SORPTION OF VARIOUS OILS BY EXFOLIATED GRAPHITE

M. Inagaki[a], A. Kawahara[a], A. Yonemoto[a] and M. Toyoda[b]
[a] Faculty of Engineering, Aichi Institute of Technology, Yakusa, Toyota 470-0392, Japan
[b] Fukui National College of Technology, Geshi, Sabae 916-8507, Japan

Introduction

Exfoliated graphite was reported to sorb a large amount of heavy oils very rapidly, more than 80 kg/kg within 1 minute [1,2]. Sorption behavior was studied by so-called wicking method [3,4] and direct observation with optical microscopy [5]. This large sorption capacity was found to be predominantly due to large space, more than 1 mm in size, among the entangled worm-like particles of exfoliated graphite with capillary phenomenon. Sorption capacity was found to depend strongly on the bulk density of exfoliated graphite and sorption rate to be governed mostly on the viscosity of heavy oil.

In the present work, sorption capacity and kinetics of various oils were studied and discussed on the effect of viscosity of the oils.

Experimental

Various oils covering a wide range of viscosity were selected: 16 oils from kerosene (0.001 Pa·s) to grade-C heavy oil (0.85 Pa·s).

Sorption capacity of the starting exfoliated graphite which had the bulk density of 7 kg/m^3 was determined by direct soaking into each oils, *i.e.*, a lump of exfoliated graphite being directly soaked into the oil, kept 15~30 min, picked up by using a steel mesh, drain off for 30 min and then measured the weight increase due to the sorption of the oil.

Sorption curves for each oils were determined at room temperature by measuring the weight increase due to the suction of the oil from the bottom of exfoliated graphite column which was packed into a glass cylinder with a glass filter at its bottom and with an inner diameter of 20 mm and a height of 22 mm (wicking method). This wicking method is schematically illustrated in Fig. 1. After correcting on the surface tension, the sorption curve was determined. The bulk density of exfoliated graphite in the glass column was kept at 10 kg/m^3 by controlling its weight. For some oils, exfoliated graphite with the bulk density of 20 kg/m^3 was also used to understand the effect of bulk density on sorption kinetics. The saturated weight increase w_{sat} was converted to the capacity m_{sat} per unit weight of exfoliated graphite. This value m_{sat} was compared with sorption capacity measured by direct soaking.

Results and Discussion

In Fig. 2, sorption curves observed by wicking method on the oils with different viscosities are compared. The sorption rate depends strongly on viscosity. Less viscous oil (*e.g.*, salad oil) reaches its saturation very quickly, but viscous oil (*e.g.*, grade-C heavy oil) was sorbed very slowly into exfoliated graphite. On the other hand, saturated amount of absorbed oil $w_{sat.}$ looked almost the same for all oils, though C-grade heavy oil does not reach the saturation in the figure.

In Fig. 3, the values of m_{sat} for various oils are plotted against viscosity of oils. m_{sat} seems not to depend on the viscosity of oils, being around 60~70 kg/kg. Sorption capacity evaluated as m_{sat} depended on bulk density of exfoliated graphite, as observed on heavy oils [1,2], but seemed not to be different between direct soaking and wicking methods.

Sorption curves measured could be expressed as a function of time as follows;

$$m = K_s t^{1/2}$$

where K_s is effective suction coefficient (sorptivity, kg/m^{2}s$^{1/2}$) [6]. In Fig. 4, sorptivity K_s is plotted against viscosity h of oils in logarithmic scale. K_s shows a strong dependence on h: the oil with the higher viscosity is sorbed with the slower rate.

At the deviation point from $t^{1/2}$-dependence to the saturation on the sorption curve, effective suction weight m* was determined. By assuming the following relation to the height of the column h (15 mm in the present case) and the viscosity of oil h;

$$e^* = (m^*/hh)$$

effective suction porosity e* was determined. In Fig. 5, effective suction porosity e* is plotted also against viscosity h.

References

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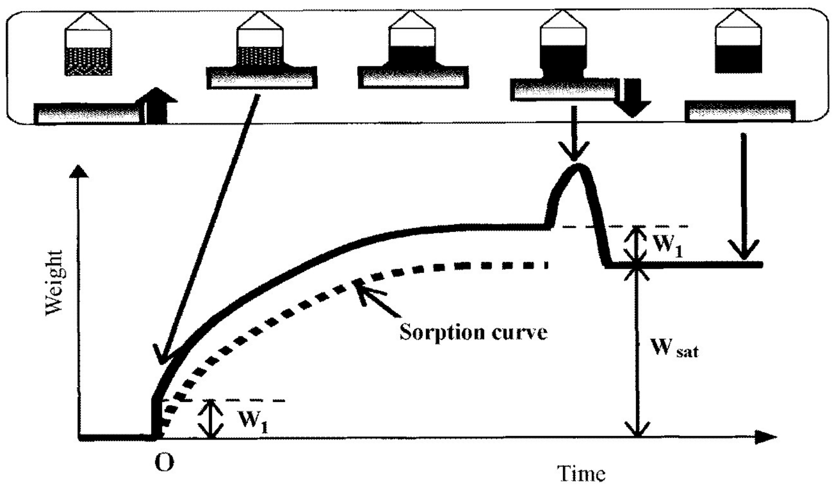

Fig. 1 Schematic illustration of wicking method.

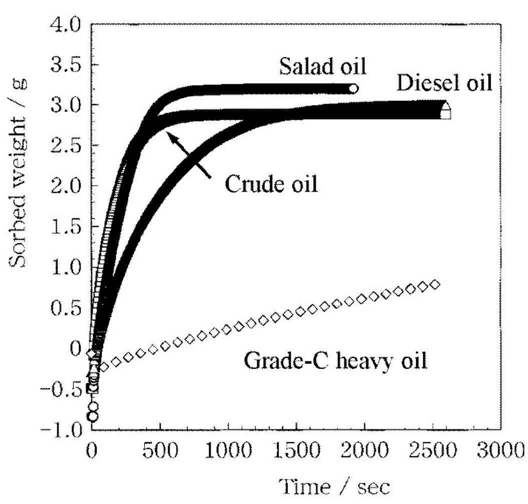

Fig. 2 Sorption curves for the oils with different viscosity

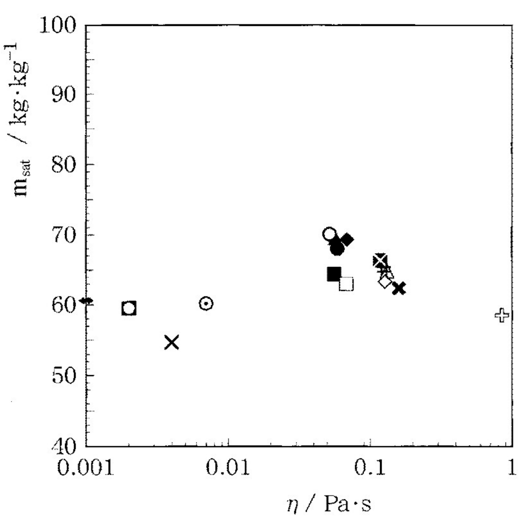

Fig. 3 Saturated sorption capacity m_{sat} against viscosity η of oils

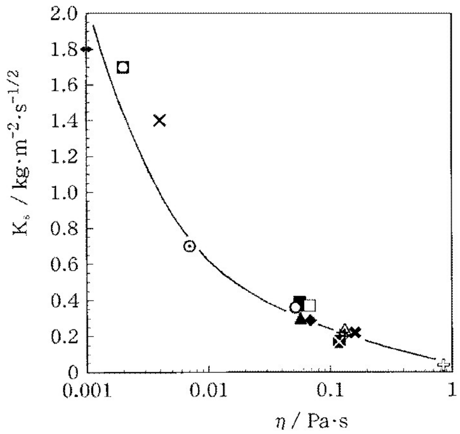

Fig. 4 Dependence of sorptivity K_s on viscosity η.

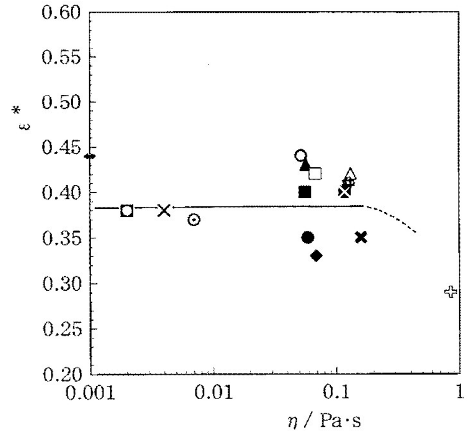

Fig. 5 Effective suction porosity ε* *vs*. viscosity η.