



CONDUCTOMETRIC STUDIES ON SOLVATION BEHAVIOUR OF DIMETHYL AMMONIUM HYDROCHLORIDE IN DMF AND WATER MIXTURE AT DIFFERENT CONCENTRATIONS AND TEMPERATURES

S. K. CHAVAN* and M. N. HEMADE

P.G. Department of Chemistry, DBF Dayanand College of Arts and Science,
SOLAPUR – 413002 (M.S.) INDIA

ABSTRACT

This paper presents the measurement and analysis of the solvation behaviour of dimethyl ammonium hydrochloride in solvent mixture of DMF and water in varying compositions as a function of temperature. The data has been analysed by the Debye-Huckel-Onsager model and the Kraus-Bay equation. The limiting molal conductance as well as the dissociation constant has been calculated from the respective methods. These methods have been used to interpret the preferential / selective solvation of cations by the DMF. The Walden Product under prevailing conditions has also been computed and the effect of variation in temperature on the conductance has been identified. These data have been used for the qualitative study of ion-solvent and solvent-solvent interactions in the system.

Key words: Conductometric studies, Dimethyl ammonium hydrochloride, DMF, Water.

INTRODUCTION

The study of solution structural effects and the preferential solvation of ions by a solvent can effectively be studied by the conductivity measurement of the solution¹. The conductance behaviour of many electrolytes in mixed solvent systems is reported to be influenced by several factors like density, viscosity, dielectric constant of medium, ion-solvent interactions and solvent-solvent interactions². Though literature is replete with such kind of information³⁻⁵, similar information on dimethyl ammonium hydrochloride is lacking. Dimethyl ammonium hydrochloride $[(\text{CH}_3)_2\text{NH}.\text{HCl}]$ is a solid form of alkylamine and has extensive pharmaceutical applications⁶. It is used as an intermediate in the synthesis of analgesic (tramadol), anti-hypertensive (amlodipine), anti-diabetic drug (metformin), etc.

* Author for correspondence; E-mail: dr_skchavan@yahoo.co.in; madhuriachittewan@rediffmail.com

The aim of the present investigation is to study the solvation behaviour of dimethyl ammonium chloride in Water + DMF system at different temperatures conductometrically.

Solvent mixtures are used in several fields, as it gives varied dielectric constant and changed solvent structure. Hence the study of electrolytes in solvent mixtures has immense importance. This has made us to take up the present work to identify the nature of ion-solvent and solvent-solvent interactions involved in the system conductometrically.

EXPERIMENTAL

Dimethyl ammonium hydrochloride used was AR grade chemical (SD Fine Chem). This chemical was used without further purification. The non-aqueous solvent DMF was purified as stated in the literature⁷. The water used was double-distilled, deionised water and filtered twice. The solvent mixtures (0 to 90% by weight) and solutions of various concentrations of electrolytes (0.02, 0.04, 0.06 and 0.08 M by weights) were prepared by using digital electronic balance.

Conductances were measured by using precision digital conductivity meter and a dip type calibrated conductivity cell (cell constant = 0.1 cm⁻¹). All measurements were made in a thermostat maintained at 298, 303, 308, 313 and 318 K ($\pm 0.05^\circ\text{C}$). The solution of known concentration was taken in a vessel and kept in a thermostat maintained at the desired temperature for approximately 10-15 minutes and its specific conductance was noted.

RESULTS AND DISCUSSION

Limiting molal conductance

Specific conductance (k) of dimethyl ammonium hydrochloride in Water + DMF system at different temperatures was directly read from the instrument and molal conductance (Λ_m) was calculated from $\Lambda_m = 1000 k/c$, where c is the molal concentration. Limiting molal conductance at infinite dilution (Λ_m^0) was determined for all the cases from the Debye Huckel Onsager equation⁸.

$$\Lambda_m = \Lambda_m^0 - (A - B \Lambda_m^0) \sqrt{c} \quad \dots(1)$$

with usual notations. The intercept of the linear plot Λ_m vs \sqrt{c} gave the Λ_m^0 values. The resultant values are reported in Table 1. It is found that Λ_m^0 values decrease with increase in organic solvent component in the mixed solvent. This may be attributed to the difference in solvation of ions which is responsible for the change in mobility of the ions and hence Λ_m^0 values⁹.

Table 1: Values of Λ_m^0 (S cm² mol⁻¹) for Dimethyl ammonium hydrochloride solution in DMF + H₂O solvent mixtures at different temperatures

% wt.	$\Lambda_{m,298}^0$	$\Lambda_{m,303}^0$	$\Lambda_{m,308}^0$	$\Lambda_{m,313}^0$	$\Lambda_{m,318}^0$
10	13.35	16.69	16.75	15.74	16.56
20	12.36	15.73	16.25	16.08	16.29
30	11.37	14.69	15.48	14.68	16.89
40	10.80	14.01	14.48	14.55	16.31
50	9.16	11.71	12.81	12.55	14.09
60	7.88	10.41	11.51	11.02	12.70
70	7.54	9.29	9.93	9.70	11.37
80	6.71	7.68	8.30	8.27	9.98
90	6.19	6.21	7.06	6.82	8.32

Dissociation constant

Kraus – Bay equation was also tried.

$$\frac{1}{\Lambda_m} = \frac{1}{\Lambda_m^0} + \frac{c}{\Lambda_m^0{}^2} \frac{\Lambda_m}{K_c} \quad \dots(2)$$

The dissociation constant K_c is calculated from the slope of Kraus-Bay linear plot of $1/\Lambda_m$ versus c/Λ_m . The resultant values of K_c are reported in Table 2. It is observed that the dissociation constant values increase with increase in percentage of the organic solvent component.

Table 2: Values of K_c for Dimethyl ammonium chloride solution in DMF + H₂O solvent mixtures at different temperatures

Wt. %	$K_{c,298}$	$K_{c,303}$	$K_{c,308}$	$K_{c,313}$	$K_{c,318}$
10	0.0384	0.0540	0.0389	0.0220	0.0205
20	0.0741	0.0917	0.0753	0.0614	0.0487
30	0.1181	0.1410	0.1212	0.0817	0.1207

Cont...

Wt. %	$K_{c,298}$	$K_{c,303}$	$K_{c,308}$	$K_{c,313}$	$K_{c,318}$
40	0.2325	0.2521	0.2173	0.1957	0.3129
50	0.3013	0.3547	0.3809	0.2858	0.4364
60	0.3894	0.5304	0.5299	0.3777	0.5646
70	0.6305	0.6835	0.6010	0.4730	0.5926
80	0.5590	0.5503	0.5883	0.4922	0.7016
90	0.7340	0.6571	0.6838	0.5286	0.7824

The variation of K_c with percentage composition and temperature is primarily due to change in dielectric constant and it also indicates that the electrolyte causes a reduction in thickness of the ionic atmosphere surrounding ionic species which reduces the repulsion between different ionic species. It may also be due to the bulky organic molecules either entering the solvation cell or coming out of it during the movement of the solvated ion in the bulk of the solution.

Walden product

Walden product shows the dependence of conductance on the viscosity of the medium¹⁰. The Walden product $\Lambda^0_m \eta_0$ is calculated at all temperatures and % compositions as stated earlier and is shown in Fig. 1.

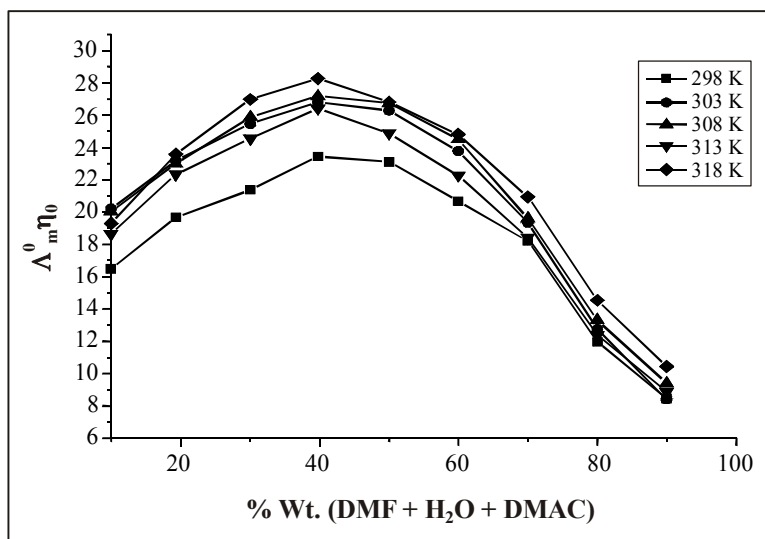


Fig. 1: Calculated Walden product, $\Lambda^0_m \eta_0$ (S cm² mol⁻¹)

It is seen that the Walden product was increased with increase in amount of co-solvent with water. It is maximum at 40% and decreases slowly further. The Walden product values was also increased regularly with rise in temperature.

This variation in the Walden product can be explained in terms of solvation of ions which suggest that the H⁺ and DMAC ions are solvated to different extents in these solvent mixtures.

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Revised : 19.08.2012

Accepted : 20.08.2012