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Optical and Polarization Parameters for Nano $MnSO_4$ Fluids in 20% (EtOH-H_2O) Solvents at Different Temperatures

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The optical properties for nano $MnSO_4$ fluids like refractive index and molar refraction of different concentrations of nano manganese sulfate fluids in mixed 20% (EtOH-H_2O) solvents were measured at four different temperatures. From the values of the measured refractive indices and their densities, the atomic, electronic polarizations, the molar volumes, polarizabilities and the induced dipole moment were calculated and discussed. The aim of the work is to estimate the different parameters depend on the refractive index and density values for new nano fluid $MnSO_4$ material. The method used is measuring refractive index by Abbe refractometer and density by using pycknometer type weighing bottle. The polarization parameters explained before were decreased by decreasing the nano manganese sulfate fluid concentrations. The refractive index properties measured are necessary for manufacturing industries especially in those using optical devices.

Introduction

Refractive index and density measurements were expected to explain solute – solvent interactions [1-2]. Detection of liquid concentration by optical refractive index was already known in old time [3]. The first laboratory instrument to accurate measure the refractive index of liquids was developed by Ernst Abbe in 1874. Many authors used both refractive index and density to evaluate the ion – solvent and solvent – solvent interactions [3-4], with water [5-7] and other organic solvents [8-10]. Optical measurement technique such as refractive indexes is used in experimental fluid mechanics to investigate pure fluids or dilute suspensions [10-12]. Refractive index as that for nano $MnSO_4$ fluids plays an important role in many areas and fields of material science with reference to thin film technology and fiber optics.

Similarly, measurement of refractive index is widely used in analytical chemistry to determine the concentration of pollutions [13-16]. The present work includes the estimation of polarizabilities and induced dipole moments for nano manganese sulfate fluids solutions at 298.15K, 303.15K, 308.15K, and 313.15K. The evaluated physical parameters for manganese sulfate are important in studying the solvation processes facilitate its need for optical, manufacturing of film and sheeting materials [17-20]. The aim of this work is giving valuable refraction data for manganese sulfate (nano $MnSO_4$ fluids) that can be used in industry and environment.

Experimental

Manganese sulfate and ethanol were supplied from EL. Nasr Pharmaceutical Chemicals Co. Nanosized $MnSO_4$ were

prepared by using ball milling method. The ball milling was of the type Retsch MM 2000 swing mill with 10 cm^3 stainless steel, double-walled beaker with fittings for circulating coolants. Two stainless steel balls of 12 mm diameter were used. Ball milling was performed at 20,225 Hz frequency and shaking were used for 30 minutes at room temperature (less than 30°C) without using circulating liquid.

Transmission electron microscopy (TEM) is a good tool for measuring the nanoparticles size. It is an accepted tool for directly imaging nanomaterials 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 $MnSO_4$ fluids which found to be spherical in the range 11.1 - 24.3 nm as in Fig. (1).

The Refractive indices for nano $MnSO_4$ fluids were measured using a refractometer of the type ATAGO 3T.NO 52507 (Abbe) and circulating water was circulated around the prism of refractometer to keep the temperature constant through ultra-thermostat of the type Kottermann.

The solutions were vigorously shaken in ultra-thermostat of the type (SIBATA-SU-20) with an output of 30 W at 50 KHz frequency.

Results and Discussion

From measured refractive indices values for nano $MnSO_4$ fluids, the molar refraction (R) was calculated using the equation

$$R = \frac{n^2-1}{n^2+2} V = P_A + P_E = P_D = P_T \quad (1)$$

Where V is the molar volume for nano $MnSO_4$ fluids which equal $(\frac{M}{d})$, where M and d, are the molecular weight and the measure density of nano fluids at different used temperatures. The right hand side of equation (1) is equal to the total molar polarization (P_T) or distortion polarization (P_D) which equal to the summation of both the electronic polarization (P_E) and atomic polarization (P_A). The value of (P_A) is calculated using the equation

$$P_A = 1.05\ n^2 \quad (2)$$

Substituting the value of (P_A) calculated from equation (2) in equation (1), (P_E) can be calculated.

Tables (1) and (2) present the measured values of refractive index **n** and the calculated values of the molar refraction (R), atomic polarization (P_A) and electronic polarization (P_E) for Nano $MnSO_4$ in mixed Ethanol 20%-H_2O solvents at different molar concentration and temperatures. The calculated values for (P_A) and (P_E) were found to be in a good agreement with references [22-24].

The values for molecular polarizability (α) can be calculated from optical refractive index (**n**) of the for nano $MnSO_4$ fluids containing N molecules per unit volume. The refractive index is related to the polarizability of saturated molecules by Lorenz-Lorenz formula [17] as explained by the equation:

$$\frac{n^2-1}{n^2+2} = \frac{4\,\bar{n}\,\alpha\,\pi}{3} \quad (3)$$

Where $\bar{n} = \frac{N}{V}$, N is Avogadro's number and V is the molar volume of nano $MnSO_4$ fluids.

Applying equation (3), the polarizabilities for different nano $MnSO_4$ fluids were calculated at different temperatures and also presented in Table 2, which agree with references [25-28].

The dipole moments μ for nano manganese sulfate induced by the solvent in mixed 20% (EtOH-H_2O) solvent mixture were calculated by the equation,

$$\frac{(\varepsilon-n^2)(2\varepsilon-n^2)}{\varepsilon(n^2+2)^2} = \frac{4\,\pi\,N g\,\mu^2}{4\,K\,T\,V} \quad (4)$$

where ε is the dielectric constant values for 20% mixed (EtOH-H_2O) solvents.

In using Onsager solution g=1, which is Onsager cavity field. The evaluated induced dipole moments for nano $MnSO_4$ fluids in 20% mixed (EtOH-H_2O) solvents were presented in Table 2, a-d at different temperatures.

Table (1). *Refractive indices* ***n*** *for Nano $MnSO_4$ in mixed Ethanol 20%-H_2O solvents at different molar concentration and temperatures.*

C (molar concentration)	***n*** at 298.15K	***n*** at 303.15K	***n*** at 308.15K	***n*** at 313.15K
0.01	1.3470	1.3470	1.3465	1.3460
0.009	1.3460	1.3460	1.3455	1.3450
0.008	1.3450	1.3445	1.3445	1.3445
0.007	1.3440	1.3440	1.3440	1.3435
0.006	1.3430	1.3430	1.3430	1.3425
0.005	1.3420	1.3420	1.3420	1.3420
0.004	1.3415	1.3410	1.3410	1.3400
0.003	1.3405	1.3405	1.3400	1.3400
0.002	1.3395	1.3395	1.3390	1.3390
0.0015	1.3385	1.3385	1.3385	1.3380

Table (2). *Molar refraction (R), atomic polarization (P_A), electronic polarization (P_E),polarizability (α) and dipole moment constant μ for different nano $MnSO_4$ solutions in 20% by volume EtOH-H_2O solvents at four different temperatures.*

a) 298.15.K.

C	**R**	**P_A**	**P_E**	**α x 10^{23}**	**μ**
0.01	36.5169	1.9054	34.6115	1.4474	1.8147
0.009	36.4214	1.9026	34.5188	1.4436	1.8120
0.008	36.3253	1.8997	34.4256	1.4398	1.8092
0.007	36.2298	1.8969	34.3329	1.4360	1.8065
0.006	36.1341	1.8940	34.2401	1.4322	1.8038
0.005	36.0381	1.8912	34.1469	1.4284	1.8011
0.004	35.9902	1.8898	34.1004	1.4265	1.7998
0.003	35.8942	1.8869	34.0073	1.4227	1.7971
0.002	35.7981	1.8841	33.9140	1.4189	1.7944
0.0015	35.7019	1.8813	33.8206	1.4151	1.7917

b) 303.15K

C	**R**	**P_A**	**P_E**	**α x10^{23}**	**μ**
0.01	31.4660	1.9054	29.5606	1.2472	1.8147
0.009	31.3838	1.9026	29.4812	1.2440	1.8120
0.008	31.2601	1.8983	29.3618	1.2391	1.8079
0.007	31.2188	1.8969	29.3219	1.2374	1.8065
0.006	31.1362	1.8940	29.2422	1.2341	1.8038
0.005	31.0534	1.8912	29.1622	1.2303	1.8011
0.004	30.9709	1.8884	29.0825	1.2276	1.7984
0.003	30.9293	1.8869	29.0424	1.2259	1.7971
0.002	30.8465	1.8841	28.9624	1.2227	1.7944
0.0015	30.7639	1.8813	28.8826	1.2194	1.7917

c) 308.15K.

C	**R**	**P_A**	**P_E**	**α x10^{23}**	**μ**
0.01	31.1070	1.9040	29.2030	1.2456	1.8133
0.009	31.0256	1.9011	29.1245	1.2423	1.8106
0.008	30.9439	1.8983	29.0456	1.2391	1.8079
0.007	30.9031	1.8969	29.0062	1.2374	1.8065
0.006	30.8213	1.8940	28.9273	1.2341	1.8038
0.005	30.7393	1.8912	28.8481	1.2309	1.8011
0.004	30.6575	1.8883	28.7692	1.2276	1.7984
0.003	30.5759	1.8855	28.6904	1.2243	1.7957
0.002	30.4939	1.8827	28.6112	1.2210	1.7930
0.0015	30.4528	1.8813	28.5715	1.2194	1.7917

d) 313.15K

C	R	P_A	P_E	$\alpha \times 10^{23}$	μ
0.01	30.9157	1.9026	29.0131	1.2254	1.8120
0.009	30.8340	1.8997	28.9343	1.2222	1.8092
0.008	30.7933	1.8983	28.8950	1.2205	1.8079
0.007	30.7120	1.8954	28.8166	1.2173	1.8052
0.006	30.6306	1.8926	28.7380	1.2141	1.8025
0.005	30.5897	1.8912	28.6985	1.2125	1.8011
0.004	30.4269	1.8855	28.5414	1.2060	1.7957
0.003	30.4269	1.8855	28.5414	1.2060	1.7957
0.002	30.3452	1.8827	28.4625	1.2028	1.7930
0.0015	30.2638	1.8799	28.3839	1.1996	1.7903

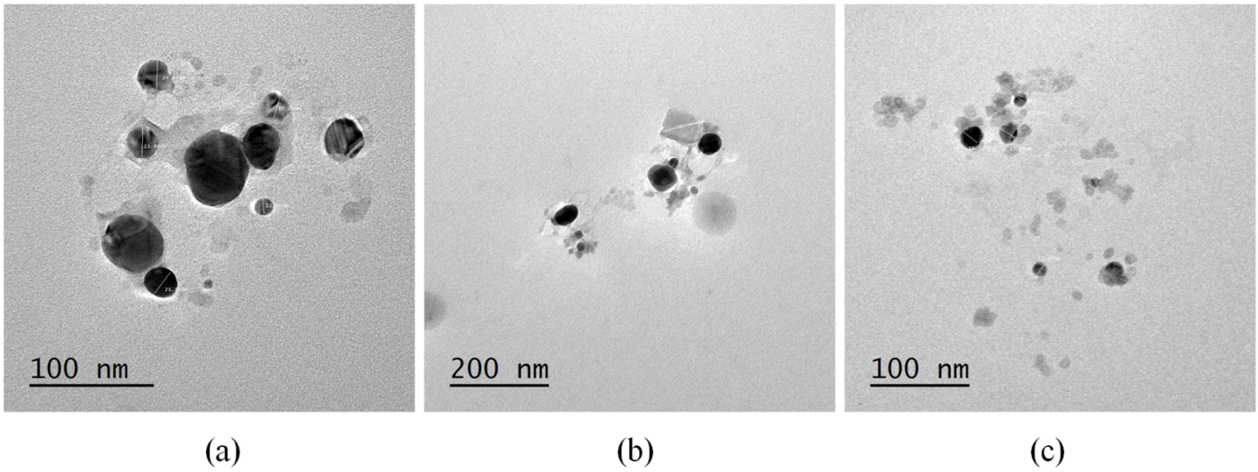

Fig. (1). *TEM images for nano manganese sulfate.*

Conclusion

It is observed from the experimental measured refractive index values and all polarization parameters calculated values that they are decreased by decreasing the nano manganese sulfate fluid concentrations. The induced dipole moments give approximately constant value indicating little effect (dependent) on them. ■

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