

Study of the solubility of anthracene in pure and modified supercritical carbon dioxide

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Abstract

In the framework of the supercritical fluid extraction regeneration of catalysts, an original experimental device was created for measuring the solubility of substances in pure and modified supercritical carbon dioxide, protected by a RF patent for a useful model. To prevent entrainment during the implementation of the process of extraction of substances in the solid state, a special vessel with a microporous membrane was used in the extraction cell. The solubility of anthracene in pure supercritical carbon dioxide was studied with 423, 435, 448 K isotherms in the pressure range from 9.6 to 22 MPa. It is established that an increase in temperature and pressure contribute to an increase in the solubility of anthracene. In order to increase the dissolving ability of SC-CO₂, a search for modifiers of various nature (acetone, hexane, ethanol) was conducted. It is revealed that hexane and ethanol are more effective modifiers. In this regard, the effect of the concentration of these modifiers on the dissolving ability was investigated. The content in the solvent 2% of the mass. hexane and ethanol have a maximum effect than their other concentration. The solubility of anthracene in SC-CO₂ modified with hexane and ethanol was studied at a 435 K isotherm in the pressure range 10-20 MPa. The use of modifiers made it possible to increase the solubility of anthracene using ethanol and hexane by 56% and 76%, respectively. The solubility of anthracene in pure supercritical carbon dioxide is described using the Peng-Robinson equation of state and three adjustable parameters. To describe the solubility of anthracene in a modified SC-CO₂, only one adjustable parameter was used. In addition, the descriptions of the solubility of anthracene in pure SC-CO₂ obtained experimentally in this work and in the works of other authors are presented. The obtained dependences of the parameters of the binary interaction on temperature make it possible to interpolate the values of solubility on the basis of existing experimental data.

References

- [1] A.A. Sagdeev, I.F. Nazmieva, R.F. Gallyamov, A.A. Sagdeev, F.M. Gumerov . Catalytic activity of the alyumopalladiyevy catalyst regenerated with use of supercritical CO₂ - extraction process. *Bulletin of the technological university*. **2014**. Vol.17. No.8. P.58-62. (russian)
- [2] R.M. Masagudov, P.M. Morozov, B.F. Morozov, B.I. Kutepov *Regeneration of catalysts in oil processing and petrochemistry*. Moscow: Chemistry. **1987**. 144p. (russian)
- [3] Patent Russian Federation 163707. **2015**. (russian)
- [4] A.T. Galimova, A.A. Sagdeev, F.M. Gumerov Supercritical fluid extraction regeneration of the catalyst aluminum oxide active. *Kazan: Brig*. **2016**. 168p. (russian)
- [5] Certificate on the state registration of the computer program of the *Russian Federation №2016613119*. **2016**.
- [6] I. Ashour. Representation of solid-supercritical phase equilibria using cubic equation of state. *Fluid Phase Equil*. **2000**. Vol.167. P.41.

- [7] X. Lou, H.-G. Janssen, C.A. Cramers. Temperature and pressure effects on solubility in supercritical carbon dioxide and retention in supercritical fluid chromatography. *J. Chromatogr. A*. **1997**. Vol.785. Iss.1-2. P.57-64.
- [8] D.J. Miller, S.B. Hawthorne. *Anal. Chem.* **1995**. Vol.67. No.2. P.273-279.
- [9] T.R. Bilalov and F.M. Gumerov. Determination of saturated vapor pressure of aromatic compounds based on experimental data on their solubility in supercritical carbon dioxide. *Butlerov Communications*. **2018**. Vol.53. No.1. P.18-32. DOI: 10.37952/ROI-jbc-01/18-53-1-18
- [10] T.W. Zerda, B. Wiegand, J. Jonas. FTIR measurements of solubilities of anthracene in supercritical carbon dioxide. *J. Chem. Eng. Data*. **1986**. Vol.31. No.3. P.274-277.
- [11] Management of ISO/MEK 98-3:2008 Uncertainty of measurement. Chast3. Guide to expression of uncertainty of measurement. Use and publishing registration. *Moscow: Standartinform*. **2012**. 100p. (russian)