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Solubilities of *p*-Aminophenol in Sulfuric Acid + Water + (Methanol, Ethanol, 1-Propanol, 2-Propanol, 1,2-Propanediol, and Glycerin, Respectively) from (292.35 to 348.10) K

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Using a laser monitoring observation technique, the solubilities of *p*-aminophenol in sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively) have been determined experimentally from (292.35 to 348.10) K. The experimental data were correlated with the modified Apelblat equation.

Introduction

p-Aminophenol (PAP) also known as 4-aminophenol or 4-hydroxyaniline, which is an aromatic amphoteric compound with unique physical, chemical, and biological properties, is an important fine chemical intermediate with wide uses and optimum application prospects.[1−3] It is manufactured through several chemical methods.[4] An alternative method is the electrolytic method[5−7] using nitrobenzene as the raw material and sulfuric acid as the supporting electrolytes. This route appears to be preferable because it is clean and poses no pollution problems. The yield is also higher than those achievable by the chemical methods, and the purity of product is better. In the synthesis process of *p*-aminophenol, the adding of some organic solvent (such as ethanol, 1-propanol, 2-propanol etc.) is important for obtaining the high current density and space−time−yield (the unit time output in unit volume electrochemical reactor, $\text{kg}\cdot\text{s}^{-1}\cdot\text{m}^{-3}$). Several studies[8−10] have also shown that the kind and concentration of the organic solvent used in electrolysis are the critical parameters that could be varied and that the adding of some alcohols in electrolyte shows especial important effect for high space−time−yield. So, it is necessary to know the solubility data of *p*-aminophenol in the mixed solvent (electrolyte) of sulfuric acid + water + alcohols, but the solubility data that have been reported[11−14]are only in water, water + sulfuric acid, or some pure organic solvents. In this study, the solubilities of *p*-aminophenol in sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively) have been measured from (292.35 to 348.10) K at atmospheric pressure. The experimental data were correlated with the modified Apelblat equation.[15,16]

Experimental Section

Materials. High-grade sulfuric acid from Louyan Chemical Reagent Co. was used directly without further purification. Its purity was determined by titration to be 0.990 in mass fraction. Methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin were of AR grade; were obtained from Shanghai Chemical Reagent Co.; and had the purities 0.995, 0.995, 0.995, 0.995, 0.990, and 0.990 in mass fraction, respectively. Analytical grade *p*-aminophenol from Peking Biotech. Co. Ltd. was further purified by recrystallizations from solutions of water. After filtration, the sample was first vacuum-dried to constant mass and then was further vacuum-dried over anhydrous NaOH to remove any existing traces of water. Its purity was determined by UV spectrophotometry (type UV-2401PC, Shimadzu Co. Ltd.) to be 0.997 in mass fraction. Water used in experiments was double-distilled water.

Apparatus and Procedure. The solubilities were measured by a dynamic method.[17,18] The laser monitoring observation technique[19−22] was used to determine the dissolution temperature of a solid−liquid mixture of known composition. The laser monitoring system consists of a laser generator, a photoelectric transformer, and a recorder. The experiments were carried out in a magnetically stirred, jacketed glass vessel (60 cm^3). A constant temperature (± 0.02 K) was maintained by circulating water through the outer jacket from a thermoelectric controller (type 501, Shanghai Laboratory Instrument Works Co. Ltd.) at the required temperature. A condenser was connected with the vessels to prevent the solvents from evaporating. A mercury-in-glass thermometer was inserted into the inner chamber of the vessels for the measurement of the temperature. The uncertainty of temperature was ± 0.05 K.

Solvents for the solubility measurement were prepared by mass using an electronic balance (type AW120, Shimadzu Co.). The balance has a range of measurement up to 120 g, with an uncertainty of ± 0.0001 g. Before the solubility measurement, through the condenser, high-purity nitrogen (99.9995 % by mass, 50 $\text{mL}\cdot\text{min}^{-1}$) was fed into the solvent for 1 h to remove the dissolved oxygen. Predetermined amounts of *p*-aminophenol was weighed and transferred into the vessel. The contents of the vessel were heated very slowly at rates less than 2 $\text{K}\cdot\text{h}^{-1}$ with continuous stirring, and the increasing rate of temperature was controlled by a TP technique (temperature controller type AI-708P, Xiamen Electronic Technology Co. Ltd). In the early stage of the experiment, the laser beam was blocked by the turbidity of the solution, so the intensity of the laser beam penetrating the vessel was diminished. The intensity increased gradually along with the increase of the amount of *p*-aminophenol dissolved. When the last portion of *p*-aminophenol disappeared, the intensity of the laser beam penetrating the vessel reached the maximum, and the temperature was recorded as the liquidus

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Table 1. Solubilities of *p*-Aminophenol in (w = 0.20) Sulfuric Acid + (w = 0.60) Water + (w = 0.20) (Methanol, Ethanol, 1-Propanol, 2-Propanol, 1,2-Propanediol, and Glycerin, Respectively)[a]

T/K	$100x$	rel dev/%	T/K	$100x$	rel dev/%
Sulfuric Acid + Water + Methanol					
294.20	2.183	−0.73	311.05	3.353	0.27
297.45	2.407	−0.62	317.20	3.677	−1.20
301.25	2.689	0.19	322.95	4.001	−0.77
305.45	2.979	0.20	326.05	4.168	−0.26
308.15	3.161	0.22	330.90	4.388	0.27
Sulfuric Acid + Water + Ethanol					
294.45	2.546	−0.47	316.60	4.021	0.024
299.50	2.922	0.82	320.95	4.273	−0.094
305.15	3.293	0.39	327.90	4.644	−0.11
307.25	3.411	−0.26	331.15	4.821	0.37
310.35	3.654	0.82	335.65	4.991	−0.060
314.70	3.914	0.31	343.45	5.292	0.68
Sulfuric Acid + Water + 1-Propanol					
292.85	2.608	−1.2	319.50	4.481	−0.47
297.45	2.964	−0.13	325.55	4.811	−0.98
302.43	3.345	0.45	332.35	5.139	−1.3
307.22	3.707	0.89	339.70	5.522	0.36
312.70	4.061	0.098	346.05	5.718	0.68
314.16	4.148	−0.17			
Sulfuric Acid + Water + 2-Propanol					
295.35	2.506	−0.24	319.90	4.232	0.45
300.75	2.888	0.069	326.35	4.598	−0.39
305.70	3.270	1.0	332.60	4.954	−0.26
311.60	3.661	0.27	340.05	5.325	0.075
313.85	3.813	0.16	348.10	5.659	0.65
316.70	4.019	0.45			
Sulfuric Acid + Water + 1,2-Propanediol					
292.35	2.486	0.40	323.35	4.569	0.39
297.10	2.799	−0.071	324.90	4.646	0.13
302.10	3.153	0.095	329.95	4.894	−0.39
306.95	3.494	0.20	336.90	5.235	−0.076
311.85	3.829	0.18	344.95	5.556	0.45
318.30	4.281	0.89			
Sulfuric Acid + Water + Glycerin					
293.65	2.474	−0.040	318.70	4.199	0.48
298.05	2.787	0.39	324.80	4.553	0.089
303.05	3.127	0.13	331.88	4.920	−0.22
308.25	3.499	0.43	338.51	5.243	0.21
313.10	3.825	0.29	343.50	5.442	0.44
313.65	3.852	0.052			

[a] x is the mole fraction solubility.

temperature.[19] In the processes of solubility measurement, the high purity nitrogen flowing at 1.5 mL·min^{-1}was maintained to prevent air from entering the vessel. Some of the solubility experiments were conducted two or three times to check the reproducibility. Reproducibility of measurements was 0.1 K, which corresponds to a relative deviation in composition smaller than 1 %. To verify the reliability of the measurement, the authors[14] had measured the solubility data of *p*-aminophenol in water using the same apparatus and procedure. The result showed that the deviations of the measured solubility from the literature values[11,14] are less than 2 %. In this work, the uncertainty for solubility measurement is estimated based on the principle of the error propagation and found to be within ± 1 % at the 95 % confidence level.

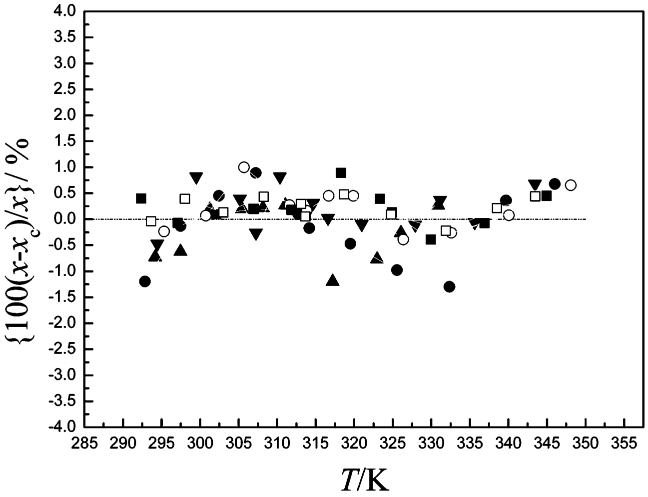

Figure 1. Graph of relative deviation function for studied systems: ▲, sulfuric acid + water + methanol; ▼, sulfuric acid + water + ethanol; ●, sulfuric acid + water + 1-propanol; ○, sulfuric acid + water + 1-propanol; ■, sulfuric acid + water + 1,2-propanediol; □, sulfuric acid + water + glycerin.

Results and Discussion

The measured mole fraction solubilities (x) of *p*-aminophenol in sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively) at different temperatures T are presented in Table 1. For each mixed solvent system, both the mass fraction of sulfuric acid and the mass fraction of alcohol are 0.20. The temperature dependence of *p*-aminophenol solubility at fixed solvent composition is described by the modified Apelblat equation:[15,16]

$$\ln x = A + \frac{B}{T/\mathrm{K}} + C\ln(T/\mathrm{K}) \qquad (1)$$

where x is the mole fraction of *p*-aminophenol. T is the absolute temperature, and A, B, and C are the parameters in eq 1. The values of these parameters together with the root-mean-square deviations (rmsd values) are listed in Table 2. The rmsd is defined as

$$\mathrm{rmsd} = \left[\sum_{i=1}^{N}\frac{(x_{ci} - x_i)^2}{N}\right]^{1/2} \qquad (2)$$

where N is the number of experimental points and x_c is the solubility calculated by eq 1. The relative deviations between the experimental value and calculated value are also listed in Table 1. Relative deviations are calculated according to

$$\text{relative deviations (\%)} = \left(\frac{x - x_c}{x}\right) \times 100 \qquad (3)$$

The graph of relative deviations function for all systems in this study is shown in Figure 1. From Tables 1 and 2 and Figure 1, it can be found that the calculated solubilities show good

Table 2. Parameters of Equation 1 for the *p*-Aminophenol + (w = 0.20) Sulfuric Acid + (w = 0.60) Water + (w = 0.20) (Methanol, Ethanol, 1-Propanol, 2-Propanol, 1,2-Propanediol, and Glycerin, Respectively) Systems

solvent	A	B	C	10^4 rmsd
sulfuric acid + water + methanol	327.12	−16840	−48.150	2.0
sulfuric acid + water + ethanol	227.70	−12116	−33.459	1.7
sulfuric acid + water + 1-propanol	230.14	−12217	−33.815	3.2
sulfuric acid + water + 2-propanol	220.80	−11935	−32.361	1.9
sulfuric acid + water + 1,2-propanediol	217.23	−11656	−31.888	1.7
sulfuric acid + water + glycerin	221.77	−11910	−32.541	1.2

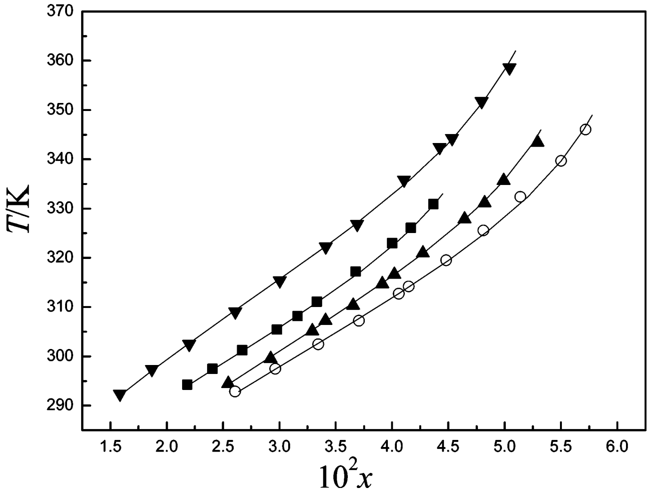

Figure 2. Solubilities of *p*-aminophenol in (w = 0.20) sulfuric acid + water + (w = 0.20) alcohols: ▼, sulfuric acid + water; ■, sulfuric acid + water + methanol; ▲, sulfuric acid + water + ethanol; ○, sulfuric acid + water + 1-propanol; —, calculated from eq 1.

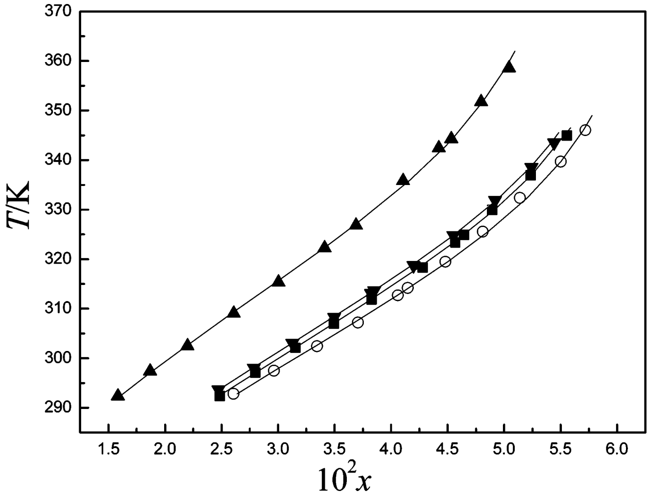

Figure 3. Solubilities of *p*-aminophenol in (w = 0.20) sulfuric acid + water + (w = 0.20) alcohols: ▲, sulfuric acid + water; ▼, sulfuric acid + water + glycerin; ■, sulfuric acid + water + 1,2-propanediol; ○, sulfuric acid + water + 1-propanol; —, calculated from eq 1.

agreement with the experimental data, which indicate that the modified Apelblat equation can be used to correlate the solubilities data of *p*-aminophenol in sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively). The overall rmsd of 66 data points for the sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively) system is 2.0×10^{-4}. The relative deviations among all these values do not exceed 1.3 %, and the average relative deviation is 0.39 %. The experimental solubility and correlation equation in this work can be used as essential data and models to serve the synthesis process of *p*-aminophenol.

In this work, the mixed solvents used contain a kind of alcohols mentioned above, respectively. By using the data shown in Table 1, $T-x$ curves for *p*-aminophenol + sulfuric acid + water + alcohols system [i.e., the *p*-aminophenol + sulfuric acid + water + (methanol, ethanol, and 1-propanol, respectively) systems as shown in Figure 2, *p*-aminophenol + sulfuric acid + water + (1-propanol, 1,2-propanediol and glycerin respectively) systems as shown in Figure 3, and *p*-aminophenol + sulfuric acid + water + (1-propanol and 2-propanol respectively) systems as shown in Figure 4] were plotted. For comparison, the $T-x$ curves for *p*-aminophenol + sulfuric acid + water based on the literature values[14] were also drawn in every figure.

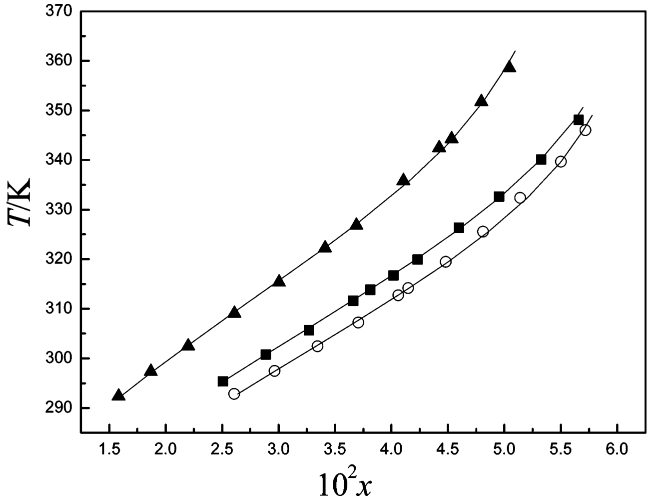

Figure 4. Solubilities of *p*-aminophenol in (w = 0.20) sulfuric acid + water + (w = 0.20) alcohols: ▲, sulfuric acid + water; ■, sulfuric acid + water + 2-propanol; ○, sulfuric acid + water + 1-propanol; —, calculated from eq 1.

From Figure 2 it can be found that, for the mixed solvent systems containing normal monohydric alcohol, the solubility of *p*-aminophenol increases with the increase of the carbon atom numbers of the alcohols at constant temperature. From Figure 3 it can be known that, for the mixed solvent systems containing 1-propanol, 1,2-propanediol, and glycerin, respectively, which all contain three-carbon atoms, the solubility of *p*-aminophenol in the mixed solvents decrease with the increase of hydroxyl group numbers of the alcohols at constant temperature.

According to Scatchard–Hildebrand's theory,[23] the solubility of the solute in the solvent is the largest when solubility parameter of the solute and the solvent are the same, which means further that the less the difference of solubility parameter value between the solute and the solvent is, the larger the solubility of the solute in the solvent is. For binary or polyatomic mixed solvent, we can regard them virtually as a "single solvent",[24,25] and the values of solubility parameter (δ_m) for mixed solvents can be calculated according to[23]

$$\delta_{\mathrm{m}} = \sum(\Phi_i\delta_i) \qquad (4)$$

where Φ_i is the volume fraction of the component i in mixed solvent; δ_i is the solubility parameter of the component i in mixed solvent. So with the values of the solubility parameter (δ_i) of methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, glycerin, water,[26]and sulfuric acid,[22] the solubility parameters (δ_m) for the binary or ternary mixed solvents shown in Figures 2, 3, and 4 can be calculated. For the sulfuric acid + water system, the calculated value is 45.7 MPa$^{1/2}$; for the sulfuric acid + water + (methanol, ethanol, 1-propanol, 1,2-propanediol, glycerin, and 2-propanol, respectively) systems, the calculated values are 41.0, 40.1, 39.7, 41.0, 42.99, and 39.5 MPa$^{1/2}$, respectively. For the solute *p*-aminophenol, with its melting point data,[11] sublimation enthalpy data,[27] molar volume data,[28] and its fusion enthalpy and heat capacity difference data between liquid and solid *p*-aminophenol at melting temperature determined by DSC (STA 449C, Germany NETZSCH Co.), its solubility parameter (δ_{PAP}) can be calculated in terms of the estimating method of the solubility parameter of the subcooled liquid presented by Prausnitz et al.,[23] where (δ_{PAP}) is 29.2

$MPa^{1/2}$. Compared with the values of δ_{PAP} and δ_m, it can be found that the value of the solubility parameter (δ_{PAP}) of the solute is far less than those (δ_m) of the mixed solvents. Since the δ_m value for the sulfuric acid + water system is the largest in all mixed solvent systems investigated, the solubility of *p*-aminophenol in sulfuric acid + water is the least at constant temperature. Adding alcohol in sulfuric acid + water leads to the decrease of solubility parameter of the mixed solvent, which makes the difference of the values of solubility parameter between the solute (*p*-aminophenol) and the mixed solvent decrease. Therefore, the solubility of *p*-aminophenol increases.

For the four mixed solvents shown in Figure 2, their solubility parameters (δ_m) decrease according to the order from sulfuric acid + water, sulfuric acid + water + methanol, sulfuric acid + water + ethanol to sulfuric acid + water + 1-propanol, which makes the difference of the values of solubility parameter between *p*-aminophenol and the mixed solvent decrease according to the same order. Therefore, the solubilities of *p*-aminophenol in the four mixed solvents increase in the same order. The difference of solubility parameters for the last three kinds of mixed solvents is small, so the difference of the solubility of *p*-aminophenol in them is also small.

For the four mixed solvents shown in Figure 3, their solubility parameters (δ_m) increase according to the order from sulfuric acid + water + 1-propanol, sulfuric acid + water + 1,2-propanediol, sulfuric acid + water + glycerin to sulfuric acid + water, which makes the difference of the values of solubility parameter between *p*-aminophenol and the mixed solvent increase according to the same order. Therefore, the solubilities of *p*-aminophenol in the four mixed solvents decrease according to the same order. The difference of solubility parameters for the first three kinds of the mixed solvents is small, so the difference of the solubility of *p*-aminophenol in the three mixed solvents is also small.

The solubility parameter (δ_m) for sulfuric acid + water + 2-propanol is very close to that of sulfuric acid + water + 1-propanol. But the solubility of *p*-aminophenol in sulfuric acid + water + 2-propanol is lower than that in sulfuric acid + water + 1-propanol (see Figure 4). The difference of the structural effects of 2-propanol and 1-propanol is probably one of the reasons for the difference of the solubility.

Further discussion can be done from the viewpoint of molecular interaction. In the *p*-aminophenol (A) + water (B) system, water molecules can associate through the O−H···O hydrogen bond. Since *p*-aminophenol is an aromatic amphoteric compound containing both a −OH group and an $-NH_2$ group in its molecule, the association behaviors among adjacent *p*-aminophenol molecules can also occur because of the special chemical interaction between alkaline $-NH_2$ group in one *p*-aminophenol molecule and acidic −OH group in another molecule. Due to the associations, the interaction intensity between A−B is far weaker than that between A−A or B−B, so the solubility of *p*-aminophenol in water is very low.[14] With the adding of sulfuric acid in the system, a stronger interaction between the alkaline $-NH_2$ group in *p*-aminophenol molecule and the H^+ in the solution occurs, which makes the solubility of *p*-aminophenol in the mixed solvent increase obviously.

The addition of alcohols increases the quantity of the −OH group in the mixed solvent, which promotes further the interaction between *p*-aminophenol molecules and solvent molecules by O−H···O hydrogen bond and N−H···O hydrogen bond[29] and makes the solubility of *p*-aminophenol increase.

In this work, the used alcohols (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin) are all the substances having association character, but their association level is different. At 298.15 K, the association constants of the first four kinds of normal monohydric alcohol are 119.2, 89.8, 70.5, and 44.4,[30] respectively. Obviously, except 2-propanol (which is particular due to its special structural effects), the association constant of 1-propanol is the minimum. In other words, the dissociation tendency of 1-propanol in mixed solvent is the largest, which is the most beneficial to increase the interaction between *p*-aminophenol molecules and the solvent molecules. So, the solubility of *p*-aminophenol is the highest in sulfuric acid + water + 1-propanol. In contrast, the association constant of methanol is the largest (i.e., the dissociation tendency of methanol in mixed solvent is the minimum, which is unbeneficial to increase the interaction between *p*-aminophenol molecules and the solvent molecules). So, the solubility of *p*-aminophenol is the lowest in sulfuric acid + water + methanol.

1,2-Propanediol and glycerin are both polyhydric alcohols, consisting of two or three hydroxyl in their molecules, respectively. Compared with those of the normal monohydric alcohols, their association constants are probably larger. Their density and viscosity are also larger, and their molecular structures are more complex. Therefore, the effect of 1,2-propanediol or glycerin in solution on the solubility of *p*-aminophenol as well as the interaction between *p*-aminophenol molecules and solvent molecules is also more complex, which needs further study.

It should also be mentioned that the shape of the solubility curves in this work is unusual. In terms of Gibbs−Helmholtz equation, the Gibbs free energy change ΔG_s in the dissolving process can be calculated according to

$$\Delta G_s = \Delta H_s - T\Delta S_s \tag{5}$$

where, ΔH_s and ΔS_s stand for the enthalpy of solution and the entropy of solution, respectively.

For the polyatomic solid−liquid phase equilibrium systems containing *p*-aminophenol, sulfuric acid, water, and alcohol in this study, when the polyatomic mixed solvents (sulfuric acid + water + alcohol) are virtually regarded as a "single solvent",[24,25] referring to the work of Chen and Wagner[31] for further information, both the activity coefficient value of *p*-aminophenol in *p*-aminophenol phase and that of the solvent in solvent phase can be assumed to be equal to 1. So, two equations to calculate the enthalpy of solution and the entropy of solution of *p*-aminophenol in polyatomic solvents can be deduced from Gibbs−Duhem equation within the temperature and solubility range investigated in this work:

$$\Delta H_s = RT^2\left(\frac{\partial \ln x_i}{\partial T}\right)_P \tag{6}$$

$$\Delta S_s = RT\left(\frac{\partial \ln x_i}{\partial T}\right)_P \tag{7}$$

where R is the universal gas constant. With the introduction of eq 1 into eqs 6 and 7 and the calculation of the derivation of T, respectively, the change rate equations of ΔH_s and ΔS_s corresponded to the temperature can be obtained:

$$\frac{d(\Delta H_s)}{dT} = RC \tag{8}$$

$$\frac{d(\Delta S_s)}{dT} = \frac{RB}{T^2} \tag{9}$$

From eq 8, it can be known that the change rate of ΔH_s corresponded to the temperature is not related to temperature T, but just determined by the parameter C. However, from eq 9, the change rate of ΔS_s is temperature dependent, which is inversely proportional to T^2. From Table 2 it can be found that the values of parameters B and C are all negative for each polyatomic solid−liquid-phase equilibrium system containing *p*-aminophenol, sulfuric acid, water, and alcohol (six groups in all), which indicates that both the ΔH_s and the ΔS_s of *p*-aminophenol in the six groups of mixed solvents decrease with the increase of temperature. Since the decrease rate of ΔH_s with the increase of temperature T is a temperature independent constant and the decrease rate of ΔS_s with the increase of temperature T is inversely proportional to T^2, with the increase of temperature, the decrease rate of ΔH_s is a constant (where the rate value equals to the product of the gas constant R and the parameter C, see eq 7), whereas the decrease rate of ΔS_s gradually declines. Compared to the influence of the enthalpy of solution, with the increase of the temperature, the influence of entropy effects on the solubility of *p*-aminophenol becomes stronger and stronger.

The values[14] of parameters B and C of all six groups are also negative for the ternary solid−liquid phase equilibrium systems containing *p*-aminophenol, sulfuric acid, and water without alcohol,[14] which are similar to those shown in Table 2 in the systems with alcohols. Similarly, according to eqs 8 and 9, it can be also known that both ΔH_s and ΔS_s of *p*-aminophenol in these mixed solvents systems also decrease with the increase of temperature. For the system[14] containing *p*-aminophenol and water, however, the value[14] of parameter C is positive. This result indicates that ΔH_s for *p*-aminophenol in water increases with the increase of temperature, which is different from those systems containing sulfuric acid. The above results also indicate that, in the discussed systems containing H_2SO_4, the interaction between *p*-aminophenol molecules and the H_2SO_4 molecules is possibly dominant. The addition of alcohols increases the quantity of the −OH group in the mixed solvent and further promotes the interaction between *p*-aminophenol molecules and solvent molecules by O−H···O hydrogen bond and N−H···O hydrogen bond,[29] but the interaction is possibly not dominant as compared with the interaction between *p*-aminophenol molecules and the H_2SO_4 molecules. What is more, due to the possible reactions[32] between the H_2SO_4 molecules and the alcohol molecules in the mixed solvents, the promoting effect to the solubility of *p*-aminophenol is weakened. So, the addition of alcohol, especially the binary and the ternary alcohol, leads to the slight, but not obvious, increase of the solubility of *p*-aminophenol.

Conclusions

Using a laser monitoring observation technique, the solubilities of *p*-aminophenol in sulfuric acid + water + (methanol, ethanol, 1-propanol, 2-propanol, 1,2-propanediol, and glycerin, respectively) have been determined experimentally from (292.35 to 348.10) K. The result shows that the solubilities of *p*-aminophenol are higher in sulfuric acid + water + alcohols than that in sulfuric acid + water.

The experimental data were correlated with the modified Apelblat equation. The solubilities calculated by the models show good agreement with the experimental data. The experimental solubility and correlation equation in this work can be used as essential data and models to serve the synthesis process of *p*-aminophenol.

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