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Full Paper

Electrical and thermodynamic properties for nano $(NH_4)_2Fe(SO_4)_2$ fluids in H_2O at different temperatures.

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Abstract
The electrical conductance and thermodynamic properties data for nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids like molar conductance, association constant and degree of dissociation of different concentrations of nano ferrous ammonium sulfate fluids,FAS in H_2O were measured at three different temperatures. Also from the values of the measured molar conductance, the limiting molar conductance, Gibbs free energies, enthalpy and entropies were calculated and discussed. The aim of the work is to estimate the different thermodynamic parameters depend on the molar conductance for nano fluid $(NH_4)_2Fe(SO_4)_2$,FAS material. The method used is measuring molar conductance by using A JENCO, Vision plus EC3175 (USA) conductance meter and temperature meter with an electrode of cell constant equal (1) connecting with ultra-thermostat of the type Kottermann 4130. The measuring electrical conductance and thermodynamic properties are necessary for manufacturing industries especially in those using electrical and thermo chemical devices.

Keywords: Molar conductance, limiting molar conductance (LC), association constant, degree of dissociation (alpha), mean activity coefficient, Gibbs free energy, enthalpy, entropy, water.

1.Introduction

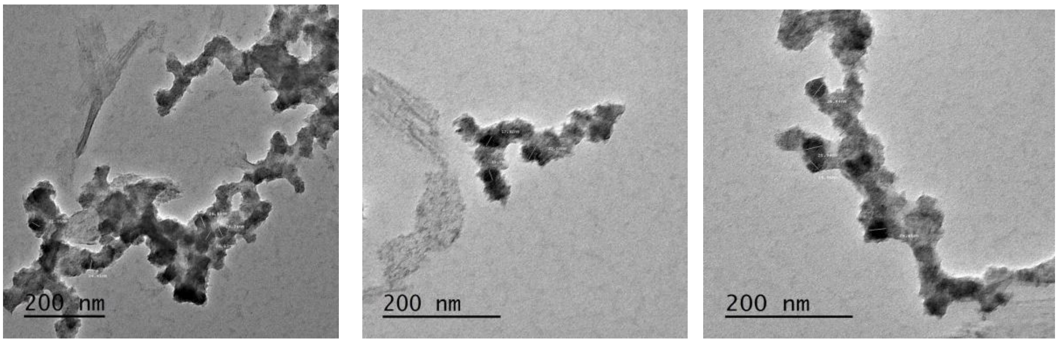
Molar conductance measurements were used to explain solute- solvent interactions [1-2]. The first laboratory instrument to accurate measure the molar conductance of liquids was developed by A JENCO, Vision plus EC3175 conductance meter. Many authors used molar conductance (MC) to evaluate the ion-solvent and solvent –solvent interactions with water, other organic solvents and mixtures of solvents.

Electrical measurement technique (EMT) is used in experimental fluid mechanics (FM) to investigate pure fluids or dilute suspensions. Molar conductance (MC) for nano $(NH_4)_2Fe(SO_4)_2$,FAS fluids play an important roles in many areas , fields and industries of electric and thermodynamic science [3-6]. Ferrous ammonium sulfate, $(NH_4)_2Fe(SO_4)_2$,FAS is a pale green . It is used in many purposes as, photography, analytical chemistry, and iron-plating baths. Ferrous ammonium sulfate, $(NH_4)_2Fe(SO_4)_2$,FAS used as a growth and greening agent, to correct iron choruses or deficiencies in plants and soils, to eliminate moss, to reduce and decrease alkalinity, and as a trace element or micronutrient in fertilizers [7]. The present work includes the estimation and evaluation of limiting molar conductance (LC), association constant, degree of dissociation; mean activity coefficient, Gibbs free energies, enthalpy and entropies for nano ferrous ammonium sulfate fluids, FAS solution at 290.15K, 298.15K and 303.15K. The evaluated physical parameters for ferrous ammonium sulfate, FAS are important in studying the solvation processes in order to facilitate its need for electric and thermodynamic applications. The aim of this work is giving valuable conductivity data for nano ferrous ammonium sulfate $(NH_4)_2Fe(SO_4)_2$,FAS fluids that can be used in industry [8-12].

2. Experimental

Ferrous ammonium sulfate, FAS was supplied from El.Nasr pharmaceutical Chemicals Co. Nano sized $(NH_4)_2Fe(SO_4)_2$, FAS were prepared by using ball milling method (BM). The ball milling (BM) was of the type Retsch MM 2000 swing mill with 10 cm^3 stainless steel long, double-walled tube for circulating coolants. Two, 2 pure stainless steel balls of 12 mm diameter were used. Ball milling was performed at 20,225 Hz frequency and shaking were done for 30 minutes at room temperature (less than 30°C) without using circulating liquid. Transmission electron microscope (TEM) is an interesting tool for measuring the nanoparticles size. It is an accepted and good tool for imaging nano sized material to obtain quantitative measures of particle and /or grain size, size distribution and morphology. TEM images are very sensitive so, it was used to investigate the size and the shape of the nano $(NH_4)_2Fe(SO_4)_2$,FAS fluids which found to be irregular spherical shape in the range 15.76 - 26.88 nm jointed together to form net with different branches as seen in Fig. (1).

The molar conductance for nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids were measured using A JENCO, plus EC3175 (USA) conductance meter and temperature meter with an electrode of cell constant equal (1) connected with ultra-thermostat of the type Kottermann 4130 (to keep the temperature constant at the desired value).



(a) (b) (c)

Fig. 1: Tem images for nano ferrous ammonium sulfate .

3. Results and Discussion

From measured specific conductance (SC) values for nano $(NH_4)_2Fe(SO_4)_2$, FAS the molar conductance (MC) was calculated using equation (1).

$$\Lambda = \frac{((K_s - S_{olve})\, K_{cell}\, 1000)}{C} \qquad (1)$$

Where Λ is the molar conductance for nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids, (K_s) and (K_{solv}) are the specific conductance of the solution and the solvent respectively, (K_{cell}) is the cell constant and C is the molar concentration [13-17].

The values of limiting molar conductance $(\Lambda_\circ)$ for nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids were obtained by extrapolating experimental (Λ) values vs $(C^{1/2})$ to zero concentration for each line. These are shown in Fig (2).

The experimental data of (Λ) and $(\Lambda_\circ)$ were analyzed firstly by using Fuoss-Kraus theory, plot of $(1/\ \Lambda_o S(Z)$ vs $C\Lambda\gamma_\pm^2 S(Z))$ method to estimate association constant (K_A) (slope equal K_A/Λ_o^2) for nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids [18-21]. This mentioned method is given by equation (2).

$$\frac{1}{\Lambda.S(z)} = \frac{1}{\Lambda_\circ} + \left(\frac{KA}{\Lambda_\circ}\ .(C.\Lambda.\gamma^2_\pm.S(z)\right) \qquad (2)$$

Where S(z) is the Onsager coefficient, $(\gamma_\pm)$ is the mean activity coefficient, which was calculated from $[\ \log \gamma_\pm = -0.5062.C^{1/2}]$ and (α) is the degree of dissociation which can be calculated from equation (3).

$$\alpha = \frac{\Lambda.S\ (z)}{\Lambda_\circ} \qquad (3)$$

The values of Gibbs free energy (ΔG) for nano $(NH_4)_2Fe(SO_4)_2$,FAS fluids were calculated from equation (4).

$$\Delta G = -R\ T\ \ln K_A \qquad (4)$$

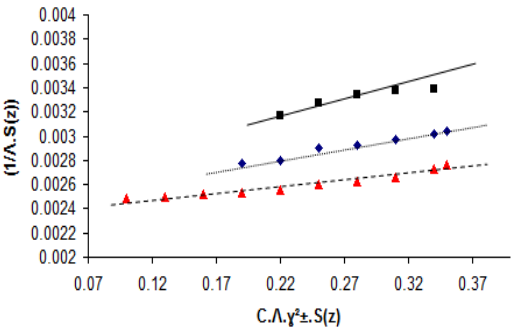
Where R is the molar gas constant $(R=8.314\ J.mol^{-1}.K^{-1})$ and T is the temperature in Kelvin.

The evaluation of enthalpy (ΔH) can be calculated from the slope which estimated by plotting relation between $\log K_A$ and temperature reciprocal (1/T) for nano $(NH_4)_2Fe\ (SO_4)_2$, FAS fluids [22,23] as shown in figure (3), Where $[\Delta H = -2.303\ R.\ slope]$.

The values of entropy (ΔS) for nano $(NH_4)_2Fe\ (SO_4)_2$, FAS fluids [23-24] can be calculated from equation (5).

$$\Delta G = \Delta H - T\ \Delta S \qquad (5)$$

The measured molar conductance (Λ),limiting molar conductance$(\Lambda_\circ)$, association constant (K_A), degree of dissociation(α), mean activity coefficient $(\gamma_\pm)$, Gibbs free energy(ΔG) in KJ/mole, enthalpy(ΔH) in KJ/mole and entropy(ΔS) in J/mole for different concentrations of nano $(NH_4)_2Fe(SO_4)_2$, FAS fluids used are listed in table 1.



(Black square dot refers to data at 290.15K, blue diamond shaped refers to data at 298.15K and red triangle shape refers to data at 303.15K).

Fig. 2: Plot of $(C.\Lambda.\gamma^2_\pm.S\ (z))$ versus $(1/\ (\Lambda.S\ (z))$ for different concentrations of nano $(NH_4)_2Fe$ $(SO_4)_2$ in H_2O at different three temperatures.

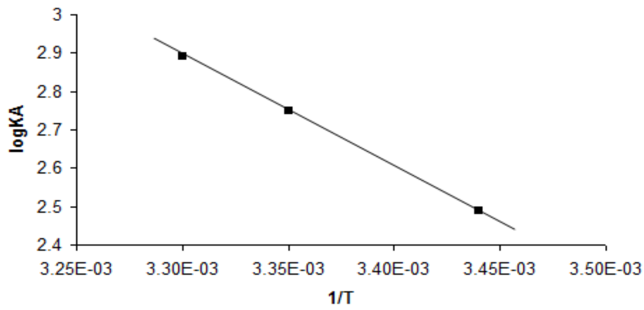


Fig. 3: Plot of (1/T) versus($\log K_A$) for nano $(NH_4)_2Fe(SO_4)_2$ (C=9.1E^{-4}Mole/L) solutions in H_2O.

Table 1: Molar conductance (Λ),limiting molar conductance($\Lambda_\circ$), association constant (K_A),degree of dissociation(α),mean activity coefficient ($\gamma_\pm$),Gibbs free energy(ΔG) in KJ/mole, enthalpy(ΔH) in KJ/mole and entropy(ΔS) in J/mole for different concentrations of nano $(NH_4)_2Fe(SO_4)_2$, FAS in H_2O.

a) 290.15K

C	Λ	$\Lambda_\circ$	K_A	α	$\gamma_\pm$	ΔH	ΔG	ΔS
0.001	208	322.5	151.4	0.6450	0.963	63.824	-12.108	261.7
9.7E-4	287.6	322.5	289.5	0.8918	0.9645	63.824	-13.671	267.1
9.1E-4	296.7	322.5	308.1	0.92	0.9654	63.824	-13.821	267.6
8.6E-4	299.5	322.5	314	0.9287	0.966	63.824	-13.867	267.8
7.7E-4	3 4.9	322.5	325.4	0.9482	0.968	63.824	-13.953	268.1
6.25E-4	315.3	322.5	347.9	0.9777	0.971	63.824	-14.114	268.7

b) 298.15K

C	Λ	$\Lambda_\circ$	K_A	α	$\gamma_\pm$	ΔH	ΔG	ΔS
0.001	329	367.6	541.2	0.8950	0.9633	63.824	-15.601	266.4
9.1E-4	335.6	367.6	563.1	0.9119	0.9654	63.824	-1 .700	266.7
8.8E-4	336.7	367.6	566.8	0.9151	0.9656	63.824	-15.716	266.8
8.3E-4	342.5	367.6	586.5	0.9334	0.9668	63.824	-15.800	267.1
8.1E-4	344.8	367.6	594.4	0.9404	0.9673	63.824	-15.834	267.2
7.3E-4	357.1	367.6	637.6	0.9687	0.9690	63.824	-16.008	267.8
7.1E-4	359.7	367.6	646.9	0.9771	0.9695	63.824	-16.043	267.9

c) 303.15K

C	Λ	$Λ_∘$	K_A	α	$γ_±$	ΔH	ΔG	ΔS
0.001	366	405	758.2	0.9037	0.9634	63.824	-16.713	265.67
8.6E-4	366.3	405	759.4	0.9044	0.9664	63.824	-16.717	265.68
8.3E-4	375.9	405	799.8	0.9281	0.9668	63.824	-16.847	266.11
7.7E-4	381.8	405	825.1	0.9427	0.9682	63.824	-16.926	266 37
7.3E-4	384.6	405	837.2	0.9533	0.9690	63.824	-16.962	266.49
6.5E-4	392.2	405	870.6	0.9709	0.9707	63.824	-17.061	266.81
6.25E-4	395.3	405	884.4	0.9760	0.9713	63.824	-17.101	266.95
6.1E-4	396.7	405	890.7	0.9795	0.9716	63.824	-17.119	267
5.8E-4	400	405	905.6	0.9877	0.9723	63.824	-17.160	267.14
5.6E-4	401.8	405	913.8	0.9921	0.9728	63.824	-17.183	267.22

Conclusion

It was observed from the calculated values that the electrical parameters increased by decreasing the concentration of $(NH_4)_2Fe(SO_4)_2$, FAS fluid and increasing the temperature. Gibbs free energy values decreased with increasing temperature and with decreasing the concentration. The entropy values are increased by decreasing the concentration of nano fluid. The calculated enthalpy is endothermic in character.

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