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Densities and Apparent Molar Volumes of Curcumin in Solvents: 1,4-Dioxane, Methanol, Ethanol and Di-methyl Sulfoxide (DMSO) at Various Temperature (293.15 to 318.15 K)

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Abstract

Apparent molar volume and density are reported for organic solutions of 1,4-Dioxane, Methanol, Ethanol, and Di-Methyl Sulfoxide (DMSO), and including those of the pure liquids, and their fluid mixtures at different temperatures (293.15 to 318.15 K) and atmospheric pressure. Apparent molar volumes (V_ϕ) of prepared binary solutions were calculated using these density values. The value of the apparent molar volumes show expansibility at intensity for binary method, signifying that there is an extension in volume of the fusion with increasing temperature

Keywords: Organic solvents; Density; Apparent molar volume

Introduction

Thermodynamics is a fundamental subject of great importance in physical chemistry and Chemical Engineering. Thermodynamic properties of curcumin solution play very significant role in understanding the nature, physicochemical behaviour and forces operating between the component molecules in the solution. During recent years noticeable important has been given to study the behaviour of electrolyte and non-electrolyte solution. Furthermore, the accurate knowledge of thermodynamic properties of organic liquid mixtures has relevance in understanding the molecular interactions between the components of the solution, and in developing new theoretical models. The quality and semblance of interactions in base 2 constitutional fluid mixtures have been deliberate in condition of mix together parameters such as excess molar volume. This limit can be calculated from directly measurement of density. The properties of a system may be segment into two categories, namely expanded and intensifying. A widen possession of a system is any title whose size serve on the amount of matter ready. The properties of clear mixtures basically serve on its provincial building, uttered in stipulation of collusion density, communicative mass or radiated apportionments behaviour. therefore, the apparent and partial molar volumes and expansibilities of free have proved to be very beneficial bowl in interpret the textural interactions happen in disruption. the limiting apparent molar volume of aspartame was discussed in terms of the scaled particle theory. the density of the investigated aqueous solutions can be adequately represented by an equation derived by Redlich. density, excess molar volume and apparent molar volume for a binary fusion are main properties. thermodynamics can be used as a tool to determine many volumetric properties like this. Factors such as temperature, pressure affect the thermodynamic and volumetric properties considerably [1-8].

Curcumin is the principal of the popular Indian spice turmeric, which is a member of the ginger family. Turmeric's other two curcuminoids are desmethoxy and bisdesmethoxy curcumin. Turmeric, derived from the plant Curcuma longs, is a gold-colour spice commonly used in the Indian subcontinent, not only for health care but also for their preservation of food and as yellow dye for textiles. Curcumin, which gives the yellow colour to turmeric, was first isolated almost two centuries ago, and its structure as diferuloyl methane was determined in 1910 [9-14].

Experimental Techniques

Experimental technique used for the measurement of density of aforementioned binary solution and their pure components have been described in detail in the present chapter. 1,4-Dioxane, Methanol, Ethanol, and Di-Methyl Sulfoxide (DMSO) product were purified by using the methods described in the literature the mass function purities as determined by gas chromatography are 1, 4-dioxane>0.997, Methanol>0.999, Ethanol>0.993, DMSO>0.995.

The (m, ρ, T) properties were investigated using a high concentration high temperature vibrating tube densimeter. The observed reproducibility and estimated maximum uncertainty of the density measurement between temperatures (293.15 to 318.15) K and concentration up to 0.001 to 0.010 m.

Curcumin, analytical grade was dried overnight in an oven, and afterwards stored over silica gel in a desiccator for use. In order to check the purity of the substances, their density values were determined at different temperatures. Before use, the pure chemicals were stored over 0.4 nm molecular sieves for 72 h to remove water, if any, and were degassed at low pressure. The mixtures were prepared by mass and were kept in special airtight stopper glass bottles to avoid evaporation. The weighing was done by using an electronic balance (model: GR-202R, and, Japan) with a precision of +0.01 mg.

Temperature Control

All the measurements were carried out in a thermostatically controlled and well-stirred water bath. Temperature being controlled with an accuracy of 0.1K. All the measurements of density, ultra-sonic velocity and refractive index was made in a thermostatic water bath

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(Model: MD/ME-31A, JULABO, Germany) in order to maintain the desired uniform temperature.

The thermostatic water bath consists of a microprocessor based digital temperature controller and an integrated circulation pump. The sample was allowed to stand in the bath for about 30 minutes in order to maintain thermal equilibrium between the test samples and the bath liquids.

Density Measurements

Description of the DE 45-meter toledo density meter

In the present study, An Anton paar DE45 type density meter was used for density measurements. The stated precision of this model is 0-3 g/cm our experimental work indicated an uncertainty of 0.00002-0.00005 g/cm. The density meter was housed in a temperature controlled environment where temperature fluctuations were kept to within 0.1K. Decision detail of the temperature controlled chamber were described by Ac four. A circular fitted with a calibrated platinum temperature sensor [IPTS-68] helped in controlling the temperature of the liquid sample in the oscillating tube with in 0.01K. A digital thermometer fitted with a calibrated platinum sensor [ITS-90], with an uncertainty of 0.01K, was employed to monitor the temperature of the liquid sample. The density measurements of some pure liquids are given in Table 1.

Results and Discussion

In this work, the (m, ρ, T) properties and apparent molar volumes V_ϕ of curcumin in different organic solvents (methanol, Ethanol, DMSO, 1,4-Dioxane) at different temperatures T (293, 15K to 318, 15K), and concentrations up to m=0.001 to 0.010 are reported. The experiments were carried out of density at m=0.001 to 0.010 m of curcumin in different organic solvent. The obtained values of density of pure components are listed in Table 1.

The experimental values of densities (ρ) of binary mixtures of curcumin with different organic solvents (Ethanol, Methanol, Diethyl sulfoxide and 1,4-Dioxane) at different temperatures and different concentrations are listed in Tables 2-5.

From the given Figure 1a-1d shows almost equal results and a significant relationship between concentration and density of solution at different temperature. As the concentration increases, the density also gets increases.

As the temperature rises, the spacing of the molecules increases, which contributes to a decrease in the attractive force and volume increases. As volume increases, the density gets decreases.

Apparent molar volume

An apparent molar volume is a quantity that can be used to calculate a property of a solution, for instance, the volume of the solution is given by:

$$V = .\tilde{V}_0 n_0 + \tilde{V}_i n_i$$

Where V_0 is the molar volume of the solvent, n_0 is the number of moles of solvent is the apparent mole volume of solute i, and n_i is the number of moles of solute in the solution. (The apparent molar volume can also be denoted V_ϕ) The equation applied to a single-solute solution serves as the definition of the apparent molar volume of the solute. For multi component solution, the equation does not give an unambiguous definition of the apparent molar properties.

Apparent molar properties are not in fact constants (even at a given temperature), but are function of the composition. As infinite dilution, they are equal to the partial molar properties. Some apparent molar properties that are commonly used are apparent molar enthalpy, heat capacity and volume.

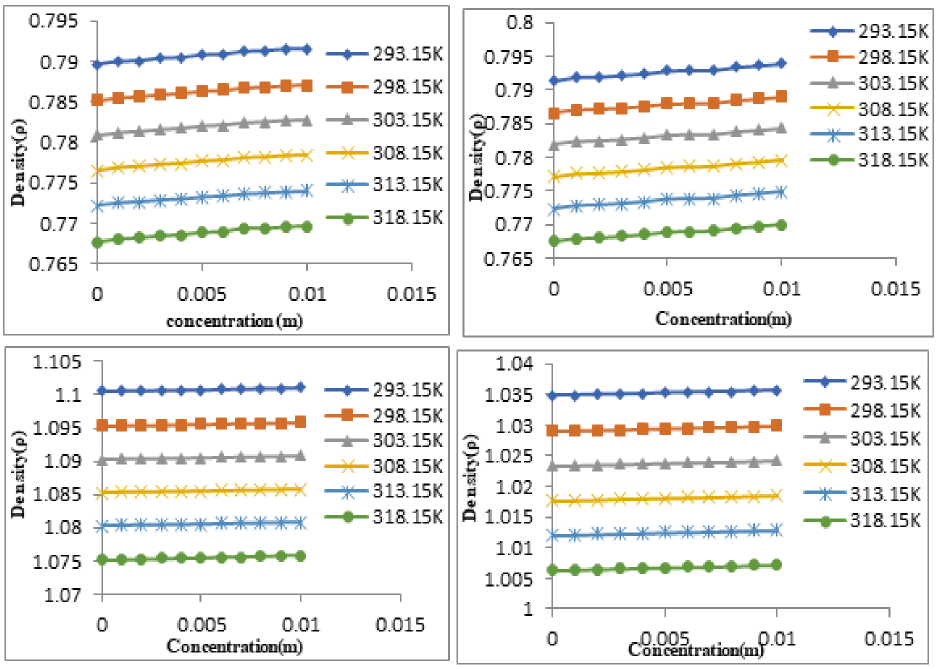

Figure 1: Plot of density of curcumin with (a) Ethanol (b) Methanol (c) DMSO (d) 1,4-Dioxane at different temperature and different concentrations.

Liquids	ρ (Kg m^{-3}) × 10^{-3}	
	Experiment	Litre
1,4 Dioxane	1.02898	1.02797 1.02787
DMSO	1.09531	1.0954 1.09524
Methanol	0.78657	0.78655 0.78676
Ethanol	0.78522	0.7852 0.78517

Table 1: Experimental values of density, of pure liquids at 298.15 K.

Temp./Conc.	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0	0.78961	0.78522	0.78089	0.77655	0.77218	0.76772
0.001	0.78998	0.78555	0.78123	0.7769	0.77251	0.76805
0.002	0.79003	0.78571	0.78138	0.77704	0.77266	0.7682
0.003	0.79038	0.78594	0.78161	0.77727	0.77289	0.76842
0.004	0.79045	0.78608	0.78175	0.77741	0.77303	0.76857
0.005	0.79078	0.78634	0.78202	0.77767	0.77329	0.76882
0.006	0.79087	0.78645	0.78213	0.77778	0.77341	0.76894
0.007	0.79119	0.78674	0.78241	0.77807	0.77369	0.76932
0.008	0.79129	0.78683	0.7825	0.77815	0.77378	0.76931
0.009	0.7915	0.78701	0.78269	0.77834	0.77396	0.76949
0.01	0.79153	0.78709	0.78276	0.77841	0.77404	0.76957

Table 2: Variation of density of curcumin with Ethanol at different temperatures and different concentration.

Temp./Conc.	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0	0.7913	0.78657	0.78184	0.77709	0.77232	0.76749
0.001	0.79187	0.78701	0.78228	0.77755	0.77278	0.76795
0.002	0.79194	0.78712	0.78239	0.77765	0.77288	0.76805
0.003	0.79217	0.78731	0.78258	0.77785	0.77308	0.76825
0.004	0.79241	0.78758	0.78286	0.77812	0.77335	0.76852
0.005	0.79281	0.78796	0.78324	0.77849	0.77372	0.76889
0.006	0.79289	0.78004	0.78332	0.77858	0.77382	0.76899
0.007	0.79295	0.78807	0.78337	0.77864	0.77387	0.76904
0.008	0.79337	0.7885	0.78379	0.77905	0.77429	0.76946
0.009	0.79361	0.78873	0.78402	0.77928	0.77453	0.7697
0.01	0.79389	0.78903	0.78432	0.77958	0.77483	0.77001

Table 3: Variation of density of curcumin with Methanol at different temperatures and different concentration.

Temp./Conc.	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0	1.10052	1.09531	1.09029	1.08528	1.0803	1.07522
0.001	1.10061	1.09539	1.09036	1.08535	1.08036	1.07528
0.002	1.10063	1.09541	1.09039	1.08538	1.08039	1.07532
0.003	1.10069	1.09546	1.09044	1.08543	1.08043	1.07537
0.004	1.10074	1.09552	1.09049	1.08548	1.0805	1.07543
0.005	1.10075	1.09554	1.09052	1.08551	1.08053	1.07545
0.006	1.10084	1.09563	1.0906	1.08559	1.08061	1.07554
0.007	1.1009	1.09569	1.09066	1.08565	1.08067	1.07561
0.008	1.10095	1.09573	1.09071	1.0857	1.08072	1.07565
0.009	1.101	1.09579	1.09076	1.08575	1.08077	1.07571
0.01	1.10107	1.09586	1.09083	1.08582	1.08085	1.07578

Table 4: Variation of density of curcumin with DMSO at different temperatures and different concentration.

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Temp./Conc.	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0	1.03482	1.02898	1.02334	1.01768	1.01203	1.00628
0.001	1.034889	1.029061	1.023415	1.017769	1.012132	1.00639
0.002	1.034972	1.029147	1.023502	1.017856	1.012219	1.006479
0.003	1.03505	1.02923	1.02358	1.01797	1.01234	1.006568
0.004	1.035139	1.02932	1.023676	1.018028	1.012393	1.006657
0.005	1.03222	1.029406	1.023763	1.018114	1.01252	1.006746
0.006	1.035305	1.029492	1.02385	1.0182	1.012567	1.006835
0.007	1.035389	1.029578	1.023937	1.018286	1.012654	1.006924
0.008	1.035472	1.029665	1.024024	1.018373	1.012741	1.007013
0.009	1.035555	1.029751	1.024111	1.018459	1.012828	1.00702
0.01	1.03565	1.02984	1.02421	1.01854	1.01289	1.007191

Table 5: Variation of density of curcumin with 1,4-Dioxane at different temperatures and different concentration.

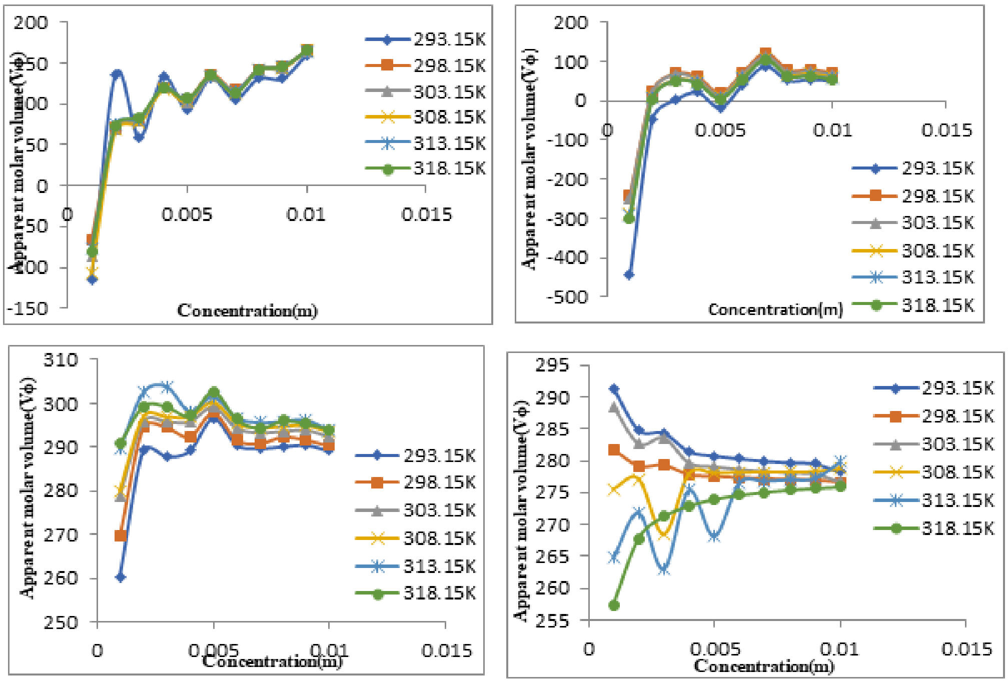

Figure 2: Plot of apparent molar volume of curcumin with (a) Ethanol (b) Methanol (c) DMSO (d) 1,4-Dioxane at different temperature and different concentrations.

The apparent molar volume V_ϕ of the curcumin in aqueous solvents was calculated by using the relation:

$$V_\phi = \frac{M}{\rho} - \frac{10^3(\rho - \rho_o)}{m\rho\rho_o}$$

Where m is the molality of the solute (curcumine), ρ and ρ_o are the densities of the solution and the solvents, respectively; M is the molar mass of the solute (curcumin).

The value of V_ϕ as functions of curcumin at different concentrations and temperatures are given in tables. The apparent Molar volume values obtained from density data are shown graphically in Figure 2. It is observed that V varies with curves were almost linear for curcumin in different organic solvents.

From the Figure 2, we can say, as the concentration increases, apparent molar volume also gets increases. As the temperature increases, apparent molar volume gets decreases.

All the above observations clearly suggest that the negative values of V_ϕ indicate ionic and hydrophilic interactions occurring in these systems. The non-linear variations of V_ϕ with respect to the solute concentration in all systems studied which indicates an existence of ion-solvent interaction. Further, the negative values of V_ϕ indicate electro strictive deliverance of ions.

Conclusion

For the first time, the (m, ρ, T) properties and apparent molar volume V_ϕ of curcumin in different organic solvents at different temperatures T (293.15 to 318.15) K and concentration up to (0.001 to 0.010) m are reported. An empirical correlation for the density of investigated solutions with composition, and temperature has been derived. The measured volumetric results are useful for the absorption refrigeration machines and heat pumps.

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