J. Chem. Thermodynamics 95 (2016) 63–71

Contents lists available at ScienceDirect

J. Chem. Thermodynamics

journal homepage: www.elsevier.com/locate/jct

Measurement and correlation of solubility of cefmenoxime hydrochloride in pure solvents and binary solvent mixtures

Jinxiu Wang [a], Chuang Xie [a,b], Qiuxiang Yin [a,b], Linggang Tao [c], Jun Lv [c], Yongli Wang [a,b], Fang He [a], Hongxun Hao [a,b,*]

[a] State Key Laboratory of Chemical Engineering, School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China
[b] Collaborative Innovation Center of Chemical Science and Chemical Engineering of Tianjin, Tianjin University, China
[c] Lionco Pharmaceutical Group, Haikou, Hainan 570100, China

ARTICLE INFO

Article history:
Received 18 September 2015
Received in revised form 4 November 2015
Accepted 25 November 2015
Available online 5 December 2015

Keywords:
Cefmenoxime hydrochloride
UV spectrometer
Solubility
Mixing thermodynamic properties

ABSTRACT

The solubility of cefmenoxime hydrochloride in pure solvents and binary solvent mixtures was measured at temperatures from (283.15 to 313.15) K by using the UV spectroscopic method. The results reveal that the solubility of cefmenoxime hydrochloride increases with increasing temperature in all solvent selected. The solubility of cefmenoxime hydrochloride reaches its maximum value when the mole fraction of isopropanol is 0.2 in the binary solvent mixtures of (isopropanol + water). The modified Apelblat equation and the NRTL model were successfully used to correlate the experimental solubility in pure solvents while the modified Apelblat equation, the CNIBS/R–K model and the Jouyban–Acree model were applied to correlate the solubility in binary solvent mixtures. In addition, the mixing thermodynamic properties of cefmenoxime hydrochloride in different solvents were also calculated based on the NRTL model and experimental solubility data.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Cefmenoxime hydrochloride ($C_{32}H_{35}ClN_{18}O_{10}S_6$, CAS registry No: 75738-58-8), one of the third-generation cephalosporins, is widely used for treatment of gonorrhea and inflammation caused by postoperative, respiratory, urinary infection [1,2]. The third-generation cephalosporins are considered to be one of the most significant therapeutic entities [3]. It was reported that cefmenoxime hydrochloride has broader antibacterial spectrum [4] and shows the highest antimicrobial activity against both gram-negative and gram-positive bacteria in comparison with other cephalosporins [5]. The chemical structure of cefmenoxime hydrochloride is shown in figure 1.

Although cefmenoxime hydrochloride has been put into market since 1983, most investigations about it are mainly focussed on its synthesis and application. Until now, few data on its thermodynamic properties have been reported except that crystal and molecular structure of cefmenoxime hemihydrochloride have been reported by K. Kamiya *et al.* [6]. The lack of thermodynamic data makes it difficult to design and optimize the manufacturing process of cefmenoxime hydrochloride. Like many other pharmaceuticals, in the manufacturing of cefmenoxime hydrochloride, solution crystallization is the final step to obtain solid state cefmenoxime hydrochloride products. The quality of the product and the yield of the process are directly associated with the design and optimization of the crystallization process of cefmenoxime hydrochloride. Therefore, it is essential to obtain credible and accurate solubility data of cefmenoxime hydrochloride in different solvents to aid the design and optimization of the crystallization process [7]. However, through extensive literature screening, few publications about the solubility of cefmenoxime hydrochloride can be found, as previously mentioned. In this work, the UV spectroscopy method was used to determine the solubility of cefmenoxime hydrochloride in three pure solvents (water, methanol and ethanol) and binary solvent mixtures of isopropanol and water at temperatures ranging from (283.15 to 313.15) K. The models applied to correlate the experimental solubility in pure solvents are the modified Apelblat equation and the NRTL model. And the solubility in binary solvent mixtures was correlated by the modified Apelblat equation, the CNIBS/R–K equation and the combined version of Jouyban–Acree. Furthermore, the mixing thermodynamic properties of cefmenoxime hydrochloride in different solvents were also calculated based on the NRTL model and experimental solubility.

* Corresponding author at: State Key Laboratory of Chemical Engineering, School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China. Tel.: +86 22 27405754; fax: +86 22 27314971.
E-mail address: hongxunhao@tju.edu.cn (H. Hao).

http://dx.doi.org/10.1016/j.jct.2015.11.024
0021-9614/© 2015 Elsevier Ltd. All rights reserved.

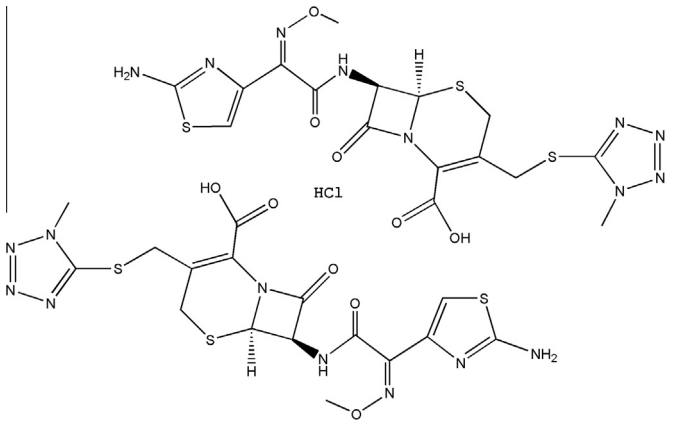

FIGURE 1. Chemical structure of cefmenoxime hydrochloride.

2. Experimental

2.1. Materials

Cefmenoxime hydrochloride was supplied by China Union Chempharma (Suzhou) Co. Ltd. and the distilled–deionised water was supplied by Nankai University, China. All organic solvents (methanol, ethanol and isopropanol) used in the experiments were purchased from Tianjin Jiangtian Chemical Co., Ltd. (Tianjin, China). They are analytical grade reagents with purity higher than 0.995 in mass fraction, determined by gas chromatography (GC). More detailed information about chemicals used in this work is showed in table 1. All chemicals were used in experiments without any further purification.

2.2. Solubility measurements by UV spectroscopy

In this work, the UV spectroscopic method was used to measure the concentration of cefmenoxime hydrochloride in the equilibrium phase. At first, an excess amount of solid cefmenoxime hydrochloride was added into the solvents which were weighed by electronic analytical balance (type AB204, Mettler-Toledo, Switzerland) with accuracy of ±0.0001 g. The equilibrium cell, a sealed glass vessel with a volume of 50 mL, was kept at a specific temperature in a shaker (Tianjin Ounuo Instrument Co. Ltd., China) equipped with a temperature-controlling system with accuracy of T = ±0.05 K. Since the slurry was kept under agitation for enough time (>10 h), the system was guaranteed to have reached (solid + liquid) equilibrium. Agitation was stopped and the slurry was kept still for about 5 h at the same temperature to ensure the separation of liquid and solid. Then the upper clear saturated solutions were filtered by an organic membrane (0.22 μm, Tianjin Legg Technology Co., Ltd, Tianjin, China) and were diluted to a certain concentration that was favorable for UV assay which was carried out on UV-3010 spectrophotometer (HITACHI, Japan) with a 1 cm path length cell [8].

Before measuring the concentration of the saturated solution, the calibration curve of cefmenoxime hydrochloride in binary (isopropanol + water) solvent mixtures was obtained at room temperature and atmospheric pressure. After full wavelength scanning, the maximum absorption wavelength in binary solvent mixtures of isopropanol and water was determined to be 271 nm. And based on the initial screening of solvents, it has been found that the solubility of cefmenoxime hydrochloride could reach relatively maximum when the mass ratio of isopropanol and water was 1:1. Therefore, in this work, all solutions which were taken out of the balanced suspension and then filtered were diluted by the binary (isopropanol + water) solvent mixtures at mass ratio of 1:1. The influence of the original solvent mixtures taken from the saturated solution on absorbance A could be ignored since the amount of it is much less than the diluent [9]. The calibration curve obtained is illustrated in figure 2. The results show that the calibration curve is linear which complies with the Lambert–Beer law. The slope α_i of the fitting line is 0.0324 with R^2 = 0.9999.

For each solubility point, the process illustrated above was repeated until three subsequent absorbance measurements were identical (within 0.05). During the measurements, the solid phases in equilibrium with the studied solvents were characterized by PXRD to determine that it is congruent with the original material added into the solvents. And the results indicate that the solid phase didn't change. And the amount of Cl was checked by titration and the results revealed that the ratio of Cl to base in the solution is the same with the solid phase (1:2). The mole fraction solubility described by equations (1) and (2) was calculated based on the average absorbance [10]:

$$m = \frac{A}{\alpha_i} \times V, \tag{1}$$

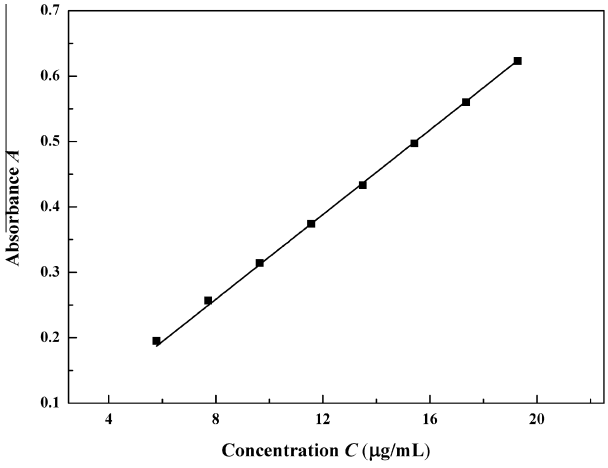

FIGURE 2. Absorbance *versus* concentration (μg · mL^{-1}) calibration curve of cefmenoxime hydrochloride.

TABLE 1
Provenance and mass fraction purity of materials studied in this paper.

Chemical name	Source	Mass fraction purity	Purification method	Analysis method
Cefmenoxime hydrochloride	China Union Chempharma	>0.99	None	HPLC[a]
Isopropanol	Tianjin Jiangtian Chemical	>0.995	None	GC[b]
Methanol	Tianjin Jiangtian Chemical	>0.995	None	GC[b]
Ethanol	Tianjin Jiangtian Chemical	>0.995	None	GC[b]

[a] High-performance liquid chromatography.
[b] Gas chromatography.

Download English Version:

https://daneshyari.com/en/article/215090

Download Persian Version:

https://daneshyari.com/article/215090

Daneshyari.com