SEPARATION OF CRACKED KEROSENE BY SOLVENT EXTRACTION

Student Number: 06_23273 Name: Kazuaki MIYAZAKI Supervisor: Ryuichi EGASHIRA

1. Introduction

Cracked oil is one fraction obtained from heavy oil and contains various compounds such as alkanes, aromatic compounds, nitrogen compounds, and so on. If cracked oil was used as feedstock of fuel oil, these chemicals have to be removed not to produce contaminants with be burned. Besides, aromatic compounds are useful for raw materials of chemical industry. On the other hand, demands for fuel oils including refined oil from cracked oil has been declined recently. So, it could be new use of cracked oils to separate aromatic compounds and utilize them as raw materials of chemical industry.

The way of separating aromatic hydrocarbons has been studied. According to study on separation of coal tar fractions, nitrogen compounds and aromatic compounds could be separated from them by aqueous methanol solution[1,2,3]. Moreover, there are industrialized processes such as sulfolane process, furfural process, etc[4].

Then, the objective of this study is to investigate liquid-liquid equilibrium relationship between cracked kerosene and some kinds of solvents, and to discuss the feasibility of separation. In this paper, the separation of aromatic compounds is mainly discussed.

2. Experimental

Specific amounts of feed oil, R_0, and solvents phase, E_0, were brought into contact and were shaken at 298 K for 72 hours. These conditions are set with reference to the previous work about absorption oil[5]. The equilibrated oil, R_1, and solvent phase, E_1, were split into each other by separation funnel. The compositions of these phases were determined by the analysis with a gas chromatograph.

The conditions of material systems are summarized in **Table 1**.

Table 1 Conditions of material systems

Feed	Cracked kerosene
	Mass, R_0 [kg]
	0.4
Solvent	Aqueous solution of methanol
	Aqueous solution of sulfolane
	Furfural
	Mass fraction of water, $y_{w,0}$ [-]
	0, 0.3, 0.5, 0.7
	Mass ratio of solvent to feed, E_0/R_0 [-]
	1

3. Results and Discussion

3.1 Composition of cracked kerosene

The gas chromatograms and composition of cracked kerosene are shown in **Fig.1** and **Table 2**, respectively. There were numbers of components in cracked kerosene as found in the chromatograms.

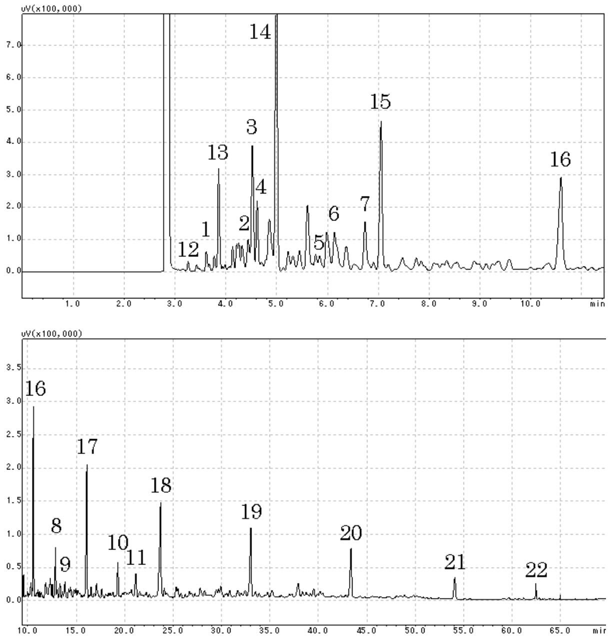

Fig.1 Gas chromatograms of cracked kerosene

Table 2 Mass fraction and normal boiling points of components in cracked kerosene

	Components		Mass Fraction [-]	Boiling Point [℃]
1	Toluene	TOL	0.0026	110.63
2	Ethylbenzene	EB	0.0067	136.19
3	m,p-Xylene	M,PX	0.0233	139.1, 138.35
4	o-Xylene	OX	0.0175	144.41
5	Propylbenzene	PB	0.0041	159.22
6	1,3,5-Trimethylbenzene	M	0.0142	164.72
7	1,2,4-Trimethylbenzene	PC	0.0131	169.20
8	Tetraline	T	0.0094	207.57
9	Naphthalene	N	0.0044	217.96
10	Hexylbenzene	HB	0.0091	226.00
11	2-Methylnaphthalene	2MN	0.0080	241.05
12	Heptane	C7	0.0017	98.43
13	Octane	C8	0.0168	125.67
14	Nonane	C9	0.0671	150.80
15	Decane	C10	0.0337	174.12
16	Undecane	C11	0.0319	195.89
17	Dodecane	C12	0.0311	216.28
18	Tridecane	C13	0.0357	235.44
19	Tetradecane	C14	0.0254	253.57
20	Pentadecane	C15	0.0194	270.63
21	Hexadecane	C16	0.0086	286.79
22	Heptadecane	C17	0.0026	301.82
-	Total aromatic compounds	-	0.2740	-
-	Total alkanes	-	0.1125	-

3.2 Conditions at equilibrium

The cracked kerosene and aqueous furfural solution ($y_{w,0}$=0.5), the other solvents formed three phases, two phases respectively.

In the case of $y_{w,0}$=1 (water), any components were not detected in the extract phase.

3.3 Numerical relationships

The distribution coefficient of component i, m_i, and the separation selectivity relative to component j, $\beta_{i,j}$, were defined by,

$$m_i = y_{i,1}/x_{i,1} \quad (2)$$

$$\beta_{i,j} = m_i/m_j \quad (3)$$

($y_{i,1}$, $x_{i,1}$: the mass fractions of constituent i in respective phases)

3.4 Distribution coefficients

The distribution coefficients derived by Eq.(2) were plotted against the carbon number of components in **Fig.2.** The m_is of aromatic compounds were higher than those of alkanes in all material systems. It confirmed that aromatic compounds in cracked kerosene could be separated. In this condition, yield of toluene was 0.35. The carbon number lowered m_i.

The m_{is} were also plotted against the kind of solvent and the water content in the extract phase, $y_{w,1}$, in **Fig.3**. The $y_{w,0}$ lowered m_i. This effect on m_i may be attributed principally to the polarities of materials.

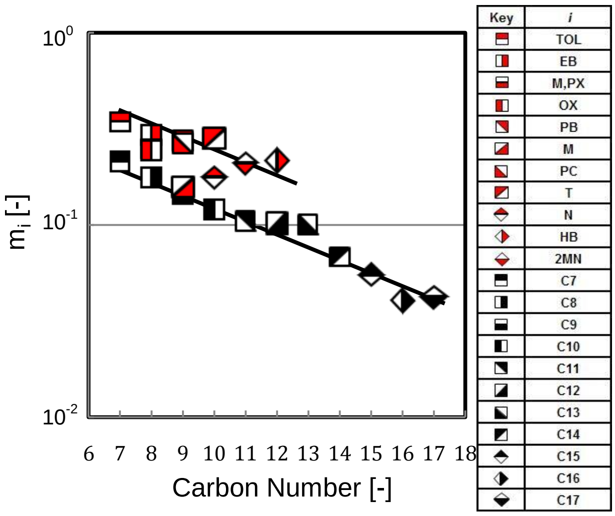

Fig.2 Effect of the carbon number of components on distribution coefficients, m_i. (Solvent: Methanol, $y_{w,0}$=0)

The m_is of methanol measured 35~330. The water content in the raffinate phase, $x_{w,1}$, measured 0 in all conditions. Therefore, the leakage of water from the solvent to the raffinate phase was favorably low.

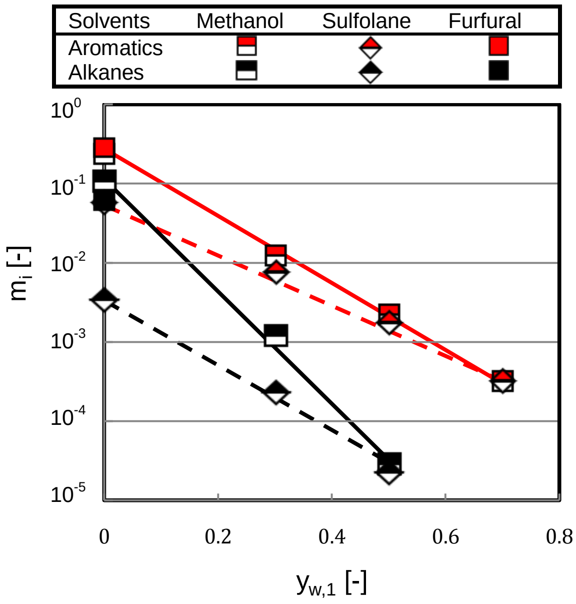

Fig.3 Effects of the kind of solvent and water content in aqueous phase, $y_{w,1}$, on distribution coefficients, m_i

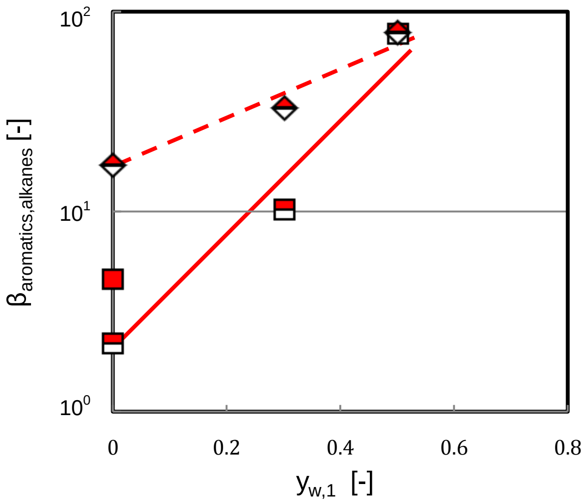

Fig.4 Effects of the kind of solvent and $y_{w,1}$, on selectivity relative to alkanes of aromatic compounds, $\beta_{aromatics,alkanes}$.

3.5 Selectivity

The separation selectivity relative to alkanes of aromatic compounds derived by Eq.(3) were plotted against $y_{w,1}$ in **Fig.4**. The $y_{w,1}$ raised βs. In the case of the sulfolane solvent, the βs were almost higher than the other solvents.

4. Conclusion

Cracked kerosene could be separated into aromatic compounds and the other hydrocarbons by three kinds of solvents (aqueous solution of methanol, sulfolane, furfural).

Literature Cited

1) Ukegawa, K., et al. J. of JPI, **33**, (4), 250 (1990)
2) Kodera, Y., et al., Fuel, **70**, (6) 765 (1991)
3) Matsumura, A., J. of NIRE, **4**,(2), 43(1995)
4) Process of the refinement of crude oil, JPI (1998)
5) Egashira, R., et al., J. of JPI, **43**, (5), 339 (2000)