Investigation of the Physical Properties of Pennsylvania Anthracites

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Introduction

Anthracite has long been considered as a good precursor for carbon materials as it is graphitizable at extreme temperature[1,2]. Our research interests in converting anthracite into carbon/graphite materials were encouraged by two considerations: the high carbon content and low cost of anthracitic material[3,4]. Assessing the potentialities of using anthracite as a raw material for the production of various carbon or graphite products requires a close investigation of the basic physical properties of anthracites, because little fundamental information is available on anthracite physical properties and structure.

In the present paper, we present results of an investigation of the major physical properties—including density, mechanical strength, hardness, coefficient of thermal expansion (CTE), and microstructure—of block specimens of six Pennsylvania anthracites. Characterization of powder samples of the same anthracites was carried out in terms of ash content, porosity, volatile matter, and proximate and ultimate analysis. The relationships among some typical properties are discussed in terms of the application of anthracite to production of carbon/graphite materials.

Experimental

Six Pennsylvania anthracites, in both block and powder specimens, were obtained from Centralia Coal Sales Company (Wilkes-Barre, PA). The specimens were collected from different fields in eastern Pennsylvania.

Specimens for physical property tests were directly cut from anthracite block specimens in two different directions. Tests were performed by standard methods used in the carbon/graphite industry. For most mechanical and physical analyses, three or five measurements were made in each direction. The final results then were calculated as the averages of the individual measurements.

Optical texture indices of anthracite blocks were obtained using an image analysis technique developed recently in our laboratory[5]. To obtain representative results, analyses were carried out in two different directions across the pellets. Twenty images were collected from different regions, so a total of forty images were analyzed for each coal sample. The procedures for image analysis were described in detail elsewhere[5].

The characterization of powder samples was carried out by following the standard analysis procedures used in coal research.

Results and Discussion

Table 1 summarizes the physical properties and ultimate analyses of six Pennsylvania anthracite block and powder specimens. The ash contents of those specimens vary with the type of sample, *i.e.*, they are below 10% in block, but can be as high as 58% in powder specimens. It should be noted that all of those samples, except for samples #3 and #5, have low sulfur content (less than 1%) and higher hydrogen content (2-3%). Oxygen contents of most specimens, on the other hand, are unexpectedly very high. The higher hydrogen and lower sulfur and oxygen contents of samples #1 and 4 may indicate that they are potential precursors for producing carbon materials.

Most of the anthracites are anisotropic, in terms of physical properties obtained from two different directions, as shown in Fig. 1. The largest anisotropy was found in compressive strength, measurement of which is more sensitive to the layer structure of carbon materials.

Volatile matter (VM) is important for the structural characterization of anthracites. Most specimens have low VM (3-5%), but one (#1) has VM as high as 11%, along with the highest hydrogen content (3.81%) among the six samples. Figs. 2 and 3 plot VM *vs.* porosity and resistivity, respectively. In most cases, good linear relationships can be found between VM and these parameters, suggesting that VM may be an important factor for the characterization of anthracite as a raw material. Fig. 4 plots porosity *vs.* optical texture indices obtained by image analysis. The larger values of OTIs correspond to good texture and quality of petroleum needle coke[5], while the porosity of anthracite has been reported to be critical in terms of structural conversion of anthracite during heat treatment or graphitization[6]. It is useful, therefore, to investigate in detail the graphitization of these

anthracite specimens having such a wide range of composition and structural characteristics[7].

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References

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Table 1 Physical properties and ultimate analysis of anthracite specimens

Samp	Block specimens						Powder specimens						
No.	Ash,%	VM	P	D	CTE	OTIs	Ash,%	C, %	H, %	N, %	S, %	O, %*	H/C
#1	3.3	11.0	7.2	1.36	37.8	150.4	18.1	91.91	3.81	1.26	0.89	2.13	0.497
#2	6.6	3.8	3.7	1.57	25.7	52.8	41.2	89.12	2.53	1.36	1.02	5..97	0.341
#3	5.6	4.1	4.0	1.56	24.5	30.7	58.0	87.35	2.86	1.14	2.05	6.60	0.393
#4	4.4	4.3	3.4	1.49	26.1	21.6	17.9	94.47	2.50	0.85	0.68	1.50	0.318
#5	7.5	5.1	2.7	1.56	14.9	41.8	44.3	89.43	2.50	1.29	1.11	5.67	0.335
#6	2.2	3.3	2.0	1.58	16.7	27.9	47.7	88.13	2.47	1.51	0.09	6.98	0.336

VM: volatile matter, %; P: porosity in water, %; D: density, g/cm^3; CTE: coefficient of thermal expansion, 10^{-6}/C°; Elemental composition: calculated by ash-free; * determined from 100-(C+H+N+S).

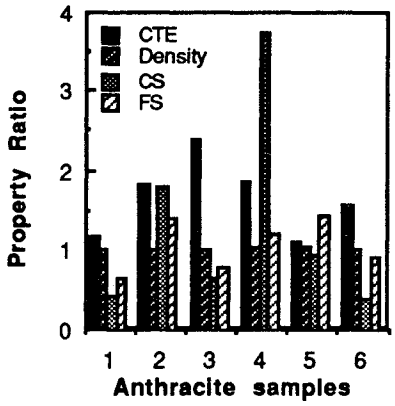

Fig. 1 Anisotropy of anthracite block specimens. (CS: compressive strength, FS: flexural strength)

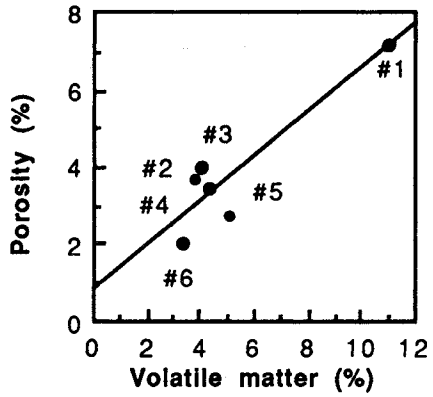

Fig. 2 Relationship between volatile matter and porosity of anthracite block specimens.

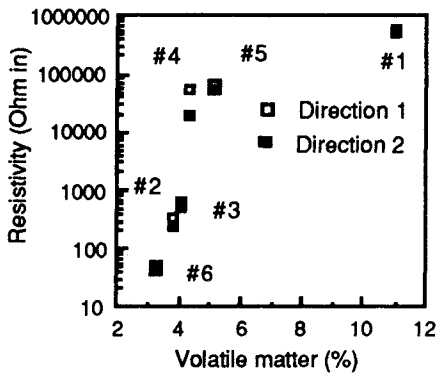

Fig. 3 Relationship between volatile matter and resistivity of anthracite block specimens.

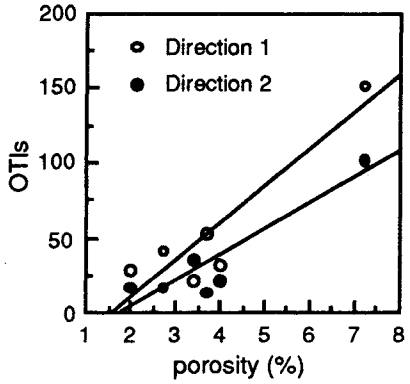

Fig. 4 Relationship between porosity and OTIs of anthracite block specimens.