Microhardness of Coal Immersed in Various Solvents

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The intrinsic mechanical strength of coal, shown by the microhardness number, may be related to inter and/or intramolecular forces[1-3]. When coal is immersed in a solvent, the solvent penetrates into coal, causing swelling. The resultant loosening of inter and/or intramolecular forces leads to changes in the mechanical strength of the coal. Recently, the microhardness of coals immersed in pyridine has been measured[4]. The hardness ratio, $H_k/H_{k,o}$, where H_k is the equilibrium Knoop hardness number of the coal immersed in in pyridine and $H_{k,o}$ is the Knoop hardness number of the original coal, when plotted against the rank of coal, shows a characteristic curve with a minimum at about an 80% carbon content[4].

In the present paper, the microhardness of coals immersed in various solvents has been measured further. The solvents used are benzene, ethanol, *p*-dioxan and dimethyl formamide (DMF). The details of measurement and the degree of error in the determination of the Knoop hardness number have been described elsewhere[1,4].

The Knoop hardness number of coal decreases with the increase in immersion time and reaches an equilibrium value after a few hours for all solvents as well as for pyridine[4]. The relation between the $H_k/H_{k,o}$, when coal is immersed in DMF and benzene respectively, and the rank of coal is shown in Fig. 1. In the case of immersion in DMF, the variation of $H_k/H_{k,o}$ in relation to the rank of coal is similar to that of pyridine, but the action of DMF is smaller than that of pyridine. In the case of benzene, the minimum in the curve of $H_k/H_{k,o}$ plotted against the rank shifts to a higher carbon content. As the constitution of coal is complex, it is difficult to explain these phenomena precisely, but the marked variation

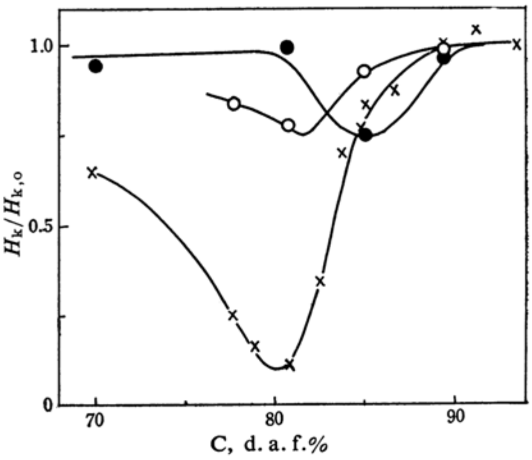

Fig. 1. Relation between hardness ratio and rank of coal.
○ DMF, ● Benzene, × Pyridine[4]

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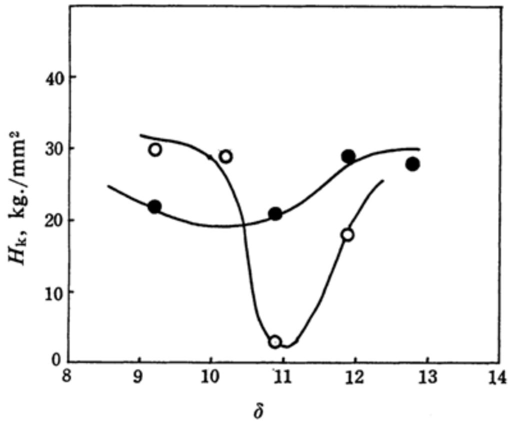

Fig. 2. Relation between equilibrium hardness number and solubility parameter of solvent, for Yūbari and Bibai vitrain immersed in solvent.
○ Bibai vitrain, ● Yūbari vitrain

in the value of $H_k/H_{k,o}$ with the rank would be expected to depend on the physical or chemical properties of the solvent and of the coal.

Figure 2 shows the relation between the H_k of Yūbari (d. a. f. 85%C) or Bibai (d. a. f. 81%C) coal immersed in solvents, and the solubility parameter*, δ, of solvents. It shows that H_k has a minimum at around 10 and 11 in the values of δ for Yūbari and Bibai coal respectively. It is known that the swelling of the polymer by various organic liquids correlates to a large extent with the cohesive energy density (CED) of the solvent and the polymer[5,6]. Such a relationship between the CED of solvents, including very highly polar ones, and the yield of extract of coals has been found[7]. Consequently, it seems that the CED is an important factor determining the solvent action on the mechanical behavior of coal.

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* The square of δ means CED; the values of δ in solvent are available in "Chemical Handbook (Kagaku Binran)", ed. by the Chem. Soc. Japan, Maruzen, Tokyo (1958), p. 1247.

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