



## EXCESS ULTRASONIC AND DIELECTRIC SETTINGS ANALYSIS: COMPLEX FORMATION BETWEEN 2-METHOXY ETHANOL (2-ME) AND ALLYL AMINE (AA)

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### Abstract

Information on material dielectric and ultrasonic behaviour provides better insight into the choice of solid and liquid insulating materials. The excess characteristics of liquid mixes are discovered to be more responsive to intermolecular interaction between the constituent components. The degree of the contact between dissimilar molecules determines the sign and magnitude of the excess characteristics. Two liquid mixes' densities, viscosities, and ultrasonic velocities The relationship between Allyl Amine (AA) and 2-ethoxy ethanol (2-EE) has been studied at room temperature at a fixed frequency (2 MHz). When Allyl Amine (AA) is combined with 2-Methoxy Ethanol, the liquid dielectric constant ( $\epsilon'$ ) and dielectric loss ( $\epsilon''$ ) have been evaluated using Surber's approach at a single microwave frequency 9.85 GHz for varying mole fractions of AA. The ultrasonic velocity ( $U$ ), viscosity( $\eta$ ) and density ( $\rho$ ), dielectric constant ( $\epsilon'$ ) are used to estimate acoustic and dielectric parameters along with their excess values. Ultrasonic and Dielectric parameters are being used to explain the formation of complexes in the system.

### Keywords

Ultrasonic velocity, Molecular interaction, Complex formation, X-band microwave bench, AllylAmine (AA), 2-Methoxy Ethanol (2-ME)

### Introduction

The nonlinear fluctuation of ultrasonic velocity and associated acoustic and excess parameters is connected to the physiochemical characteristics of liquid mixtures. In 2004 (Jerie K.), (M. I. Alaraguppi. 2006) (2012) Sahu S. et al. (2013) Gangwar Munendra Kumar et al. Binary mixtures' composition and the development of complexes through molecular interaction were revealed by dielectric analysis. When molecules create complexes, their features are altered.

The current work focuses on the binary liquid combination of AA and 2-EE's acoustic and dielectric characteristics. Both are polar, with 2-EE acting as a solvent and AA as the solute. 2-EE is firmly connected by an intermolecular hydrogen bond because it is a good proton donor and acceptor.

The paper focused on the molecular interaction between binary mixtures of polar liquids. The possible formation of AA and 2-ME complex may be due to molecular association between these liquids.

### Material And Methods

In the present study allyl amine and 2-Methoxy Ethanol of AR grade were procured from Across, Qualigen, Merck and S.D. fine chemical, Mumbai respectively and used without further purification. Samples of solution with different mole fractions of Allylamine in 2-Methoxy Ethanol were prepared. The density ( $\rho$ ), viscosity ( $\eta$ ) and ultrasonic velocity ( $U$ ) of pure components and their mixtures were measured using pycnometer, Ostwald's viscometer and ultrasonic frequency interferometer model No. M-83 provided by Mittal Enterprises, New Delhi, India, respectively. Acoustic parameters were computed according to **R.S.Kawale et al ; 2015**. The refractive indices for Sodium-D-lines were

measured by Abbe's Refractometer. The Dielectric constant measurements were carried out from the X-band microwave bench of oscillating frequency 9.85 GHz using Surber's Technique. The values of  $(\epsilon')$  and  $(\epsilon'')$  for low loss liquids are calculated according to Hestone, W. H. et al ;1950 Other dielectric parameters Loss tangent  $(\tan \delta)$ , molar polarization ( $P_{12}$ ) and activation energy ( $E_A$ ) are obtained according to Tumberphale U.B:2013.

Excess Acoustic impedance ( $\Delta Z$ ) etc. parameters were calculated using the relation.  $\Delta Y = Y_m - (X_1 Y_1 + X_2 Y_2)$

Where,  $\Delta Y$  is any excess parameter, and  $Y$  refers to above mentioned parameter. The subscripts  $m, 1$  and  $2$  used in the above equation are respectively for the mixture, component (1) and component (2).  $X_1$  and  $X_2$  are the mole fractions of two components in the liquid mixture.

### Results and Discussion:

The values of mole fraction of Allyl Amine AA ( $X_A$ ), density ( $\rho$ ), Viscosity ( $\eta$ ), Ultrasonic velocity ( $U$ ), dielectric constant ( $\epsilon'$ ), and refractive index ( $n_D^2$ ) are reported in Table -1.

**Table-1**

Mole fraction of Allyl Amine AA ( $X_A$ ), density ( $\rho$ ), Viscosity ( $\eta$ ), Ultrasonic velocity ( $U$ ), refractive index ( $n_D^2$ ), dielectric constant ( $\epsilon'$ ), and refractive index ( $n_D^2$ ) for binary mixture at 30<sup>o</sup> C.

$X_A$	Density $\rho$	Viscosity $\eta$ cp	Ultrasonic velocity $U$ (ms <sup>-1</sup> )	$\epsilon'$	$N_D^2$
0	0.9591	1.5225	1653.32	9.0615	1.9724
0.2578	0.9157	1.3340	1328.89	8.4503	1.9979
0.3847	0.8854	1.1845	1471.10	8.4703	2.0007
0.5103	0.8464	1.0182	1431.11	7.7720	1.9989
0.6346	0.8302	0.7705	1466.66	7.9383	2.0194
0.7576	0.8038	0.6068	1302.22	7.3701	2.0188
0.8794	0.7897	0.5312	1297.76	6.9952	2.0179
1	0.7610	0.4130	1275.55	6.3802	2.0170

The values of Excess ultrasonic velocity ( $\Delta U$ ), Excess adiabatic compressibility ( $\Delta \beta_{ad}$ ), Excess intermolecular free length ( $\Delta L_f$ ) and excess impedance ( $\Delta Z$ ) of the binary liquid mixture of AA+ 2-ME with mole fraction of AA are reported in Table - 2.

**Table -2** Excess ultrasonic velocity ( $\Delta U$ ), Excess adiabatic compressibility ( $\Delta \beta_{ad}$ ), Excess intermolecular free length ( $\Delta L_f$ ) and excess impedance ( $\Delta Z$ ) of the binary liquid mixture of AA+ 2-

**ME** with mole fraction of AA .

$X_A$	$\Delta U$ $ms^{-1}$	$\Delta \beta_{ad}$ $(10^{-10}m^2N^{-1})$	$\Delta L_f$ $(10^{-11}m)$	$\Delta Z$ $(10^6kgm^{-2}s^{-1})$
0	0	0	0	0
0.1317	-222.601	1.225204	0.595354	-0.20633
0.2578	-275.67	1.638963	0.769354	-0.25608
0.3847	-36.8919	-0.23884	-0.02312	-0.04658
0.5103	110.0009	-1.38024	-0.50098	0.085285
0.6346	6.116031	-0.49982	-0.12869	-0.03047
0.7576	-111.3670	0.581823	0.297509	-0.11431
0.8794	-69.3614	0.342175	0.183712	-0.07663
1	0	0	0	0

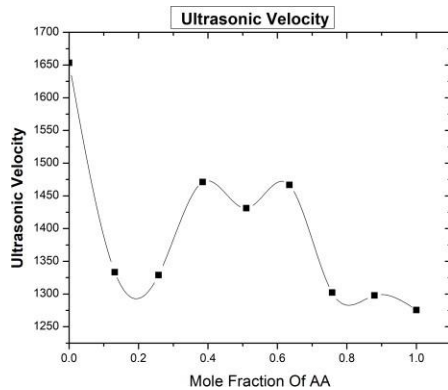
Excess parameter like dielectric constant ( $\Delta\epsilon'$ ), dielectric loss ( $\Delta\epsilon''$ ), loss tangent ( $\Delta\tan \delta$ ), activation Energy ( $\Delta E_a$ ) and molar polarization ( $\Delta P_{12}$ ) for binary mixture at 30<sup>0</sup> Calong withMole fraction (x) of Allyl Amine AA are reported in Table -3.

**Table -3**

Excess parameter dielectric constant ( $\Delta\epsilon'$ ), dielectric loss ( $\Delta\epsilon''$ ), loss tangent ( $\Delta\tan \delta$ ), activation Energy ( $\Delta E_a$ ) and molar polarization ( $\Delta P_{12}$ ) along withMole fraction ( $x_A$ ) of Allyl Amine AA.

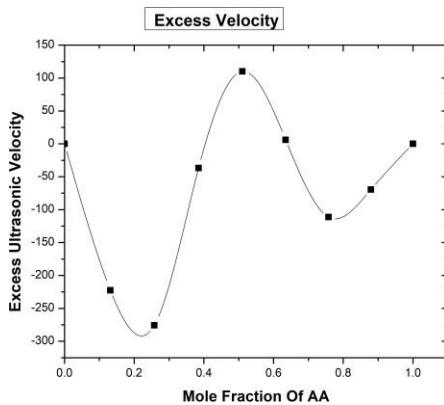
$X_A$	$X_B$	$\Delta\eta$	$\Delta\epsilon'$	$\Delta\epsilon''$	$\Delta\tan$	$\Delta P_{12}$	$\Delta E_a$
0	1	0	0	0	0	0	0
0.1317	0.8698	0.0975	0.2880	0.0872	0.0023	-0.2370	0.1180
0.2578	0.7422	0.0975	0.0800	0.0122	0.0009	-0.9920	0.1372
0.3847	0.6153	0.0888	0.4403	0.2083	0.0141	-0.0553	0.1631
0.5103	0.4897	0.0619	0.0788	0.0079	0.0011	0.7728	0.1683
0.6346	0.3654	-0.0479	0.5784	0.1336	0.0015	1.7765	0.0956
0.7576	0.2424	-0.0751	0.3400	0.1036	0.0050	1.5901	0.0459
0.8794	0.1206	-0.0156	0.2917	0.1167	0.0080	0.2628	0.0592
1	0	0	0	0	0	0	0

Figure-1



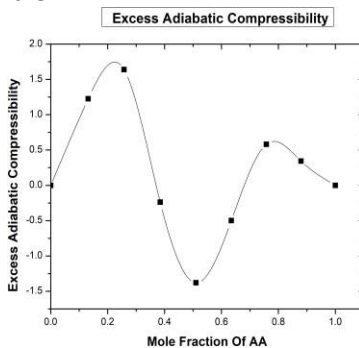
The ultrasonic velocity values vary nonlinearly in figure-1 shows the existence of strong interactions between the components of molecules in the binary mixtures. This indicates the Dipole-dipole interaction or hydrogen bonded complex formation between unlike molecules (Ravichandran, S. 2011) In present system the formation of the complex is likely to be at 0.5103. the minima between the two maxima Deogaonkar VS (1977).

Figure-2



Excess velocity fig-2 shows a slight negative deviation in allyl amine and 2-methoxy ethanol mixture and relatively large positive deviation at  $X = 0.5103$  in allyl amine and 2 methoxy ethanol mixture suggesting the presence of weak and strong dipole – induced dipole interactions in the molecules respectively.

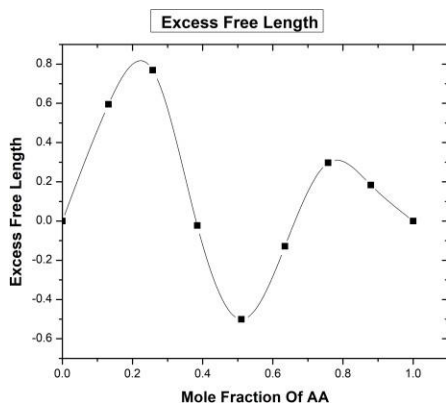
Figure-3



Variation of Excess adiabatic Compressibility ( $\Delta\beta_{ad}$ ) with molar concentration ( $X$ ) of AA in the mixture is depicted in figure-3 which is increasingly positive up to  $X = 0.3154$  then negative and becomes positive for rich mole fraction of AA. At  $X = 0.5103$  breaks dipolar associations in alcohols

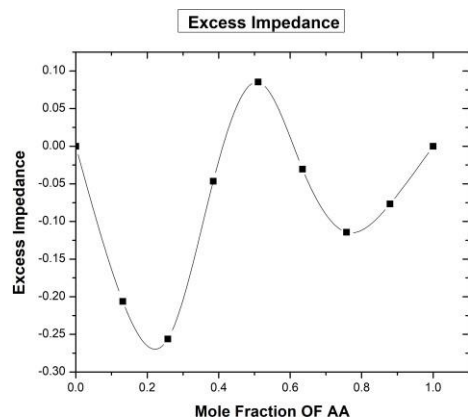
inducing dipole moments in molecules leads to dipole-induced dipole type of interactions making less compressible. At other compositions 2-EE is less bother to break dipolar associations, increasing space between the molecules and making them more compressible as exhibited by positive deviation in  $\beta_{ad}$ . (Rita Mehra et al 2006)

Figure-4



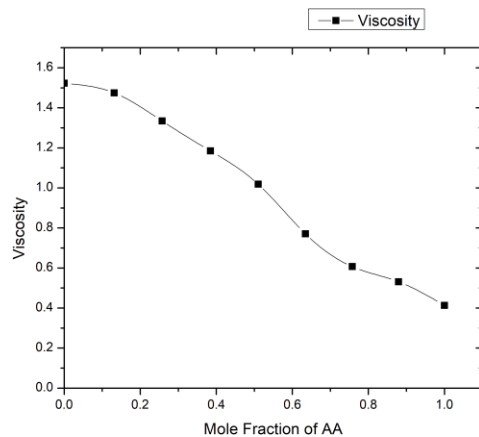
As observed from figure- 4  $\Delta L_f$  values are positive and negative. The maximum negative value of Excess free length ( $\Delta L_f$ ) at the 0.5103 mole fraction of AA indicates the formation of complex. This behaviour suggests that there exist strong interactions between the components of liquid mixture at negative values and positive values suggest weak interactions between the components of liquid mixture due to the existence of dispersion forces.

Figure-5



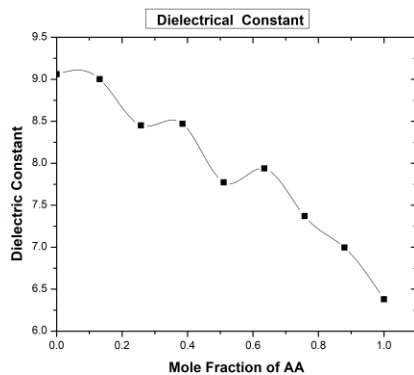
Excess impedance depicted  $\Delta Z$  in figure-5 are found to be negative except  $X=0.5103$  suggesting the presence of weak interaction in both the system, reporting complex formation at this composition. Sangeeta Sagar et al 2017 investigation reported similar kind of behaviour. It has been suggested that the concentration at which the excess functions exhibiting maxima or minima indicates strong interactions between the component molecules which in turn suggests the complex formation at this composition between the unlike molecules. B. V. K. Naidu, 2003.

**Figure-6**



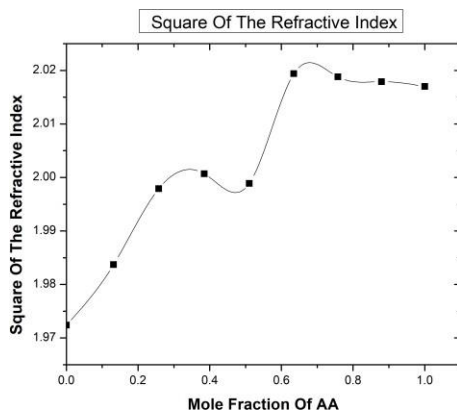
Viscosity curve figure -6 indicates that due to solute-solvent interaction, viscosity decreases with increase in the mole fraction of AA. **J.Sengwa, et al :2006**, so the molecules are held together by comparatively lesser intermolecular dipole-dipole interactions in the complex.

**Figure-7**



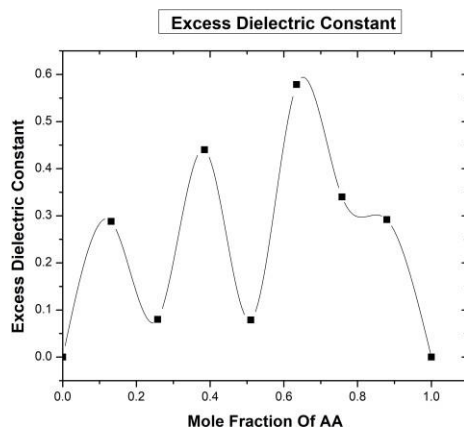
The dielectric constant varies non-linearly from figure -7 as a function of amine concentration in binary systems, due to H-bond interaction between the mixture constituents. The wobbling nature of the mixture may be due to -O- and -OH group in 2-ME results in multiple complexions. **Kinart C M et al ;2009. Bhupesh Nemmaniwar et al ;2014**.

**Figure-8**



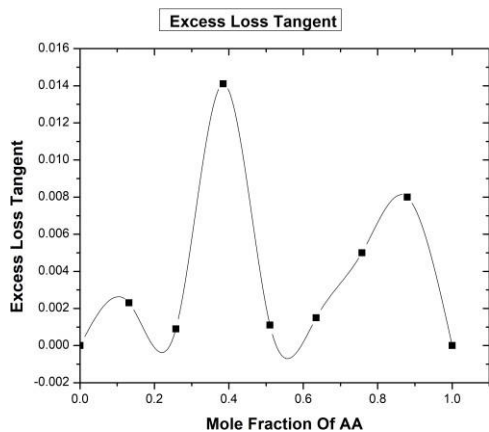
The values of square of refractive index are plotted against mole fraction of AA shown in **figure-8**. In our investigation the graph shows minima at  $X=0.5103$  supports to our earlier conclusion of formation of complex at mole fraction  $X=0.5103$  of AA.

**Figure-9**



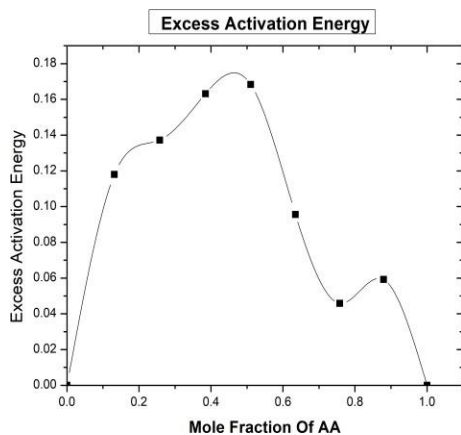
The positive excess dielectric constant ( $\Delta\epsilon$ ), figure (9) also suggests that the effective number of dipoles in the mixture might be greater than the corresponding average number in the pure liquids, probably due to the creation of new structure leading to a higher macroscopic permittivity **B G Lone et al ;2008** , **V V Navarkhele et al ;2010** . The number of effective number of dipoles in the mixture are maximum at  $X=0.5103$  ,minima between two maxima.

**Figure-10**



Variation in excess loss tangent figure 10 supports the complex formations showing minima at  $X = 0.5103$  and is positive for entire molar concentration region of AA.

**Figure-11**



Excess Activation energy  $\Delta E_a$ , noted in figure 11 is positive for entire mole fraction of AA indicating strong interaction between AA and 2-ME molecules at about  $X = 0.5103$ . The similar observation were noted in case of propane diol (PD) and Etyhylene diamine (EDA) molecules. **Rekha Pande et al ;2005.**

### Conclusions:

For various mole fractions of AA, values for acoustic, dielectric parameter, ultrasonic velocity, viscosity, density, refractive index, and dielectric constant have been published. The possibility of complex formation at  $X = 0.5103$  is suggested by excess parameters such as excess Ultrasonic velocity, excess adiabatic Compressibility(ad), excess free length(Lf), and excess acoustic impedance(Z), which is confirmed by the excess dielectric constant(), excess loss tangent(tan), and excess activation energy( $E_a$ ). Strong interaction between dissimilar molecules is indicated by excess activation energy. The combinations' positive excess permittivity further implies that any meaningful intermolecular





interaction is evident at ambient temperature.

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