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Short communication

Changes in the hydrophobicity of anthracite coals before and after high temperature heating process

Wencheng Xia *, Guangyuan Xie *

School of Chemical Engineering and Technology, China University of Mining and Technology, Xuzhou 221116, Jiangsu, China

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ABSTRACT

Coal spontaneous combustion can make coal suffer a high temperature heating process. This heating process can change physical and chemical properties of coal, but the changes in the hydrophobicity of coals before and after high temperature heating process have not been investigated adequately since the natural hydrophobicity of coal usually determines the flotation behavior of fine coals. Therefore, this paper is to investigate the changes in the hydrophobicity of coals before and after the high temperature heating process. X-ray photoelectron spectroscopy (XPS) and contact angle measurements were used to indicate these changes. The heating temperature was 600 °C. The heating times were 0 (original coal), 10, 20, 60, and 120 min, respectively. An ultra-low-ash anthracite coal with ash content of 1.55% was used to conduct the high temperature heating process in the laboratory. Throughout this study, the hydrophobicity of anthracite coal can be reduced quickly after high temperature heating process since the content of hydrophilic functional groups on anthracite coal surface is increased while the content of hydrophobic functional groups is reduced by the high temperature heating process.

1. Introduction

Natural weathering process can reduce the natural hydrophobicity of coal and also make coal difficult to float with common oily collectors [1–12]. In other words, coal can be easily oxidized under the natural weathering environment since the surface properties of coal can be changed during the weathering process [13–19]. Natural weathering process usually produces many weathered coals. These weathered coals are usually difficult to float with common oily collectors. In addition, some humic acids can also be produced while coal suffers a very long period of weathering process. In some cases, the hydrophobicity of weathered coal may be partly improved by some pretreatments, such as grinding, microwave, attrition, premixing and some enhanced collectors or promoters [1,4–6,20–27].

Besides, coal spontaneous combustion in coal mines can make coal suffer a high temperature heating process. Coal spontaneous combustion in coal mines includes combustion process and high temperature heating process. Both of them change the physical and chemical properties of coal. Coals from the outside of coal mines or piles primarily suffer the oxidation process (or combustion process) while coals from the inside of coal mines or piles primarily suffer the high temperature heating process. Therefore, Taixi oxidized coal is produced since Taixi coal mines suffer the coal spontaneous combustion process. Most of coals in the inside of coal mines suffer the high temperature heating process. Taixi oxidized coal is difficult to float with common oily collectors. It is necessary to investigate the changes in the hydrophobicity of Taixi coals before and after the high temperature heating process. In here, Taixi coal is anthracite coal.

The changes in the physical and chemical properties of coals before and after the high temperature heating process have been widely investigated [28–38]. However, the changes in the hydrophobicity of coals before and after the high temperature heating process have not been adequately investigated. Therefore, this paper is to investigate the changes in the hydrophobicity of coals before and after the high temperature heating process.

2. Experimental section

2.1. Coal samples

In this investigation, fresh anthracite coal with very low ash content was selected prior by hand preparation. These coal bulks were crushed and screened to different size fractions. The size fraction of 0.125–0.074 mm was selected to be used in this investigation. The proximate analysis of coal samples (air dried) is given in Table 1. Where *Mad* is the moisture content, *Vad* is the volatile content, *FCad* is the fixed carbon content, *Aad* is the ash content, and *St* is the total sulfur content.

Table 1
Proximate analysis of coal samples (air dried).

Mad (%)	Vad (%)	FCad (%)	Aad (%)	St (%)
4.20	7.40	86.85	1.55	0.10

* Corresponding authors.
E-mail addresses: w.xia.cumt@gmail.com (W. Xia), xgywl@163.com (G. Xie).

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Table 2
Fraction of C on the surface of coals before and after the heating process (relative % of C1s).

Coal types	C–C, C–H (%)	C–O (%)	C═O (%)	COOH
0 min (original coal)	88.8	5.3	3.2	2.7
10 min	82.2	5.4	7.1	5.3
20 min	72.0	14.7	7.1	6.2
60 min	69.4	14.8	10.4	5.4
120 min	67.4	14.9	10.2	7.6

High temperature heating process reduces the content of hydrophobic functional groups (C–H and C–C) but increases the content of hydrophilic functional groups (C–O, C═O and COOH). The contact angles of heated anthracite coals are much lower than that of fresh (original) anthracite coal. After the high temperature heating process, anthracite coal surface becomes more hydrophilic.

2.2. High temperature heating process

The high temperature heating process was conducted in a quartz crucible in Muffle furnace. The heating temperature was 600 °C. The heating times were 0 (original coal), 10, 20, 60, and 120 min, respectively. After the heating process, coal samples in a quartz crucible were cooled in a drying chamber.

2.3. XPS measurements

For the indication of the surface chemical properties of coals before and after the heating process, coal samples were pressed into pellets.

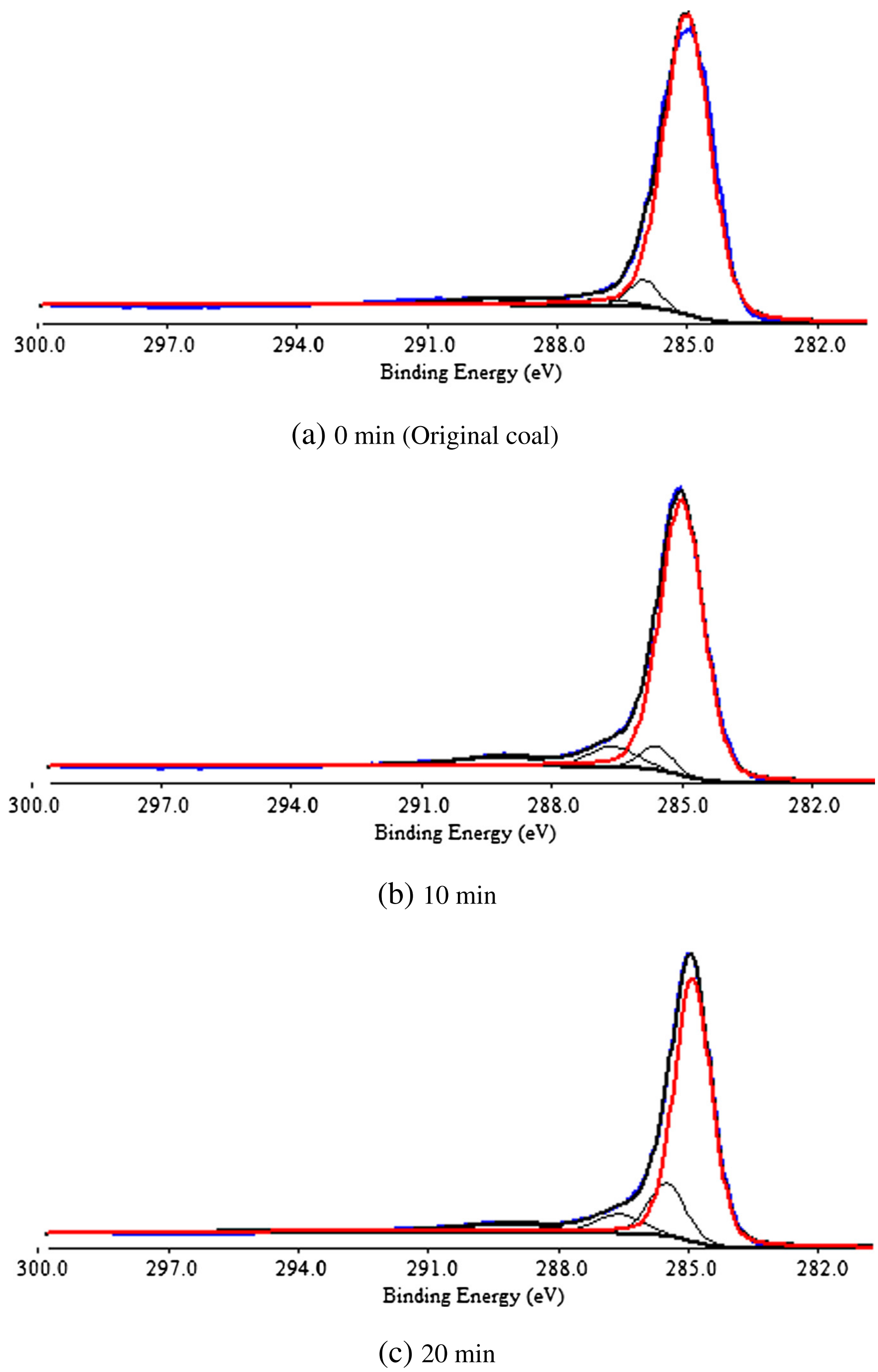

Fig. 1. C1s peaks for the coal surface before and after the heating process.