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Apparent Molar Volume Studies of Triton X-100 in Aqueous and Mixed Solvents

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In the present study densities of Triton X-100 + water, Triton X-100 + water + propanol and Triton X-100 + water + fructose have been measured at different concentrations and temperatures. Apparent molar volumes have been calculated for the studied systems from density values to study the effect of added co-solute/co-solvent on the structure of the studied systems. The apparent molar volumes in Triton X-100 + water + additive (2- propanol/fructose) systems are found to be less than in Triton X-100 + water system. This is attributed to entrapping, as well as hydrogen bonding. With increase of temperature the apparent molar volume (ϕ_v) values increase in all the studied systems, owing to breaking of water structure at higher temperature.

Key Words: Apparent molar volume, Triton X-100, CMC, Solvents.

INTRODUCTION

Surfactants play an important role in the field of agriculture and food technology, energy, environment, biology, medicines and benefication of ores[1]. The physicochemical properties of surfactants are affected by presence of co-solutes/co-solvents and these provide a potential tool to investigate structural changes in these solutions. In the present studies, densities of the following systems *i.e.*, Triton X-100 + water, Triton X-100 + water + propanol, Triton X-100 + water + fructose have been measured at different concentrations and at different temperatures. From density values, apparent molar volumes (ϕ_v) have been calculated for the studied systems to investigate the effect of added co-solute/co-solvents on the structure of the studied systems.

EXPERIMENTAL

Triton X-100 a purified product from Koch-light laboratories was used as such. 2-Propanol was from Ranbaxy laboratories and fructose from Sisco research laboratories. These were used as supplied. Double distilled water having specific conductance of the order of 10^{-6} S cm^{-1} at 298 K was used for preparing solutions.

Densities of the studied systems were measured with the help of a bicapilliary pyknometer. It ensured accuracy in density measurements better than ± 5 $\times 10^{-5}$ g cm^{-3}.

RESULTS AND DISCUSSION

Densities of the studied systems at different concentrations were measured at 298, 308 and 318 K. Apparent molar volumes (ϕ_v) studies of Triton X-100 in aqueous as well as mixed solvents (2-propanol + water and fructose + water) were calculated using the relation[2].

$$\phi_v = \frac{M_2}{d}\left[1 - \frac{m_3 M_3 / 1000 (d - d_s)}{(m_2 M_2 / 1000) d_s}\right]$$

where, m_2, m_3 and M_2, M_3 are the molalities and molecular weights of surfactants and co-solutes. d_s and d are the densities of solvent (water in case of aqueous surfactant system and water + 2-propanol/fructose in mixed solution) and the solution respectively. Tables 1-5 represent data of densities of the studied systems.

Tables 6-10 represent apparent molar volumes (ϕ_v) of Triton X-100 in aqueous as well as mixed solvents (2-propanol + water and fructose + water). The observed apparent molar volumes (ϕ_v) of Triton X-100 in water + 2-propanol system are less than that in water. This may be due to entrapping of surfactant molecules[2,3]. The apparent molar volumes (ϕ_v) values are low at pre-micellar stage of surfactant, but in post-micellar range, ϕ_v values are comparatively high. This is owing to the fact that prior to micellization, the surfactant monomers are well assimilated in the bulk phase. However beyond CMC the surfactant aggregates lack geometrical adjustments. As the temperature is increased, ϕ_v values also increase in all the studied systems, due to collapsing of water structure at higher temperatures. In case of Triton X-100 + water + additive (2-propanol or fructose), the decrease in ϕ_v values may be attributed to the hydrogen bonding of water molecules with poly (ethylene oxide). Each oxygen centre on poly(ethylene oxide) has roughly been

observed to fix, on an average, 2-3 water molecules. Entrapping, as well as hydrogen bonding is, therefore, possible in the network of the many flexible head groups on the outer mantle of the micelles[3,4]. Presence of water structure forming additive help in entrapping and hydrogen-bonding with head groups and hydrophobic-hydrophobic interactions with thin outer core of the micelles, thereby decreasing apparent molar volume at low concentrations of non-ionic surfactants imply more order and hence more structure or clustering in the aqueous environment[5-9]. In case of Triton X-100 systems, such sharp decrease in apparent molar volume is due to the fact that Triton X-100 molecules occupy a void space in a more structured water lattice, thereby giving rise to a marked decrease in their apparent molar volumes.

TABLE-1
DENSITIES OF TRITON X-100 + WATER SYSTEMS AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	Density (gm cm^{-3}) at 298 K	Density (gm cm^{-3}) at 308 K	Density (gm cm^{-3}) at 318 K
0.0004	1.0083	0.99884	0.99667
0.0008	1.00432	0.99839	0.99738
0.0024	1.00351	0.99932	0.99798
0.0032	1.00321	0.99976	0.99699
0.0060	1.00314	0.99930	0.99745
0.0100	1.00219	0.99832	0.99658

TABLE-2
DENSITIES OF TRITON X-100 + 2-PROPANOL (X_p = 0.0936) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	Density (gm cm^{-3}) at 298 K	Density (gm cm^{-3}) at 308 K	Density (gm cm^{-3}) at 318 K
0.0004	0.95912	0.95651	0.95172
0.0008	0.96054	0.95638	0.95252
0.0024	0.96039	0.95689	0.95249
0.0032	0.96008	0.95665	0.95236
0.0060	0.96006	0.95602	0.95169
0.0100	0.96007	0.95608	0.95149

TABLE-3
DENSITIES OF TRITON X-100 + 2-PROPANOL (X_p = 0.1906) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	Density (gm cm^{-3}) at 298 K	Density (gm cm^{-3}) at 308 K	Density (gm cm^{-3}) at 318 K
0.0004	0.92692	0.91704	0.91098
0.0008	0.92560	0.91679	0.91082
0.0024	0.92666	0.91624	0.91078
0.0032	0.92683	0.91694	0.91047
0.0060	0.92738	0.91721	0.91043
0.0100	0.92791	0.91728	0.91054

TABLE-4
DENSITIES OF TRITON X-100 + FRUCTOSE (X_p =0.01) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	Density (gm cm^{-3}) at 298 K	Density (gm cm^{-3}) at 308 K	Density (gm cm^{-3}) at 318 K
0.0004	1.03175	1.0288	1.0252
0.0008	1.03253	1.0295	1.0244
0.0024	1.03295	1.0298	1.0249
0.0032	1.03204	1.0292	1.0250
0.0060	1.03207	1.0293	1.0256
0.0100	1.03206	1.0293	1.0258

TABLE-5
DENSITIES OF TRITON X-100 + FRUCTOSE (X_p =0.02) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	Density (gm cm^{-3}) at 298 K	Density (gm cm^{-3}) at 308 K	Density (gm cm^{-3}) at 318 K
0.0004	1.06809	1.0649	1.0610
0.0008	1.06724	1.0646	1.0609
0.0024	1.06680	1.0638	1.0608
0.0032	1.0675	1.0627	1.0615
0.0060	1.0670	1.0623	1.0593
0.0100	1.0671	1.0650	1.0591

TABLE-6
APPARENT MOLAR VOLUMES (ϕ_v) OF TRITON X-100 IN WATER AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	ϕ_v cm^{-3} mol^{-1} at 298 K	ϕ_v cm^{-3} mol^{-1} at 308 K	ϕ_v cm^{-3} mol^{-1} at 318 K
0.0004	334.59	431.38	356.74
0.0008	481.77	549.33	486.41
0.0024	595.65	606.74	589.69
0.0032	609.60	613.98	610.36
0.0060	625.88	630.93	625.95
0.0100	635.53	639.38	636.72

TABLE-7
APPARENT MOLAR VOLUMES (ϕ_v) OF TRITON X-100 + WATER + 2-PROPANOL (X_p = 0.0936) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	ϕ_v cm^{-3} mol^{-1} at 298 K	ϕ_v cm^{-3} mol^{-1} at 308 K	ϕ_v cm^{-3} mol^{-1} at 318 K
0.0004	413.74	407.33	382.82
0.0008	421.26	501.19	421.02
0.0024	463.44	585.75	447.62
0.0032	550.39	600.99	522.29
0.0060	560.03	674.99	673.65
0.0100	633.83	672.76	661.27

TABLE-8
APPARENT MOLAR VOLUMES (ϕ_v) OF TRITON X-100 + WATER + 2-PROPANOL (X_p = 0.1906) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	ϕ_v cm^{-3} mol^{-1} at 298 K	ϕ_v cm^{-3} mol^{-1} at 308 K	ϕ_v cm^{-3} mol^{-1} at 318 K
0.0004	-	-	-
0.0008	-	-	-
0.0024	363.41	411.98	404.27
0.0032	460.51	430.45	570.75
0.0060	463.19	518.95	642.14
0.0100	481.63	603.67	658.37

TABLE-9
APPARENT MOLAR VOLUMES (ϕ_v) OF TRITON X-100 + WATER + FRUCTOSE (X_p = 0.01) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	ϕ_v cm^{-3} mol^{-1} at 298 K	ϕ_v cm^{-3} mol^{-1} at 308 K	ϕ_v cm^{-3} mol^{-1} at 318 K
0.0004	211.12	237.22	290.01
0.0008	326.90	448.84	458.40
0.0024	509.06	596.08	586.30
0.0032	595.66	591.83	594.25
0.0060	593.26	606.96	601.08
0.0100	606.40	617.24	610.54

TABLE-10
APPARENT MOLAR VOLUMES (ϕ_v) OF TRITON X-100 + WATER + FRUCTOSE (X_p = 0.02) SYSTEM AT DIFFERENT MOLAR CONCENTRATIONS OF TRITON X-100

Conc. (mol/L)	ϕ_v cm^{-3} mol^{-1} at 298 K	ϕ_v cm^{-3} mol^{-1} at 308 K	ϕ_v cm^{-3} mol^{-1} at 318 K
0.0004	-	-	-
0.0008	-	-	-
0.0024	452.61	323.88	321.28
0.0032	462.69	466.24	401.31
0.0060	564.26	575.92	577.50
0.0100	580.58	613.26	603.53

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REFERENCES

1. D.O. Shah, *Chem. Eng. Educ. Winter*, 14 (1977).
2. E.F. Crassa and H. Eisenberg, *Advan. Protein Chem.*, **19**, 287 (1964).
3. M.V. Kaulgud and K.S.M. Rao, *J. Chem. Soc. Faraday Trans*, **75**, 2237 (1979).
4. B. Mandal, S. Ray, A.M. Biswas and S.P. Moulik, *J. Phys. Chem.*, **84**, 856 (1980).
5. A. Paul and Y.P. Singh, *J. Chem. Thermodyn.*, **26**, 1063 (1994).
6. S.W. Wettig and R.E. Verrall, *J. Colloid. Interf. Sci.*, **235**, 310 (2001).
7. E. Vignola, G. Person and J.E. Desnoyers, *Langmuir,* **18**, 6035 (2002).
8. S.K. Shah, A. Bhattarai, G. Shrivastava and S.K. Chatterjee, *J. Nepal Chem. Soc.*, **24**, 24 (2009).
9. C. Klofutar, J. Horvat and D. Rudan-Tasic, *Acta Chim. Slov.*, **53**, 274 (2006).