Fizykochemiczne Problemy Mineralurgii, 31 (1997), 229–234

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CORRELATION OF NATURAL HYDROPHOBICITY OF COAL WITH ITS PETROGRAPHIC COMPOSITION

The electrokinetic potential variation with the pH of the parent Çay coal seam appeared to be the result of the combined effects of the three (vitrain, durain, fusian) lithotypes. Vitrain was found to be the highest naturally hydrophobic lithotype as a result of contact angle measurements. This observation was supported by the findings during adsorption tests. On the basis of electrokinetic measurements, contact angle and adsorption tests, a correlation was established between the natural hydrophobicity of coals and their petrographic composition. Vitrain with a composition of mainly vitrinite was the most hydrophobic lithotype. The natural hydrophobicity of channel coals improve with the increase in their vitrinite contents.

INTRODUCTION

Coal has natural floatability which is dependent upon its rank as well as its chemical composition. Coal of different ranks and even of the same rank may differ greatly in their amenability to froth flotation. It is also found that macroscopically recognizable bands of bituminous coal, termed as lithotypes, have different floatabilities. If the floatability characteristics of lithotypes could be determined, it would be possible to interpret and explain the floatability of the parent coal.

The objective of this investigation was to determine the natural hydrophobicities of lithotypes and channel samples by means of electrokinetic potential measurements, contact angle and adsorption tests, and also to interpret the hydrophobicity of the parent coal from the results for its lithotypes.

EXPERIMENTAL PROCEDURES

The bituminous coal samples used in this research are channel coals (Çay, Acýlýk, Piriç seams) and lithotypes which were taken from Zonguldak Coal Basin. Large intercalations of mineral matter were removed from the channel samples. Four lithotypes were collected from Çay seam, due to their occurrences in rather large

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bands which facilitated the hand-picking of the pure lithotypes. All samples were stored in glass bottles under nitrogen until they were used in the experiments. For proximate analyses, ASTM standard methods were followed.

Leitz-Orthoplan-Pol polarizing microscope equipped with an automatic point counter was used for petrographic analyses of polished coal surfaces by reflected light. The specific electrokinetic technique used in this investigation was electrophoresis. Rank Brothers Particle Electrophoresis Apparatus MK-II, using a flat cell of rectangular cross-section was used for the measurement of mobilities of the particles.

Measurement of the contact angles were performed by using a NRL Contact Angle Goniometer, constructed by Rome-Hart Inc. For adsorption tests, the procedure described by Sun (1954) was followed.

EXPERIMENTAL RESULTS AND DISCUSSION

Chemical and petrographical analyses of samples

The results of proximate analyses of three channel samples and the three lithotypes are given in Table 1.

Table 1. Proximate analyses of coals

Sample	As received			
	Moisture	Ash	Volatile Matter	Fixed Carbon
Piriç Channel Coal	0.84	8.96	28.30	61.90
Acýlýk Channel Coal	1.14	10.05	27.42	61.39
Çay Channel Coal	0.88	12.19	28.62	58.31
Vitrain	1.28	3.24	29.98	65.50
Durain	0.85	13.27	23.51	62.37
Fusain	0.77	5.38	11.85	82.00

Table 2. Petrographic analyses

Maceral [% vol.]	Sample					
	Piriç	Acýlýk	Çay	Vitrain	Durain	Fusain
Vitrinite	88.8	75.4	71.0	95.4	20.2	7.4
Exinite	3.8	3.0	3.8	1.0	10.0	0.3
Inertinite	4.0	17.8	21.2	2.3	66.2	92.0
Shale	2.2	0.8	3.6	1.3	2.6	–
Pyrite	0.2	–	–	–	–	–
Other Min. Mat.	1.0	3.0	0.4	–	1.0	0.3
Mean Reflectance	1.22	1.11	1.07	–	–	–

The analyses indicated that the channel samples collected were relatively clean having 9–12% ash, whereas the original ash contents of the seams were above 30%.

Table 2 indicates the petrographic composition of the coals. It shows that the lithotypes have a high purity (vitrain band consisted of 95% vitrinite while the fusain band was composed of 92% inertinite). In view of the rank of the coal, durain sample was also reasonably pure.

Electrokinetic potential measurements of coals

Figure 1 and 2 show the variation of zeta-potentials of coal samples with pH. It can be seen that all channel samples and the lithotypes have negative zeta-potentials in double distilled water, due to the anisotropic nature of the coal structure. As it is described by Chander, Wie and Fuerstenau (1975), the anisotropic surface consists of two parts, one which is formed by the rupture of van der Waals bonds and the other which is formed by the rupture of ionic or covalent bonds and is hydrophilic. Although, pure graphite-like areas on the surface of coal are hydrophobic and practically non-ionogenic (inert) and that there are also hydrophilic sites on the surface which are polar, probably "oxide complexes", which behave as weakly acidic groups, at the edges and places of lattice breakage. Besides these, coal contains some inorganic impurities which are hydrophilic in nature. Therefore, the coal surface will show negative charge due to the presence of hydrophilic sites at the surface. At neutral pH, the zeta-potential values of coal samples varied from –15 mV to –25 mV.

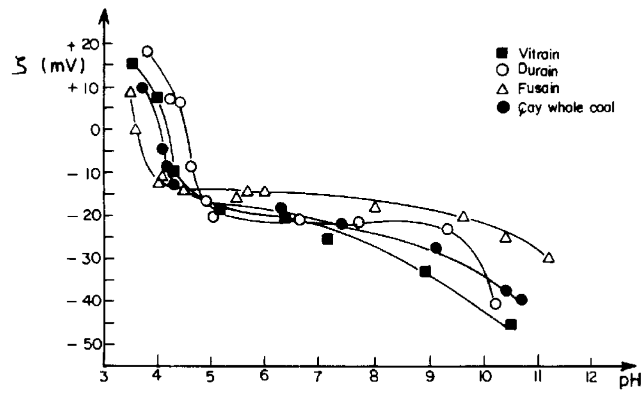

Fig. 1. Variation of electrokinetic potential of lithotypes with pH

The IEP (iso-electric point)'s for the different lithotypes occur at different pH's. The IEP's of vitrain, durain and fusain are 4.1, 4.5, and 3.6 respectively. The IEP's of their parent Çay coal occurs at pH 4.05. Two other channel samples Piriç and Acýlýk have IEP's at 3.85 and 4.3, respectively. The lower zeta-potential and IEP's of Piriç may be due to the slight in situ oxidation of the seam which took place during the previous mining.

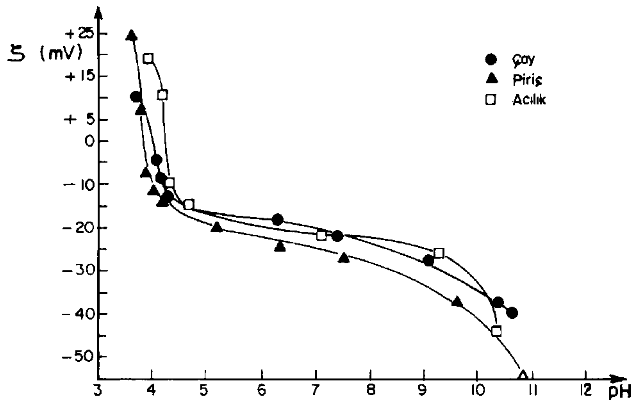

Fig. 2. Variation of electrokinetic potential of channel samples

Contact angle measurements

Table 3 shows the contact angles of each channel sample and each lithotype measured in distilled water. It proves that the three channel samples have natural floatabilities, by giving finite contact angles between 47° to 55°. Contact angle measurements also indicated that there was a marked difference among the natural floatabilities of lithotypes. Vitrain appeared to be the most floatable lithotype showing 61° contact angle. As Piriç has the highest vitrinite content, it has highest contact angle.

Table 3. Natural contact angles at various coal surfaces

Sample	Contact angles, deg		
	Min.	Max.	Average*
Vitrain	57	63	61
Durain	24	47	42
Fusain**	–	–	–
Çay Channel Sample	26	53	49
Acýlýk Channel Sample	28	50	47
Piriç Channel Sample	28	59	55

* Mean of 9 measurements.

** Contact angle could not be measured due to its disintegration in water.

Adsorption of kerosene by coal samples

The premise that the floatable components are much more oil-avid than the non-floatable components was verified by testing the adsorbability of minerals for neutral oils such as kerosene. The results are represented in Table 4.

As it is seen, the adsorption of kerosene by vitrain was maximum. Similarly, the contact angle which is a measure of natural hydrophobicity, was the highest for vitrain. As vitrinite is the main constituent of vitrain, there is a relationship between the hydrophobicity and petrographic composition.

Table 4. Adsorption of kerosene by coals

Sample	Amount of kerosene adsorbed by 1 g of coal, mg/g
Çay channel coal	21.47
Acýlýk channel coal	20.14
Piriç channel coal	26.12
Vitrain	30.83
Durain	16.66
Fusain	17.48

Adsorption of kerosene by Piriç coal was also highest between the three channel samples, owing to the increase of vitrinite content.

CONCLUSIONS

- The electrokinetic potential variation with the pH of the parent Çay coal seam appeared to be the result of the combined effects of the three lithotypes (vitrain, durain, fusain).
- Vitrain was found to be the highest naturally hydrophobic lithotype as a result of contact angle measurements. This observation was supported by the findings during adsorption tests.
- On the basis of electrokinetic measurements, contact angle and adsorption tests, a correlation was established between the natural hydrophobicity of coals and their petrographic composition. Vitrain with a composition of mainly vitrinite was the most hydrophobic lithotype. The natural hydrophobicity of channel coals improve with the increase in their vitrinite contents.

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Zmiana potencjału elektrokinetycznego badanych węgli wraz ze zmianą pH jest prawdopodobnie wynikiem wpływu wszystkich trzech litotypów (witryt, duryt, fuzyt) węgla. Na podstawie pomiarów kąta zwilżania można stwierdzić, że witryt ma najwyższą naturalną hydrofobowość. Ta obserwacja znalazła potwierdzenie w wynikach testów adsorpcyjnych. Na podstawie pomiarów elektrokinetycznych, kąta zwilżania i testów adsorpcyjnych znaleziono korelację pomiędzy naturalną hydrofobowością węgli a ich składem petrograficznym. Witryt zawierający głównie witrynit był najbardziej hydrofobowym litotypem, a naturalna hydrofobowość węgli rosła wraz ze wzrostem w nich zawartości witrynitu.