

Preliminary Study on Mixed Solvent Extraction of Zhaotong Lignite

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Abstract. The extraction of Zhaotong lignite in Yunnan province was studied by using organic solvent 1- methyl -2- (NMP) and CS₂ mixed solvent as extraction solvent. The effects of solvent ratio, rotation speed, coal particle size and extraction times on the extraction rate were investigated by multi - factorial experiments. The results showed that the extraction rate was the highest when the extraction times was 8, and the extraction rate was 67.19%. Finally, the infrared spectra of the extract were analyzed. The results showed that there were C = O (around 1645 cm⁻¹), C = C (around 1506 cm⁻¹) and CN (1303 cm⁻¹), CH₂ / CH₃ (around 2930, 1429 cm⁻¹), and aryl ether (around 1264 cm⁻¹).

Introduction

At present, China has proven lignite and sub-bituminous coal accounted for 55% of coal reserves, in which the reserves of volatile is equivalent to 100 billion tons of oil and gas resources[1,2]. In addition, lignite is also rich in montan wax and humic acid, which are available materials. Therefore, the extraction of lignite is one of the efficient and clean utilization ways[3,5].

Elemental analysis and industrial analysis of raw coal

The coal used in the experiment is Zhaotong lignite. The elemental analysis data of raw coal are listed in Table 1.

Table 1 Elemental analysis of coal samples

coal samples	elemental analysis /%			
	Nad	Cad	Had	Sad
Zhaotong	1.38	50.88	5.01	0.68

Results and discussion

Effect of solvent ratio on extraction rate

Three samples of coal were placed in different beakers and the weight of each coal sample was 5 g. The extraction solvent CS₂ and NMP were injected into the beaker according to the proportion of 1: 1, 1: 1, 2: 1 by syringe[6,7]. The dosage of CS₂ was 20ml, 30ml, 40ml respectively, and that of NMP was 40ml, 30ml, 20ml. The solvent and coal samples were shaken, extracted 12h into the centrifuge centrifuge, centrifuge 30min, centrifuge speed 8000r / min. After centrifugation, the supernatant was removed and the residual coal was washed with acetone, filtered and dried. Table 2 shows the effect of the solvent ratio on the extraction rate.

Table 2 Effect of solvent ratio on extraction rate

solvent ratio	1: 1	2: 1	1: 2
extraction rate /%	30.14	20.52	23.63

As can be seen from Table 2, when the ratio of CS₂ and NMP was 1: 1 the highest extraction rate reached 30.14%. This is because NMP itself can not form hydrogen bonds, but can form strong hydrogen bond with phenolic hydroxyl group in lignite. While CS₂ can weaken the interaction of NMP, the interaction is reduced to the lowest in the proper solvent ratio, so that the non covalent bond force in coal is reduced, so as to improve the solubility of coal and increase the extraction rate.

Effect of rotational speed on extraction

Take 4 samples of coal into the marked good cone flask, the weight of each coal sample was 5g, with solvent selected from the best ratio of 1: 1. Then put the coal and extraction solvent on the oscillator shake, the oscillator speed was 50r / min, 100r / min, 150r / min, 200r / min. And then the experimental procedure was the same as above.

Table 3 Effect of rotational speed on extraction

rotational speed / r·min ⁻¹	50	100	150	200
extraction rate /%	34.51	37.20	41.29	43.33

Table 3 shows that the faster the speed, the higher the extraction rate of lignite. When the rotation speed was 200 r / min, the extraction rate was 43.33%. This is because with the speed up, the impact of the extraction solvent on the lignite is greater, the more the solvent and coal particles contact. So the extraction solvent can better extract the organic solvent from the macromolecular network structure of coal.

Effect of particle size on extraction rate

Lignite is divided into +100 mesh, 100~200 mesh, 200~400 mesh, -400 mesh. 5g coal samples were weighed from each grade and then placed in a well-marked conical flask, with solvent selected from the best ratio of 1: 1. Place the conical flask in the shaker at 200 r / min. And then the experimental procedure was the same as above.

Table 4 Effect of particle size on extraction rate

particle size/ mesh	+100	100~200	200~400	-400
extraction rate /%	37.24	39.89	44.92	42.66

Table 4 shows that the extraction of lignite firstly increased with the decrease of the particle size, and then the extraction rate decreased. The maximum extraction rate was 44.92% in 200~400 mesh. When the particle size of coal is relatively small, the contact opportunity of the solvent molecules and the coal molecules is increased, and the extraction solvent can enter the coal molecule to extract the organic solvent. However, when the coal sample is too fine, it will change the distribution of associated minerals in the coal sample, which is not conducive to the extraction of coal, so the particle size of coal sample can not be too small.

Effect of extraction times on extraction rate

Weigh 4 parts 200 to 400 mesh coal samples, each coal sample weight 5g. Then put the coal and extraction solvent on the oscillator shake, the oscillator speed was 200r / min. And then the experimental procedure was the same as above.

Table 5 Effect of extraction times on extraction rate

Extraction times / times	2	4	6	8
Extraction rate /%	55.74	61.85	65.62	67.19

Table 5 shows that the extraction rate is higher and higher with the increase of the extraction times. When the extraction times were 8 times, the extraction rate reached the highest 67.19%.The increase of the extraction times is equivalent to the increase of the extraction time and the increase of the solid-liquid ratio, which contributes to the improvement of the extraction rate.

Analysis of extracts

The extracts of Zhaotong lignite were analyzed by IR, and the IR spectra of the extracts were shown in Figure 1.

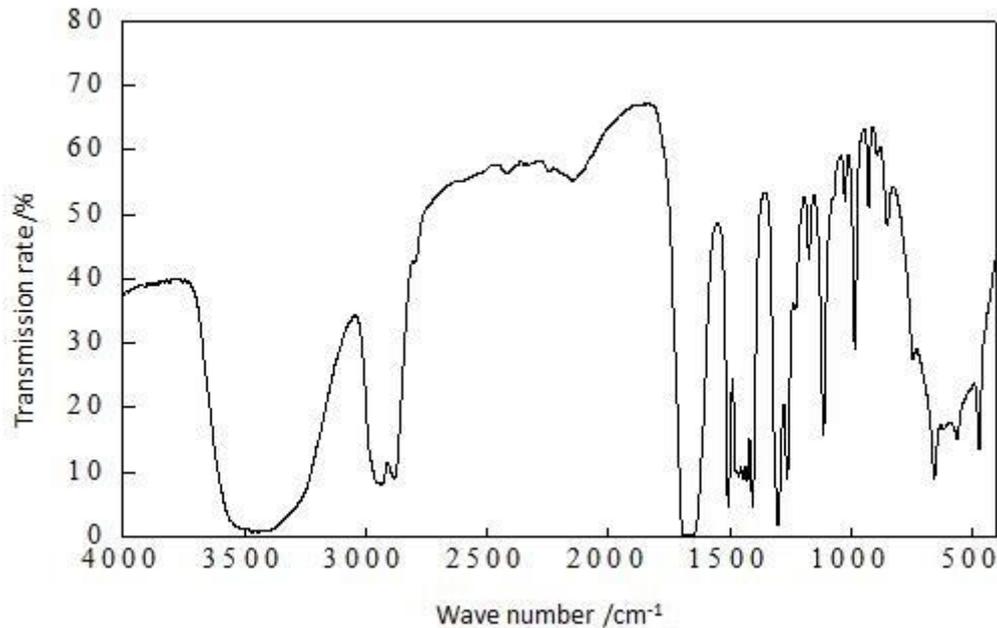


Fig. 1 Infrared Spectra of Zhaotong lignite extract

It can be known that C=O (1668.42 cm^{-1}), aromatic hydrocarbon C=C (1506.45 cm^{-1}), C-N (1303.2 cm^{-1}), (CH_2/CH_3) shear vibration (1429.32 cm^{-1}), aryl ether C-O (1264.4 cm^{-1}) and so on. The content of -C=O was the most, followed by C-N, aromatic C=C and carboxylic acid ion -COO-, and the remaining functional groups were relatively few.

Conclusion

The highest extraction rate of mixed solvent conditions: solvent ratio of 1: 1, speed of 200r / min, 200 to 400 mesh size fraction, extraction times 8 times, and the extraction rate reached 67.19%.

Functional groups of extraction have C=O, aromatic hydrocarbon C=C, (CH_2/CH_3) shear vibration, aryl ether C-O and so on. The content of -C=O was the most, followed by C-N, aromatic C=C and carboxylic acid ion -COO-, and the remaining functional groups were relatively few.

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