CHAPTER V

THE SOLUBILITIES AND THERMODYNAMIC MODEL OF ORGANIC COMPOUNDS IN AQUEOUS AND SEVERAL ORGANIC SOLVENTS AT DIFFERENT TEMPERATURE SOLUTIONS

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This chapter is the summary from the two articles have been published in Journal: Fluid Phase Equilibria. Page: 217-223. Volume: 338. Year: 2013 and Journal of Molecular Liquids. Page: 252-259. Volume: 180. Year: 2013.

5.1 SOLUBILITY DATA

The solubility is one of the most fundamental physico-chemical properties. Solubility of solids in liquids is the most important process parameters and of scientific interest for the development of the solution theory. Solubility data of the solid–liquid equilibrium of organic compounds are particularly useful for a wide variety of applications important in the biological, chemical and environmental industries [1]. Accurate solubility data are needed for chemical manufacturing processes and product design. The chemical manufacturing processes require these data for designing purification processes, e.g. precipitation [2], crystallization [3], chemical reaction systems [4], pollution prevention [5], biomass processing [6], production and purification of chemical compounds [7] and production and purification of chemical compounds [8]. For many separation and purification processes, a mixture of two or more solvents has been occasionally found to offer the best operation properties. Water mixed with alcohols or acids has been frequently used as solvent [9, 10]. However, only limited solubility data have been reported in the literature. As far as we know, the solubility is available only for water and a few organic solvents at low temperatures. Unfortunately, only limited data on the solubility and temperature dependence of organic compounds are available. These solubility data were gained under conditions far from industrial conditions.

5.2 SOLUBILITY IN THE HOLLOW FIBER SUPPORTED LIQUID MEMBRANE SYSTEM

In the recent years, hollow fiber supported liquid membrane (HFSLM) draws considerable interest due to its industrial applications. HFSLM technique has specific characteristics of simultaneous extraction and stripping processes of low-concentration of target species in one single stage [11]. Some other advantages of the HFSLM over traditional separation techniques include lower capital and operating costs [12], lower energy consumption [13], low solvent used and high selectivity [14]. These advantages of the HFSLM are suitable to apply to treatment of chemical synthesis-based pharmaceutical wastewater. The main mechanism of solute transport in HFSLM loaded only with organic solvent is based on diffusion. The solute species dissolve in the liquid membrane and diffuse across the membrane due to concentration gradient. Solute solubility plays a key role in passing through liquid membrane. The solute does not react chemically with the organic solvents. The solute is only dissolve in feed phase and stripping phase [15]. The solute complex and extractant dissolve in organic phase. From the reason, the solubility is the most important for HFSLM separation process and purification of chemical compounds.

5.3 SOLUBILITY IN AQUEOUS SOLUTION

The solubility in aqueous solution is defined as the equilibrium distribution of a solute between water and solute phases at a given temperature and pressure. Aqueous solubility is one of the most important process parameters for the development of HFSLM separation process. Aqueous solubility of organic compounds may be due to the fact that absolute concentration in the liquid boundary layer increases with the increase in the initial concentration in the aqueous phase, which brings the concentration polarization phenomenon. The mechanism of organic compounds transfers through liquid membrane incorporates several mass transfer resistances, and aqueous solubility may have a controlling effect on the extraction performance. The aqueous solubility in the aqueous phase was decreased. The extraction rates increased.

The organic compounds surrounding the membrane immediately diffused into the membrane. Measurement and correlation of aqueous solubility of organic compounds was used the 4-position substituted benzoic acid compounds to demonstrate as shown the detail in appendix A [16].

5.4 SOLUBILITY IN ORGANIC SOLVENTS

In a two-phase HFSLM system, the selection of an appropriate organic extractant to locate inside the pores and the lumens of the hollow fiber is of major important to achieve good sensitivity, efficient extraction, and selectivity in the extraction of the target organic compounds. The purpose is to enable organic extractant to dissolve easily in the organic phase and to dissolve with difficulty in the aqueous phase. Generally speaking, the organic extractant compounds must been a very good organic solubility. The organic solubility was considerated in case of extractance and organic target compounds complex in membrane phase. The organic solubility of organic target compounds complex in the membrane or organic phase was increased. The extraction rates increased. Determination and modeling of organic solubility of organic compounds was used the 4-acetylbenzoic acid to demonstrate as shown the detail in appendix B [17].

5.5 THERMODYNAMIC MODEL OF SOLUBILITY CALCULATION

Temperature has an important impact on the mass transfer of organic target compounds across a hollow fiber supported liquid membrane. Higher temperature means a general increase in the rate of solubility, diffusion and permeation. The extraction rates and extraction efficiencies increase when the operation temperature increases. Generally speaking, high temperature increases the organic extractants capacity of dissolving the organic target compounds because increasing temperature can disrupt the strong interactions between the solute and aqueous matrix caused by van der Waal's forces, hydrogen bonding, and dipole attractions of the solute molecules [18]. Therefore, fast diffusion rates occurred as a result of increasing temperature. On the other hand, a decrease in viscosity of the target pollutants is observed at higher temperature. It improved the penetration of the aqueous matrix, and thereby improved the extraction [19]. In the thermodynamic models for solubility calculations activity coefficients are used to investigate the solid-liquid equilibrium system [20]. According to the thermodynamic theory there are many equations applied generally [21], such as the Wilson equation model, the modified Apelblat equation model, the Buchowski–Książczak λH equation model, NRTL, UNIQUAC and UNIFAC. In this work in appendies A [16] and B [17] the modified Apelblat equation and the λH equation models were used to describe satisfactory all experimental data. These two models were selected also for our study.

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