

# Study of Acoustic Properties of Luminol in DMSO-Water Mixture

R. G. Shinde<sup>1</sup>, M. L. Narwade<sup>2</sup>

<sup>1</sup>Government Vidarbha Institute of Science & Humanities, Amravati. (M.S) India

<sup>2</sup>Government Vidarbha Institute of Science & Humanities, Amravati. (M.S) India

**Abstract:** *The acoustical properties like adiabatic compressibility ( $\beta_s$ ), apparent molal volume ( $\phi_v$ ), apparent molal compressibility ( $\phi_k$ ), intermolecular free length ( $L_f$ ), specific acoustic impedance ( $Z$ ) and relative association ( $RA$ ) of Luminol have been calculated from measured sound velocities ( $U$ ) and densities ( $\rho$ ) of their solutions of 0.01M concentrations in different percentage of DMSO-water mixture at 298.15 K. The variations in acoustical properties with increasing percentage of DMSO have been used to understand the changes in molecular interactions between water, DMSO and Luminol and to know the structure making and breaking property of solvent molecules on addition of DMSO in presence of Luminol.*

**Keywords:** Luminol, Acoustic Properties, Ultrasonic velocity, DMSO, Water.

## 1. Introduction

The solvent plays a crucial role in chemiluminescence reactions. Luminol CL in water is mostly applied for analytical purposes. The chemiluminescence of the system Luminol-DMSO has several practical applications[1], so it is also useful to know more about the spectroscopic behavior of this system. Dimethyl sulfoxide (DMSO) shows a remarkable promoting effect on the luminescent reaction of the luminol-H<sub>2</sub>O<sub>2</sub> system[2]. Two luminescent processes occur when a mixed solvent of water and DMSO is used. The total luminescence increases exponentially with increasing DMSO concentration.

The Chemiluminescence of Luminol has been studied either in aqueous alkaline solutions sodium hydroxide[3] or carbonates[4]. Various solvents[5] like glycerol, glycol, pyridine, piperidine and ammonia have been used for Chemiluminescence of Lucigenin. Similarly various solvent[6]-[7], or solvent mixtures[8] have been utilized for chemiluminescence of luminol. Recently, the effect of temperature on the chemiluminescence of alcohols and aldehydes has been studied by Kher et al[9]. A very little work on Chemiluminescence of Luminol and Lucigenin in aqueous aliphatic amines[10] and aniline[11] has been reported in literature. Therefore it is important to study the effect of solvent on chemiluminescence of Luminol. Thus the present chapter deals with the study of effect of solute solvent interaction on chemiluminescence of Luminol interferometrically.

## 2. Experimental

Analytical reagent grade DMSO was purified by standard method[12]. Double distilled water was used for the preparation of solutions and the solutions of solutes were always used a fresh in present investigation. All the glassware's used during the experiment were of Pyrex quality. Pyknometers used for this study were of borosil make and of various volumes. Weighing was done on single pan electronic balance. Solutions of each Luminol of 0.01 M

were prepared in different compositions of DMSO and water (75-100% of DMSO) by dissolving exact amounts of Luminol in liquid mixtures. Densities of different solutions were measured by using precalibrated bicapillary pycnometer at 298.15K. Densities were determined using three different pycnometers. Using the weight of solution and volume of pycnometers, density of solution was calculated. Same procedure was followed with other two pycnometers and average of three density values was considered in calculations. Pycnometers were standardized by the standard procedure[13]. Accuracy of the balance was  $\pm 0.001$  g. Ultrasonic velocity of each solution was obtained by using variable path, single crystal interferometer (Mittal Enterprises, Model F-81) with accuracy of  $\pm 0.03\%$  and frequency 2 MHz. Uncertainty in ultrasonic velocity measurements was 0.03%. The ultrasonic interferometer was calibrated with triply distilled water. The instrument was calibrated by measuring velocity of water at 298.15 K which was in good agreement with literature value. A special thermostatic arrangement was done for density and ultrasonic velocity measurements. Densities and sound velocities of solutions were measured in different percentage of dioxane-water mixture at temperature 298.15 K.

## 3. Theory and Calculations

The principle used in the measurement of velocity ( $U$ ) is based on the accurate determination of the wavelength ( $\lambda$ ) in the medium, equation (1)

$$d = \lambda / 2 \dots \dots \dots (1)$$

Where,  $d$  is the distance traveled by micrometer screw to get one maxima in ammeter in mm and  $\lambda$  is wavelength. From the knowledge of wavelength ( $\lambda$ ), the velocity ( $U$ ) can be obtained by the relation (2)

$$U = \lambda \times \gamma_{\text{ins}} \times 10^3 \dots \dots \dots (2)$$

Where,  $U$  is the sound velocity in m/sec and  $\gamma_{\text{ins}}$  is the frequency of instrument (2 MHz). The acoustical properties

like adiabatic compressibilities of solution ( $\beta_s$ )[14], relative association (RA), intermolecular free length (Lf) and specific acoustic impedance (Z) were calculated by using equations (3-6)[15]

$$\beta_s = \frac{1}{U_s^2 \times \rho_s} \dots\dots\dots(3)$$

$$RA = \frac{\rho_s}{\rho_o} \times \left[ \frac{U_o}{U_s} \right]^{1/3} \dots\dots\dots(4)$$

$$L_f = K' \sqrt{\beta_s} \dots\dots\dots(5)$$

$$Z = U_s \times \rho_s \dots\dots\dots(6)$$

Where, ( $U_s$ ) and ( $U_o$ ) are ultrasonic velocity in solution and solvent mixture, ( $\rho_s$ ) and ( $\rho_o$ ) are density of solution and solvent mixture respectively and  $K'$  is temperature dependent Jacobson's constant[16]. The apparent molal compressibility ( $\phi_k$ ) was calculated by using equation (7).

$$\phi_k = \frac{1000 (\beta_s d_o - \beta_o d_s)}{m \cdot d_s \cdot d_o} + \frac{\beta_s M}{d_s} \dots\dots\dots(7)$$

Where,  $\beta_s$  and  $\beta_o$  are adiabatic compressibilities of solution and solvent mixtures respectively,  $M$  is molecular weight of Luminol and  $m$  is the molality of solution. The apparent molal volume,  $\phi_v$  of different solutions was calculated by finding difference in densities of solvent and solution, molecular weight and molality of compounds using equation (8).

$$\phi_v = \left[ \frac{M}{\rho_s} \right] + \left[ \frac{(\rho_o - \rho_s) \times 10^3}{m \cdot \rho_s \cdot \rho_o} \right] \dots\dots\dots(8)$$

**4. Result and Discussion**

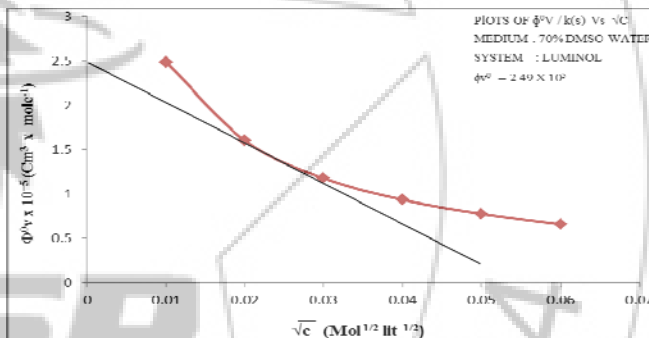
Velocities, densities and calculated acoustical properties in different percentage of DMSO and in 0.01M solution at 298.15K are given in Table (1) and variation in these properties with DMSO % for one of system are shown in Figure (1-2). Existence of molecular association between the components of the liquid mixtures can be understood from the increase in ultrasonic velocity (U) with increasing percentage of DMSO. The values of adiabatic compressibility, ( $\phi_s$ ) decrease with increase in the percentage of DMSO which may be due to departure of solvent molecules around the ions[17]. The apparent molal volumes ( $\phi_v$ ) found to be increase with increase in the percentage of DMSO. It is observed that ( $\phi_k$ ) values increases with increase in the percentage of DMSO. It could also be seen that the intermolecular free length (Lf) increases with increase in the percentages of DMSO, this may be due to the weaker interaction between ions and solute molecules, which suggest the structure promoting behaviour of solute. This may also imply that the increase in free ions, showing the occurrence of ionic dissociation due to weak ion-ion

interaction. The values of relative association (RA) decrease with increase in the percentage of DMSO-water mixture, which may be due to breaking up of solvent molecules on addition of DMSO in it. Specific acoustic impedance (Z) decreases non-linearly with increase in percentage of DMSO. Studies of acoustic properties on the same line have been performed by many researchers [18]-[20].

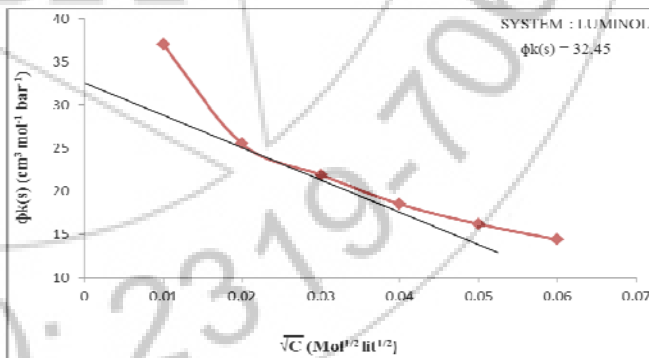
**4.1 Tables**

**Table 1:** Acoustic Properties of Luminol in different percentage of DMSO-water mixture

% of DMSO	100.0	95.0	90.0	85.0	80.0	75.0
$U_s$ (cm sec <sup>-1</sup> )10 <sup>2</sup>	1414	1415	1409.	1401	1397	1392
$d_s$ (g cm <sup>-3</sup> )	0.752	0.760	0.770	0.780	0.787	0.792
$B_s$ (bar-1) 10 <sup>-6</sup>	66.54	65.70	65.44	65.41	65.19	65.21
$L_f$ (A <sup>0</sup> ) 10 <sup>2</sup>	4.910	4.879	4.869	4.868	4.860	4.860
$\Phi^0_v$ (cm <sup>3</sup> mole <sup>-1</sup> ) 10 <sup>5</sup>	6.521	6.238	5.885	5.575	5.357	5.196
$\phi_k(s)$ (cm <sup>3</sup> mole <sup>-1</sup> bar <sup>-1</sup> )10 <sup>2</sup>	0.872	0.830	0.801	0.779	0.759	0.749
RA	0.770	0.778	0.790	0.801	0.808	0.814
$Z$ (cm sec <sup>-1</sup> g cm <sup>-3</sup> ) 10 <sup>2</sup>	1062	1072	1080	1092	1098	1101



**Figure 1:** Plot of  $\Phi^0_v \times 10^5$  Vs  $\sqrt{C}$



**Figure2:** Plot of  $\Phi_k(s) \times 10^5$  Vs  $\sqrt{C}$

**5. Conclusion**

It can be concluded from above study that there exist the interactions between Luminol and DMSO-water mixture. Breaking up of solvent molecules on addition of DMSO in the solution is observed. Solute-solvent interactions are more favorable than other interactions.

## References

- [1] H.W. Schneider, "A new, long-lasting luminol chemiluminescent cold light", *Journal Chem. Educ.* 47(7), pp. 519-521, 1970.
- [2] Y. Ikariyama, M. Aizawa and S. Suzuki, "Chemiluminescence Analysis of Biological Constituents using Metal-complex Catalyst", *Journal of Molecular Catalysis*, 31(1), pp. 39-41, 1985.
- [3] P. B. Shelvin and H. A. Neufeld, "Mechanism of the ferricyanide-catalyzed chemiluminescence of luminol", *Journal Org. Chem.*, 35(7), pp. 2178-2182, 1970.
- [4] G. Merengi, J. Lind and T. E. Eriksen, "The equilibrium reaction of the luminol radical with oxygen and one electron reduction potential of 5-aminophthalazine, 4-dione". *Journal Phys. Chem.*, 88, pp. 2320-2323, 1984.
- [5] R. M. Acheson, "Acridines", *The Chemistry of Heterocyclic Comp.*, Ed., A Weissberger, Intersciences, New York, pp. 282, 1956.
- [6] V.K. Jain and B.P. Chandra, "Effect of Solvent on the Intensity of CL produced during decomposition reaction between Luminol and Hydrogen Peroxide", *Int. J of Luminescence and its applications*, 3(II), pp. 2277 - 6362, 2013.
- [7] J. Lee and H. H. Seliger, "Quantum Yield of Luminol Chemiluminescence", *Photochemistry and Photobiology*, 15(2), pp. 227-237, 1972.
- [8] J. D. Gorsuch and D. M. Hercules, "Studies on the Chemiluminescence of Luminol Dimethyl Sulphoxide and Dimethyl Sulphoxide Water Mixture", *Photochem. And Photobio*, 15(6), pp. 567-583, 1972.
- [9] R. S. Kher, S. A. Khan, S. Chandresh, "Effect of temperature on the Chemiluminescence of alcohols and aldehydes", *Int. J. of Pharm. & Life Sci.*, 3(4), 1617-1619, 2012.
- [10] V. M. Raut, P. S. More, Y. B. Kholam, R. S. Sonone, S. B. Kondawar and P. Koinkar. Chemiluminescence of Luminol in the Presence of Xanthene Dyes", *Int. J. Mod. Phys. Conf. Ser.* 6, pp. 162-165, 2012.
- [11] V. M. Raut, V. W. Banewar, G. H. Murhekar, M. P. Wadekar, R. P. Pawar and M. P. Bhise, "Chemiluminescence of lucigenin in aqueous aliphatic amines", *Material Sci. Res. India*, 6(2), pp. 545-550, 2009.
- [12] A. I. Vogel, *Practical Organic Chemistry*, 3rd Edition, Longman 171, 1974.
- [13] A. M. Jaines, *Practical Physical Chemistry*, J. & A. Churchill Ltd., 8, 1961.
- [14] J. D. Pandey, K. Mishra, A. Shukla & R. D. Raj, Can. "Ultrasonic and thermodynamic studies of tetracyclines in solutions", *Journal Chem.*, 65, pp. 303-306, 1987.
- [15] A. N. Kannappan & R. Palani, "Acoustical behaviour of glycerine, dextrose and sucrose in Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> buffer solution", *Ind. J. Pure and App. Phy.*, 45, pp. 573-579, 2007.
- [16] P. J. Vasoya, N. M. Mehta, V. A. Patel & P. H. Parsania, "Effect of Temperature on Ultrasonic Velocity and Thermodynamic Parameters of Cardio Aromatic Polysulphonate Solutions", *Journal Sci. Ind. Res.*, 66, pp. 841-848, 2007.
- [17] J. D. Pandey, A. Shukla, R. D. Rai & K. J. Mishra, "Ultrasonic, volumetric and viscometric studies of tetracycline and its allied compound.", *Journal Chem. Eng. Data*, 34, pp. 29-31, 1989.
- [18] P. R. Malasane & A. S. Aswar, "Thermodynamic and ultrasonic studies of adenosine in the presence of metal Ions", *Ind. J. Chem.*, 44 (A) (12), 2490-2494, 2005.
- [19] Idrees M. Siddique, P. B. Agarwal, A. G. Doshi, A. W. Raut & M. L. Narwade, "Ultrasonic studies of Schiff's base and substituted-2-azetidinones in CCl<sub>4</sub>-water, ethanol-water and acetone-water mixtures at 298.5+ 0.1 K" *Ind. J. Chem. A*, 42 (3), pp. 526-530, 2003.
- [20] Deepali P. Gulwade, M. L. Narwade & K. N. Wadodkar, "Ultrasonic behaviour and study of molecular interactions of substituted azole in N,N-dimethylformamide at different temperatures and concentrations", *Ind. J. Chem. A*, 43 (10), 2102-2104, 2004.