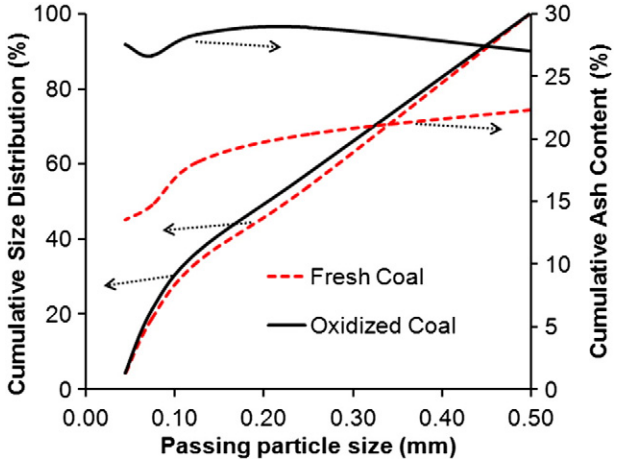

Fig. 1. Particle size and ash content distributions of fresh and oxidized coal.

Table 1
Proximate analysis of fresh and oxidized coals (air dried, wt.%).

Coal types	Mad	Vad	FCad	Aad
Fresh coal	3.00	16.52	58.17	22.31
Oxidized coal	5.05	15.81	52.14	27.00

fresh coal. It is obvious that ash contents of fresh and oxidized coal samples are different. The proximate analysis of two coal samples can be shown in Table 1. Where *Mad* is the moisture content, *Vad* the volatile content, *FCad* the fixed carbon content, and *Aad* is the ash content on an air dry basis. After oxidation, oxidized coal should have much more ash content than fresh coal as shown in Table 1. This result will be further discussed by XPS results in Section 3.1.

Table 2
Contents of C1s, O1s, Si2p and Al2p on fresh and oxidized coals (C + O + Si + Al = 100 at.%).

Coal types	C1s (%)	O1s (%)	Si2p (%)	Al2p (%)
Fresh coal	63.86	24.30	6.66	5.18
Oxidized coal	37.65	42.81	11.05	8.49

2.2. XPS and contact angle measurements

The XPS experiments were carried out at room temperature in an ultra high vacuum (UHV) system with the surface analysis system (ESCALAB 250Xi, America). The base pressure of the analysis chamber during the measurements was lower than 1.0×10^{-9} mbar. Al Ka radiation (hv = 1486.6 eV) from a monochromatized X-ray source was used for XPS. For all analyses, the take-off angle of the photoelectrons was 90° and the spot size was 900 μm. The spectra of survey scan were recorded with the pass energy of 100 eV; the energy step size was 1.00 eV. High resolution spectra were recorded with the pass energy of 20 eV, and the energy step size was 0.05 eV. The data processing (peak fitting) was performed with XPS Peakfit software. The binding energies were corrected by setting the C1s hydrocarbon ($-CH_2-CH_2-$ bonds) peak at 284.6 eV.

The fresh and oxidized coals were firstly pressed into the plates. The plates of fresh and oxidized coals were measured using water contact angle analyzer (JC2000D), such as a water droplet on the surface of coal plates in air. The contact angles were obtained as the water droplet contacted with the coal plate at the exact moment.

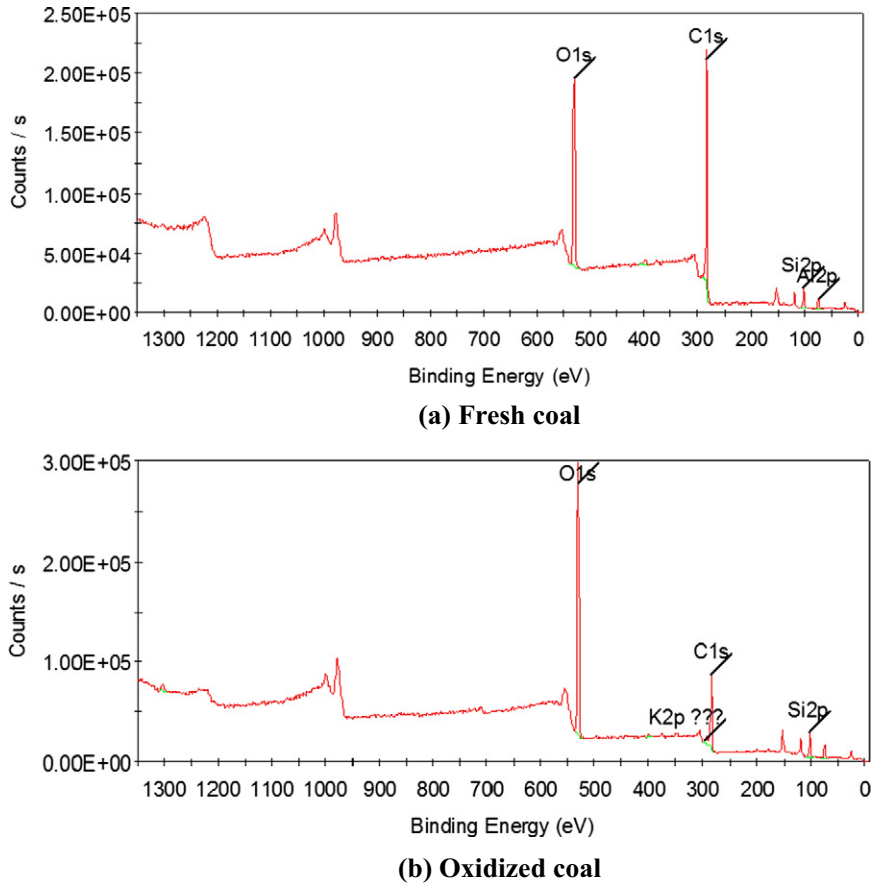

Fig. 2. XPS wide energy spectrums of fresh and oxidized coals.