초임계 **CO_2** 와 **Palm Oil** 을 이용한 상평형 실험

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Mutual Solubilities of Palm Oil and Supercritical Carbon Dioxide

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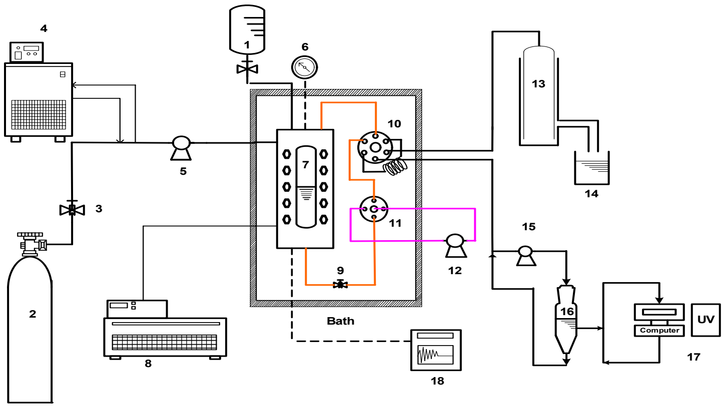
Introduction

More than 90% of the world production of fats and oils are used for foodstuff [1]. Among these, vegetable oils take a big part. Considerable interest has been shown in the development of supercritical fluid processing in the oil and fat industry. Some examples are deacidification [2,3], degumming and bleaching [4], extraction [5] and fractionation of oil [5]. Palm oil is usually used to make fatty food, such as chips and instant noodle. Although fatty food is delicious, high calories of it make human beings gain weight. In this work, we would like to measure the mutual solubilities of palm oil and SC carbon dioxide in a circulation type equilibrium apparatus at various conditions and correlate the data by cubic EOS(equation of state) method.

Experiment

The palm oil and carbon dioxide, used in this experiment, was provided by Lotte Samgang Co. and Shinhan Sanso Co. respectively. The purity of carbon dioxide was 99.95 (wt%). The schematic flow diagram of the experimental apparatus is shown in Fig. 1.



1. Oil Storage Tank 2. CO_2 Cylinder 3. CO_2 Cylinder Valve
4. Low Temperature Circulator 5. Feed Pump 6. Pressure Gauge
7. Equilibrium Cell 8. Constant Temperature Circulator 9. Valve
10. Sampling Valve 11. Switching Valve 12. Circulation Pump
13. Vapor Holder 14. Water Receiver 15. Solvent Pump
16. Solvent Reservoir 17. UV Detector 18. Temperature recorder

Fig. 1. A schematic diagram of the experimental setup for phase equilibrium measurement

Experimental procedure is as follows : First, palm oil was fed into the equilibrium cell and carbon dioxide followed. The equilibrium cell and air bath were heated to experimental temperature. After confirming the temperature of the cell and bath were maintained constant (± 0.1°C), carbon dioxide was supplied once more to the cell up to desired pressure. Carbon dioxide phase was selected and circulates first for five hours. It seems enough to reach equilibrium to circulating for five hours as shown in Fig.2. After convincing to reach equilibrium, sample was taken by sampling valve and determined the quantities of carbon dioxide and palm oil. Palm oil was dissolve by n-Hexane and palm oil concentration in n-Hexane was analyzed by UV-VIS spectrophotometer (Varian Model Cray 100).

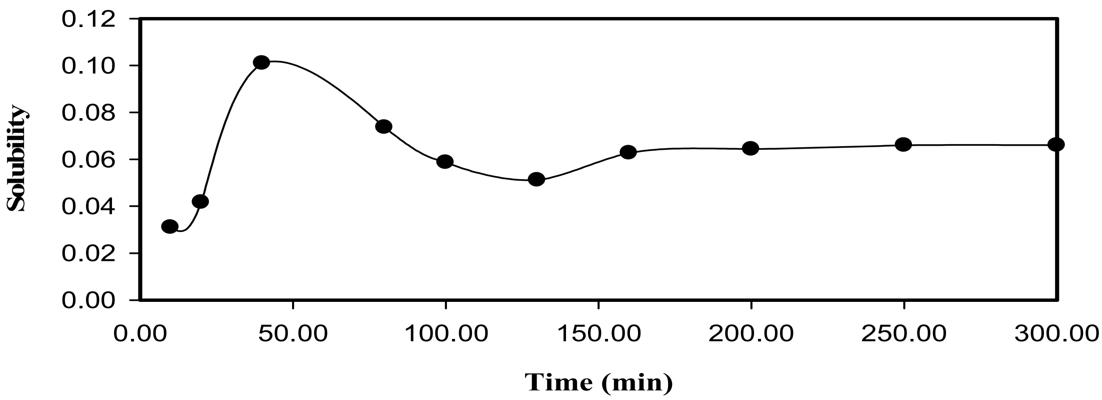


Fig. 2. Solubility for the system Palm oil /carbon dioxide

Results and Discussions

Fig.3 shows the results of experimental data of the palm oil and SC carbon dioxide system at 333.15, 353.15 and 373.15 K and 85 – 240 bar. For all isotherms obtained in this experiment, the solubility of palm oil in SC carbon dioxide and that of carbon dioxide in palm oil increased at higher pressure. This behavior is expected because the SC solvent solvating power increased with its density. At higher the temperature, the lower the solubility. This is because of the competing effect between the solvent density and palm oil vapor pressure. An increase in temperature causes carbon dioxide density to decrease thereby decreasing solubility. Phase equilibria data were correlated using the Peng-Robinson EOS with the van der Waals mixing rule for binary interaction parameters.

The Peng-Robinson EOS is given as[6]: $P = \frac{RT}{V-b} - \frac{Q(T)}{V(V+b)+b(V-b)}$

The van der Waals mixing rules with the combining rules for two binary interaction parameters are given by the following equations:

$$a_m = \sum_i \sum_j x_i x_j a_{ij} \qquad b_m = \sum_i \sum_j x_i x_j b_{ij}$$

$$a_{ij} = \sqrt{a_{ii} a_{jj}}\left(1 - k_{ij}\right) \qquad b_{ij} = \frac{1}{2}\left(b_{ii} + b_{jj}\right)\left(1 - l_{jj}\right)$$

Palm oil was assumed to consist with triglyceride to estimate the pure properties of palm oil of the Peng-Robinson EOS. The lines in Fig.3 were calculated line by the Peng-Robinson EOS. As shown in Fig.3, experimental data were well correlated by the Peng-Robinson EOS with reasonable errors.

Fig. 4 presents the interaction parameter obtained when the equillibria data were optimized by the Peng-Robinson EOS modeling.

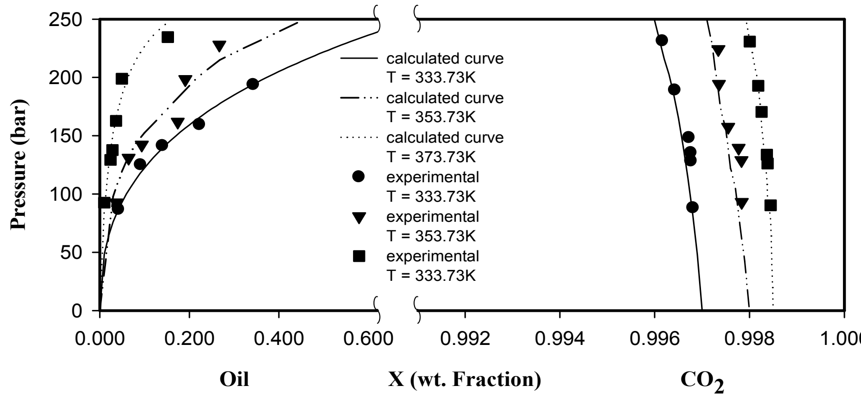


Fig. 3 Experimental and calculated equilibrium data of palm oil/ CO_2 system correlated with Peng-Robinson EOS

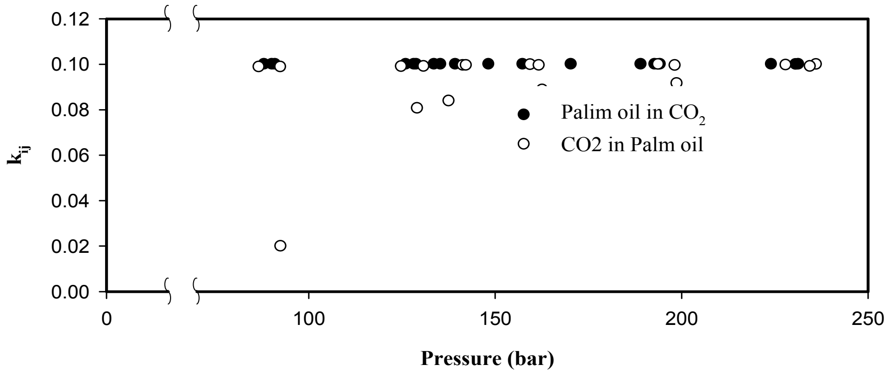


Fig. 4 Binary interaction parameter of Peng-Robinson EOS for palm oil/ CO_2 system

Conclusions

In this work, phase equilibria data were measured in a newly designed circulation type apparatus of the palm oil and SC carbon dioxide system at 333.15, 353.15 and 373.15 K and 85 – 240 bar. The experimental data were well correlated with the Peng-Robinson EOS with van der Waals mixing rule.

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