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Acoustic Studies and Other Acoustic Parameters of Cu(II) Soap Derived from Non-Edible Neem Oil (*Azadirecta Indica*), in Non-Aqueous Media at 298.15 K

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Summary

Ultrasonic speed have been measured in binary and ternary systems containing copper soap derived from neem oil (newly synthesized natural fungicide) in 100% benzene, 80 % and 60% benzene-methanol mixture. From these values, the specific acoustic impedance Z, adiabatic compressibility β, intermolecular free length L_f, apparent molar compressibility ϕ_k, molar sound velocity R, primary solvation number S_n have been calculated. The results have beenfitted to Bachem's and Masson's equation. The results have been explained on the basis of intermolecular interactions and indicate that there is sufficient solute–solvent interaction due to which micellar alignment is considerably affected. The decrease in adiabatic compressibility β and intermolecular free length L_f of the Cu(II) neem soap solution with increasing concentration of soap in 100% benzene, 80% and 60% benzene–methanol has been observed which suggest that the non-polar long chains or lypophilic segment of the molecule in the solution are enveloped by a layer of solvent molecules bound and oriented towards lypophilic end. The orientation of the solvent molecules around the solutes may be due to the influence of electrostatic fields of solutes and results in the increase in the internal pressure and in lowering the compressibility of the solution i.e. the solution becomes harder to compress.

PACS no. 43.20.-f, 43.58.-e

1. Introduction

Ultrasonic wave in recent years, acquired the status of an important probe for the study of structure and properties of matter in basic essence. Several workers studied the ultrasonic propagation parameters, determined Intermolecular free-Length (L_f) in liquids and liquid mixtures using the Jacobson's relation, many acoustical parameters of liquid fluorine, H_2S, CO, C, HCN, C_2N_2, $POCl_3$ and also plastic crystals. Parameters like adiabatic compressibility β etc. of solvent, solvent mixtures and the soap solutions have also been studied [1, 2]. Ultrasonic parameters of various solutes have been studied in binary and ternary mixtures with respect to variation in concentration of the solute and temperatures [3]. Ultrasonic investigation of liquid mixture have significant importance in understanding intermolecular interaction between the component molecules as that finds application in several industrial and technological processes [4, 5]. The neem oil is a major non wood product of neem. The oil is used in skin diseases, ulcers, rheumatism, leprosy, sprain metritis, ear trouble, dental and gum troubles and asthma. It exhibits antiseptic, anti-microbial and anti-fertility activities. Oil contains nimbidin and nimbin as active principles. Neem is very good for skin because it contains natural ingredients with anti-fungal, antibacterial, antiseptic (germicidal), and anti-inflammatory properties. It has moisturizing, regenerative and restructuring properties, and is used to heal eczema, psoriasis, dry skin and dandruff [6]. Synthesis of Cu(II) soaps and their complexes derived from various non-edible oils will provide fundamental information regarding their colloidochemical behaviour and fungicidal activities. Cu(II) soaps have gained importance, due to their use in wood preservation, pesticidal and fungicidal activities, foaming, wetting, detergency, emulsification, plants lubrication etc. [7].

In our previous contribution studies of physical parameters, TGA, photochemical degradation and fungicidal effect has been reported on Cu(II) soaps and their complexes derived from various oils [8, 9, 10, 11, 12, 13, 14, 15]. In this paper we report synthesis of copper soaps derived from neem (*Azadirecta Indica*) oil and studied for structural aspects, which were confirmed using various techniques like IR and NMR. The purity of these soaps was checked by elemental analysis and by determination of their melting points [16, 17]. Physical properties were analysed to provide a fundamental and informa-

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tive account of micellar features of Cu(II) soaps derived from various non-edible oils i.e. neem in pure benzene, 80% benzene-methanol and 60% benzene-methanol solvent system [18]. The present work deals with the determination of ultrasonic velocity measurements which have been used to obtain information regarding various acoustic parameters of Cu(II) soap of non-edible neem oil. The studies were done in non-aqueous solvents (benzene and its varying compositions with methanol) to access the effect of polarity of solvent molecules on the micellar nature of solute molecule and solute-solute interactions. Because the synthesized compound is maximum soluble in benzene. This information is of fundamental importance for understanding solute-solute, solute-solvent interactions in solutions below and above critical micelle concentration and the structural aspects of the micelle. It is anticipated that it will generate a new hopes in various industrial and analytical applications of the newly synthesized surface active agrochemicals.

2. Experimental

All the chemicals used were of LR/AR grade. Copper soap was prepared by refluxing the non-edible oil i.e. neem oil (extracted from kernels and purified) with ethyl alcohol and 2N KOH solutions for 3–4 h (Direct Metathesis). Copper soap so obtained was then washed with warm water and 10% alcohol at 50 °C and recrystallized using hot benzene. Molecular weights of copper soaps were determined from saponification value [19]. The copper soap is abbreviated as copper – neem (CN). The underlying principle of ultrasonic experimental technique used in the measurement of velocity (U) is based on the accurate determination of the wavelength (λ) of the medium. Ultrasonic waves of known frequency (f) are produce by a quartz plate fixed at the bottom of the cell. Ultrasonic interferometer from Mittal Enterprises, Model M-82 with accuracy of ±0.03% was used for the measurements of ultrasonic velocities in various solutions at a fixed frequency 2 MHz. Water maintained at 298.15 K temperature in a thermostat was passed through the jacket of the cell before the measurement was actually made. Further, the operative part of the measurement involves the slow movement of micrometer till the anode current meter shows a maximum. A number of maxima readings of anode current are passed on and their number n are counted. The total distance d (1 cm) thus moved by the micrometer gives the value of wavelength λ with the help of the following relation,

$$\lambda = 2d/n, \tag{1}$$

where d is the distance moved, λ the wavelength of medium and n the number of counts.

Once the wavelength is known, the ultrasonic velocity U defined as the speed of ultrasound waves in a particular mediumand can be calculated with the help of the relation

$$U = \lambda \cdot f, \tag{2}$$

where U is the ultrasonic velocity and f the fixed frequency of interferometer.

3. Results and discussions

A number of workers [20] have discussed the physicochemical aspects of ultrasonic velocity and related parameters. Ultrasonic measurements have also been use to determine the solvation number.

The specific acoustic impedance Z, adiabatic compressibility β, intermolecular free length L_f, apparent molar compressibility ϕ_k, molar sound velocity R, and primary solvation number S_n have been calculated by using [21]

$$Z = U\rho, \tag{3}$$

$$\beta = \frac{1}{U^2\rho}, \tag{4}$$

$$L_f = K\sqrt{\beta}, \tag{5}$$

$$\phi_k = \left[1000\frac{\beta\rho_0 - \beta_0\rho}{c\rho_0}\right] + \frac{\beta m}{\rho_0}, \tag{6}$$

$$R = m \cdot U^{1/3}\rho_0, \tag{7}$$

$$\overline{M} = M_1X_1 + M_2X_2 + M_3X_3, \tag{8}$$

$$S_n = \frac{n_0}{n}\left[1 - \frac{\overline{V}\beta}{n_0V_0\beta_0}\right], \tag{9}$$

where β_0 represents the adiabatic compressibility of solvent, β is the adiabatic compressibility of solute, ρ_0 is the density of solvent, ρ the density of solute, n_0 the number of moles of solvent, n is the number of molesof solute. ∇_0 is the molar volume of solvent, ∇ the molar volume of solute and K Jacobson's constant ($6.31 \cdot 10^4$), c represents the concentration of the solution.

The expression for molar volume of the solvent V_0 and soap solution V may be written as

$$\nabla = M_1X_1 + M_2X_2 + M_3X_3/\rho, \tag{10}$$

$$\nabla_0 = M_1X_1 + M_2X_2 + M_3X_3/\rho_0, \tag{11}$$

where M is the molecular weight of the component, X the mole fraction of the component.

Here the 1 refer to pure solvent (100 % benzene), 2 refer for 80 % benzene-methanol mixture and 3 refer to 60 % benzene–methanol mixture respectively.

The values of U and allied parameters for CN soap in pure benzene (CN_{100}), 80% benzene–methanol (CN_{80}), and 60% benzene–methanol (CN_{60}) system are recorded in Tables I–III. Relative Density of pure solvents, solvent mixtures and solutions of different concentration of solute in solvent mixtures as ternary solutions had been measured using pyknometer at constant temperature in duplicate and compared with literature for solvents. The possible error in the density was estimated to be less than ±1. The densities ρ were reproducible to within ±0.02 kg/m^3. Similarly the error in ultrasonic velocity was ±0.02 m/s.

The perusal of the data suggests that, in general the values of L_f, R, β and ϕ_k decrease then increase with increasing concentration of the soap till a particular concentration corresponding to Critical Micelle Concentration (CMC) whereas Z value increases than decreases till a

Table I. Acoustic parameters of Cu(II) neem soap solutions in 100% benzene (at 298.15 K).

c (mol/L)	ρ (g/cm^3)	U (m/s)	Z (10^{-5}µg/cm^{2}s)	β (10^{11}cm^2/dyn)	L_f (A°)	ϕ_k ($\cdot 10^{10}$)	R	S_n ($\cdot 10^{-3}$)
0.0002	0.8750	1379	12.068	6.0074	0.4891	-3072.90	4613.109	-143.817
0.0003	0.8751	1379	12.070	6.0065	0.4890	-2500.02	4612.714	-95.846
0.0004	0.8761	1379	12.084	5.9998	0.4888	-5130.96	4607.844	-71.668
0.0005	0.8747	1379	12.065	6.0093	0.4892	-200.53	4615.457	-57.593
0.0006	0.8727	1379	12.038	6.0228	0.4897	4376.73	4626.060	-48.296
0.0007	0.8735	1379	12.048	6.0175	0.4895	2318.25	4622.326	-41.301
0.0008	0.8742	1379	12.058	6.0124	0.4893	809.90	4618.703	-36.056
0.0009	0.8752	1379	12.072	6.0056	0.4890	-743.90	4613.769	-31.952
0.0010	0.8759	1379	12.081	6.0011	0.4888	-1532.55	4610.582	-28.699
0.0012	0.8766	1379	12.091	5.9964	0.4886	-1994.07	4607.532	-23.868
0.0014	0.8764	1379	12.088	5.9978	0.4887	-1451.57	4609.163	-20.475
0.0016	0.8762	1379	12.085	5.9991	0.4887	-1053.23	4610.742	-17.929

Table II. Acoustic parameters of Cu(II) neem soap solutions in 80% benzene–methanol (at 298.15 K).

c (mol/L)	ρ (g/cm^3)	U (m/s)	Z (10^{-5}µg/cm^{2}s)	β (10^{11}cm^2/dyn)	L_f (A°)	ϕ_k ($\cdot 10^{10}$)	R	S_n ($\cdot 10^{-3}$)
0.0002	0.8576	1290	1.1066	7.0036	0.5281	-2247.78	3637.625	-130.344
0.0003	0.8582	1290	1.1073	6.9988	0.5279	-4485.26	3635.407	-86.725
0.0004	0.8586	1290	1.1079	6.9953	0.5278	-4990.46	3633.826	-64.950
0.0005	0.8583	1290	1.1075	6.9979	0.5279	-2845.00	3635.420	-52.025
0.0006	0.8573	1290	1.1062	7.0057	0.5281	301.15	3639.689	-43.506
0.0007	0.8581	1290	1.1072	6.9999	0.5279	-1325.62	3636.917	-37.200
0.0008	0.8585	1290	1.1077	6.9965	0.5278	-1952.90	3635.377	-32.504
0.0009	0.8590	1290	1.1084	6.9920	0.5276	-2676.06	3633.289	-28.839
0.0010	0.8597	1290	1.1092	6.9869	0.5274	-3384.42	3630.866	-25.899
0.0012	0.8598	1290	1.1094	6.9856	0.5274	-2952.10	3630.669	-21.575
0.0014	0.8600	1290	1.1097	6.9840	0.5273	-2678.19	3630.346	-18.484
0.0016	0.8596	1290	1.1091	6.9873	0.5275	-1861.61	3632.556	-16.200

Table III. Acoustic parameters of Cu(II) neem soap solutions in 60% benzene-methanol (at 298.15 K).

c (mol/L)	ρ (g/cm^3)	U (m/s)	Z (10^{-5}µg/cm^{2}s)	β (10^{11}cm^2/dyn)	L_f (A°)	ϕ_k ($\cdot 10^{10}$)	R	S_n ($\cdot 10^{-3}$)
0.0002	0.8443	1176	0.9933	8.5575	0.5837	-6781.00	2942.234	-116.608
0.0003	0.8445	1176	0.9935	8.5554	0.5836	-5746.89	2941.704	-77.682
0.0004	0.8450	1176	0.9941	8.5506	0.5835	-6526.45	2940.269	-58.157
0.0005	0.8442	1176	0.9932	8.5586	0.5838	-1965.11	2943.223	-46.681
0.0006	0.8428	1176	0.9915	8.5727	0.5842	3077.56	2948.279	-39.125
0.0007	0.8439	1176	0.9928	8.5619	0.5839	-315.46	2944.777	-33.396
0.0008	0.8443	1176	0.9933	8.5571	0.5837	-1410.03	2943.305	-29.168
0.0009	0.8447	1176	0.9938	8.5530	0.5836	-2083.38	2942.113	-25.888
0.0010	0.8452	1176	0.9943	8.5484	0.5834	-2741.36	2940.713	-23.258
0.0012	0.8454	1176	0.9945	8.5467	0.5833	-2481.40	2940.524	-19.373
0.0014	0.8451	1176	0.9943	8.5491	0.5834	-1711.71	2941.762	-16.626
0.0016	0.8450	1176	0.9941	8.5503	0.5835	-1283.97	2942.583	-14.558

particular concentration and then increases again with the increase in soap concentration. Earlier many physical studies like density, molar volume, apparent molar volume, viscosity and related parameters, ultrasound and related parameters etc. had been studied for the referred system. CMC had been determined by plotting various plots after applying different equations and compared [22].The values of solvation number (S_n) increases consistently with increase in CN soap concentration.

The increase in the values of specific acoustic impedance Z, with the concentration can be explained on the basis of lyophobic interactions between the solute and solvent molecules, which increases the intermolecular distance leaving relatively wider gaps between the molecules and becoming the main cause of impedance in the propagation of ultrasound waves. Also it is suggested that, the decrease in the intermolecular free length L_f with the increase in the concentration of the soap indicated that in

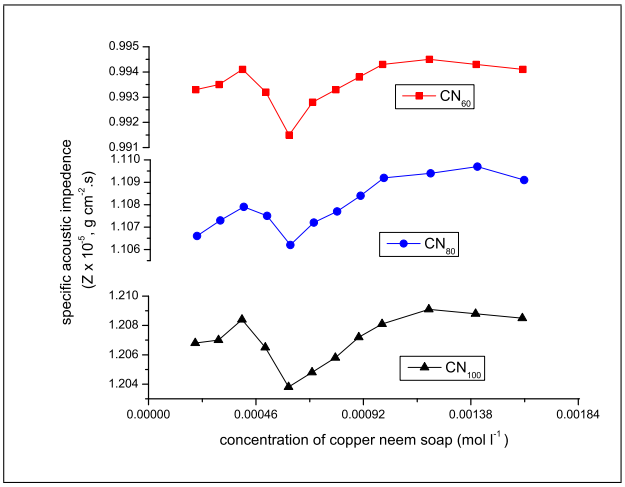

Figure 1. Plot of specific acoustic impedence versus concentration for Cu(II) neem soap in 100% benzene, in 80% benzene, in 60% benzene at 298.15 K.

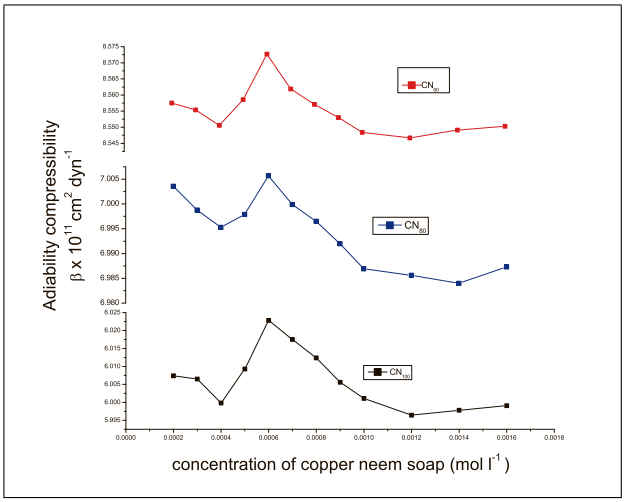

Figure 2. Plot of abiabatic compressibility versus concentration for Cu(II) neem soap in 100% benzene, in 80% benzene, in 60% benzene at 298.15 K.

all systems intermolecular free length is positive indicating the presence of weak dipolar and dispersive interactions between the component molecules in the mixtures and suggestingthatthere is significant interaction between solute and solvent molecules and that the structural arrangement is considerably affected [23].

The plots U versus c shows a parallel line with reference to X-axis suggesting that the ultrasonic velocity, U of very dilute solutions of Cu(II) neem soap in 100% benzene, 80% benzene–methanol and 60% benzene–methanol system remains the same on increasing the concentration of CN soap. The difference in the ultrasonic velocity U values of soap solutions in varying composition of benzene i.e. CN_{100}, CN_{80} and CN_{60} is seen which is mainly due to the difference in the U of the solvents only.

The plots of Z versus c, β versus c and L_f versus c are characterized by an intersection of two curvatures atthe definite concentration (Figures 1–3) corresponding to the CMC of CN_{100}, CN_{80} and CN_{60}. At CMC, the hydrocarbon chain structure of the soap molecules derived from neem oil, allow extensive contact between adjacent chain, possibly accompanied by change in vibrational and rotational degree of freedom of methylene groups of fatty acids of varying composition present in the neem oil [24]. The values of CMC of these plots are recorded in Table IV.

The decrease in adiabatic compressibility β and intermolecular free length L_f of the Cu(II) neem soap solution with increasing concentration of soap in 100% benzene, 80% benzene–methanol and 60% benzene–methanol may be interpreted on the basis of the fact that the non-polar long chains or lypophilic segment of the molecule in the solution are enveloped by a layer of solvent molecules bound and oriented towards lypophilic end. The orientation of the solvent molecules around the solutes may be due to the influence of electrostatic fields of solutes and results in the increase in the internal pressure and in lowering the compressibility of the solution i.e. the solution becomes harder to compress. It is explained as be-

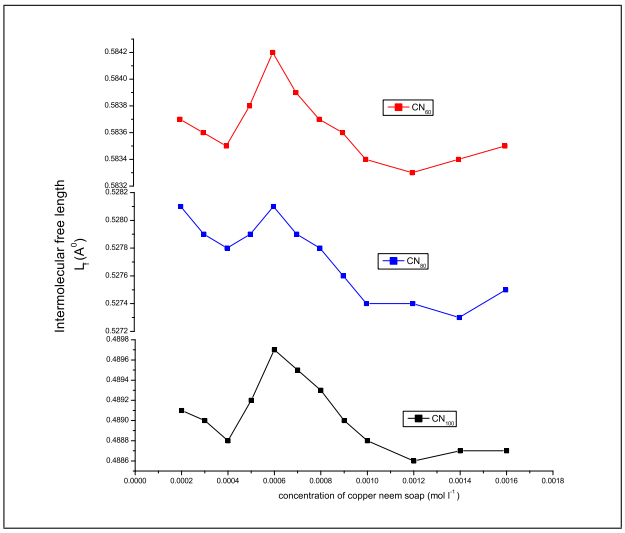

Figure 3. Plot of intermolecular free length versus concentration for Cu(II) neem soap in 100% benzene, in 80% benzene, in 60% benzene at 298.15 K.

Table IV. Value of CMC obtained from various acoustic parameters for Cu(II) neem soap solutions in 100% benzene, 80% benzene-methanol and 60% benzene-methanol system at 298.15 K.

Graph plotted	CN_{100}	CN_{80}	CN_{60}
Z versus c	0.00060	0.00057	0 .00055
B versus c	0.00060	0.00057	0 .00055
L_f versus c	0.00060	0.00057	0 .00055
ϕ_k versus $\sqrt{c}$	0.00060	0.00057	0 .00055
$(\beta - \beta_0)/c$ versus $\sqrt{c}$	0.00060	0.00057	0 .00055

fore the formation of critical micelle, the molecules of solute are moving separately in the solution so the solution is easy to compress, as the concentration of solute molecules increases the micelle formation starts and solution becomes harder to compress, after CMC formation

of micelle takes place and due to larger size of micelle, the solution becomes more hard and difficult to compress, Hence the compressibility decreases after CMC.This indicates that here is sufficient solute–solvent interaction like dipole-dipole, dipole-induced dipole and dispersive forces due to which micellar alignment is considerably affected [25].The observed trend can be explained, at least partially, in terms of structural ion-ion interactions i.e. hydrophilic–hydrophilic, hydrophilic–hydrophobic and hydrophobic–hydrophobic interactions. The solute which is studied is Cu(II) neem soap has both hydrophilic and hydrophobic features i.e. COO^- of fatty acid chain is hydrophilic in nature and long alkyl chain is hydrophobic in nature. Whereas the solvents i.e. non-polar solvent, benzene is hydrophobic and polar solvent methanol is hydrophilic in nature. Thus the various interactions, to occur between solute and solvent have been analyzed [26].

Literature survey [27, 28] also reveals that the decrease in the values of β and L_f indicates that there in significant interaction between solute–solvent molecules suggesting a consistent change in the lucid micellar orientation in such systems.

Various scientists [29, 30] have suggested that the correlation between solvation number S_n and molar concentration of the solute in the solvent can be understood assuming that solvent molecules in the immediate vicinity of solute molecules have modified properties, similar to those of pure solvent under high pressure. Thus solvation about a solute is conceived as sphere of bound solvent at high pressure and virtually incompressible at the boundary of which compressibility falls to Zero. A close perusal of data's leads us to see a persistent rise in solvation property of the solute with increase in concentration. This may be attributed to a greater number of solvent molecules forming solvation shells around the solute in the non-polar segment of the molecule in CN_{100} and it is around the whole molecule (i.e. polar and non-polar segment) in CN_{80} and CN_{60}. Therefore it is observed from the data that, in general, the numerical values of S_n increases in all the three systems and follows the order: (Figure 4) S_n values:

$$CN_{100} < CN_{80} < CN_{60}.$$

The adiabatic compressibility β of CN soap solutions, i.e. CN_{100}, CN_{80} and CN_{60} system used is found to obey Bachem's relationships [31]. The adiabatic compressibility β was reproducible to within $\pm 0.02\,\mathrm{cm^2/dyn}$.

$$\beta = \beta_0 + Ac + Bc^{3/2}. \tag{12}$$

On rearranging, we get

$$\frac{\beta - \beta_0}{c} = A + B\sqrt{c}. \tag{13}$$

The values of constants 'A' and 'B' have been evaluated from the intercept and slope of the plots $(\beta - \beta_0)/c$ versus $\sqrt{c}$.

The plot of $(\beta - \beta_0)/c$ versus $\sqrt{c}$ in Figure 5 is characterized by intersection of possible two straight lines of two

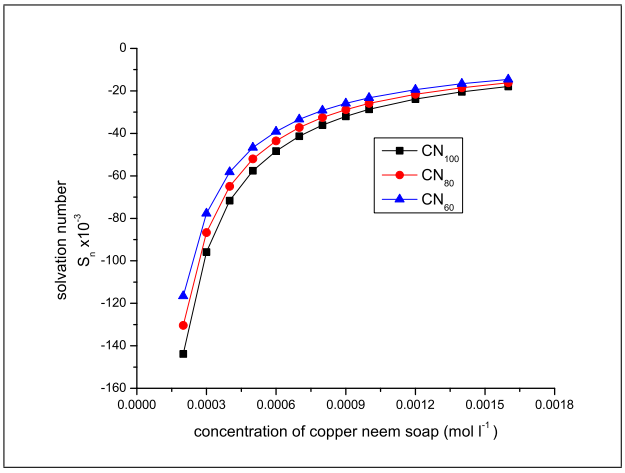

Figure 4. Plot of solvation number versus concentration for Cu(II) neem soap in pure benzene, 80% benzene, in 60% benzene at 298.15 K.

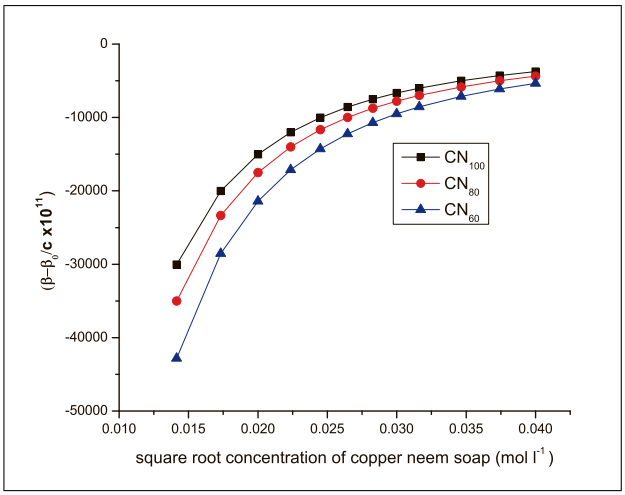

Figure 5. Plot for Bachem's relation for Cu(II) neem soap in pure benzene, 80% benzene, in 60% benzene at 298.15 K.

curves at CMC of the soap solution Thus the values 'A' and 'B' have been evaluated both below and above CMC and are designated A_1, A_2 and B_1, B_2 respectively. The values of A_1 A_2 and B_1, B_2 follow the order

$$A_1 < A_2 \quad \text{and} \quad B_1 > B_2.$$

The value of apparent molar compressibility ϕ_k has also been evaluated in terms of Masson's equation [32]. The apparent molar compressibility ϕ_k was reproducible to within ± 0.2,

$$\phi_k = \phi_k^0 + S_k\sqrt{c}. \tag{14}$$

Here, ϕ_k^0 is the limiting apparent molar compressibility and is a measure of solute–solvent interactions. S_k is the experimental slope, a measure of solute–solute interactions. The plot of ϕ_k versus $\sqrt{c}$ is characterized by an intersection of two straight line thus Masson's equation fits well both below an above CMC (Figure 6). Correspondingly, two values of both ϕ_k^0 and S_k are obtained i.e. below

Table V. Computed parameters for Bachem's relationship and Masson's equation for Cu(II) neem soap solutions in 100% benzene, 80% benzene-methanol and 60% benzene- methanol system at 298.15 K.

Soap	Bachem's Relation				Masson's Equation			
	$A_1 \cdot 10^{11}$	$A_2 \cdot 10^{11}$	B_1	B_2	$\phi_{k1}^0 \cdot 10^{10}$	$\phi_{k2}^0 \cdot 10^{10}$	S_{k1}	S_{k2}
CN_{100}	-122.56	132.11	237660.70	-4607.16	-47445.84	24690.70	2114749.23	-839312.46
CN_{80}	-145.54	43.93	5854.60	-1998.50	-28641.18	9310.41	1172516.15	-400299.54
CN_{60}	-253.20	47.44	10833.78	-2022.22	-49339.93	9871.00	2133042.58	-398720.30

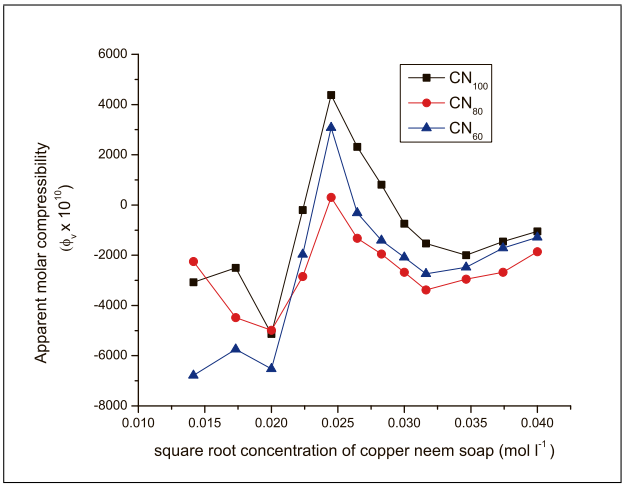

Figure 6. Plot of apparent molar compressibility for Cu(II) neem soap in pure benzene, 80% benzene, in 60% benzene at 298.15 K.

and above CMC and designated as ϕ_{k1}^0 and ϕ_{k2}^0 and S_{k1}, S_{k2}. A close study of Table V reveals that negative values of ϕ_{k1}^0 and positive value of ϕ_{k2}^0 are obtained. The orders of the two parameters are observed to be as follows:

$$\phi_{k1}^0 < \phi_{k2}^0 \quad \text{and} \quad S_{k1} > S_{k2}.$$

Literature survey [33, 34] reveals that negative values of ϕ_{k1}^0 indicate electrostriction and hydrophobic interaction. The negative value of ϕ_{k1}^0 is also attributed to the loss of structural compressibility of solute molecules due to the increased population of hydrophobic non-polar solvent benzene. It shows that structural disruption is much in evidence in solution [35].

Since $\phi_{k1}^0 < \phi_{k2}^0$ thus it may be suggested that solute–solvent interaction is more prominent above CMC as compared to below CMC. It may also be suggested that above CMC, hydrophobic–hydrophobic group interactions, between the long alkyl chain fatty acids of CN soap derived from neem oil and non-polar solvent benzene are more dominant as compared to below CMC in CN_{100} system and in CN_{80} and CN_{60} system the hydrophilic-hydrophilic interaction between COO^- and polar solvent also become prominent.

4. Conclusion

The nonlinear variation of ultrasonic velocity and other acoustical parameters with various molar concentrations of newly synthesized natural fungicide derived from neem oilin different polar and non-polar solvents showssufficient intermolecular interaction between constituent molecules. The decrease in adiabatic compressibility band intermolecular free length L_f with the increase in the concentration of the soap indicate that there is significant interaction between solute and solvent molecules and the structural arrangement of micelles below and above CMC is considerably affected. The types of micellar structures formed are needed to be study further. The acoustic behavior of the referred systems studied as solute in ternary system may provide valuable information's for its applications in different fields. This provides useful information about the nature of intermolecular forces existing in the solution.

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References

[1] G. Savaroglu, M. Ozdemir: Apparent molar volume and apparent molar isentropic compressibility of glycerol in fructose water at different temperature. J. Mol. Liquids **137** (2008) 51–57.

[2] V. K. Syal, S. Chauhan, R. Gautam: Ultrasonic velocity measurements of carbohydrates in binarymixtures of DMSO +H2O at 25 °c. Ultrasonics **36** (1998) 619–621.

[3] S. Punitha, R. Uvarani: Physico-chemical studies on some saccharides in aqueous cellulose solutions at different temperatures. Acoustical and FTIR analysis. J. Saudi Chem. Soc. **18** (2014) 657–665.

[4] V. M. Kagathara, M. R. Sanariya, P. H. Parsania: Sound velocity and molecular interaction studies on chloroepoxy resins solutions at 30 °c. Eur. Polym. J. **36** (2000) 2371–2374.

[5] A. K. Dash, R. Paikaray: Acoustical study on ternary mixture of dimethyl acetamide (DMAC) in diethyl ether and isobutyl methyl ketone at different frequencies. Phys. Chem. Liq. **51** (2013) 749–763.

[6] S. Khan, R. Sharma, A. K. Sharma: Cu surfactants derived from non-edible oils: Bio-chemical aspects. LAP Lambert Academic Publishing, Germany, 2017. ISBN 978-620-2-00001-7.

[7] R. Sharma, A. K. Sharma: Natural edible oils: Comparative health aspects of sesame, coconut, mustard (rape seed) and groundnut (peanut). A biomedical approach. Biomed J. Sci. & Tech Res. **1** (2017) BJSTR.MS.ID.00044.

[8] P. Tank, R. Sharma, A. K. Sharma: A pharmaceutical approach and antifungal activities of copper soaps with their N and S donor complexes derived from mustard and soyabean oils. Glob. J. Pharmaceu. Sci. **3** (2017) GJPPS.MS.ID.555619.

[9] P. Tank, R. Sharma, A. K. Sharma: Thermal behaviour and kinetics of copper(II) soaps and complexes derived from mustard and soyabean oil. J. Anal. Pharm. Res. **4** (2017) 1–5.

[10] S. Sharma, R. Sharma, A. K. Sharma: Synthesis, characterization and thermal degradation of Cu(II) surfactants for sustainable green chem. Asian J. Green Chem. **2** (2017) 129–140.

[11] A. K. Sharma, S. Sharma, R. Sharma: Thermal degradation of Cu(II) metallic soaps and their characterizations. A pharmaceutical application. Chronicles of Pharmaceutical Science **1** (2017) 312–319.

[12] S. Sharma, R. Sharma, L. C. Heda, A. K. Sharma: Kinetic parameters and photo degradation studies of copper soap derived from soybean oil using ZnO as a photo catalyst in solid and solution phase. J. Inst. Chemists (India) **89** (2017) 119–136.

[13] A. K. Sharma, M. Saxena, R. Sharma: Synthesis, spectroscopic and fungicidal studies of Cu(II) soaps derived from groundnut and sesame oils and their urea complexes. Bulletin of Pure and Applied Sciences **36** (2017) 26–37.

[14] A. K. Sharma, M. Saxena, R. Sharma: Synthesis, spectroscopic and biocidal activities of environmentally safe agrochemicals. J. Biochem. Tech. **7** (2018) 1139–1147.

[15] A. Joram, R. Sharma, A. K. Sharma: Thermal degradation of complexes derived from copper(II) groundnut soap (Arachis hypogaea) and copper(II) sesame soap (Sesamum indicum). Z. Phy. Chem. **2018** accepted.

[16] S. Khan, R. Sharma, A. K. Sharma: Antifungal activities of copper surfactants derived from neem (Azadirecta indica) and karanj (Pongamia pinnata) oils. A pharmaceutical application. Glob. J. Pharmaceu. Sci. **3** (2017) GJPPS.MS.ID.555616.

[17] R. Sharma, S. Khan: Synthesis, characterization and antifungal activities of copper(II) soaps and their complexes derived from Azadirecta indica (neem) and Pongamia pinnata (karanj) oil. Tenside Surf. Det. **46** (2009) 145–151.

[18] P. Kumawat, R. Sharma, N. Sharma: Synthesis and characterization of bactericidal agents derived from neem (Azadirecta indica) oil. Clinical Biotechnology and Microbiology **1** (2017) 209–218.

[19] R. Sharma, R. Bhutra, S. Khan: Micellar behaviour of copper surfactants derived from fresh (untreated) sesame oil and used (treated at high temperature) sesame oil. Tenside Surf Det. **47** (2010) 106–112.

[20] A. K. Sharma, M. Saxena, R. Sharma: Ultrasonic studies of Cu(II) soaps derived from mustard and soybean oils. J. Pure Appl. Ultrason. **39** (2017) 92–99.

[21] P. Tank, R. Sharma, A. K. Sharma: Studies of ultrasonic and acoustic parameters of complexes derived from copper(II) surfactant of mustard oil with N and S atoms containing ligands in non-aqueous media (benzene) at 303.15 K. J. Acous. Soc. Ind. **44** (2017) 87–99.

[22] R. Bhutra, R. Sharma, A. K. Sharma: Viscometric and CMC studies of Cu(II) surfactants derived from untreated and treated groundnut and mustard oils in non-aqueous solvent at 298.15 K. J. Inst. Chemists (India) **90** (2017) 29–47.

[23] S. Khan, R. Sharma, A. K. Sharma: Ultrasonic studies of Cu(II) soap derived from seed oil of Pongamia pinnata (karanj) in non-aqueous binary and ternary systems at 298.15 K. Malaysian J. Chem. **19** (2017) 99–110.

[24] P. Tank, R. Sharma, A. K. Sharma: Viscometric studies of Cu(II) surfactants derived from mustard oil in benzene at 303.15 K. Tenside Surf Det. (2018) accepted.

[25] P. Tank, R. Sharma, A. K. Sharma: Micellar features and various interactions of copper soap complexes derived from edible mustard oil in benzene at 303.15 K. Curr. Phy. Chem. (2018) accepted.

[26] A. K. Sharma, M. Saxena, R. Sharma: Ultrasonic studies of Cu(II) soaps derived from groundnut and sesame oils. Tenside. Surf. Det. **54** (2018) accepted.

[27] A. K. Sharma, M. Saxena, R. Sharma: Acoustic studies of copper soap. Urea complexes derived from groundnut and seasamoils. J. Phy. Studies **21** (2018) 4001–4006.

[28] V. Sivakumar, R. V. Verma, P. G. Rao, G. Swaminathan: Studies on the use of power ultrasound in solid liquid myrobal an extraction process. J. Clean Prod. **15** (2007) 1813–1818.

[29] G. Singh, T. S. Banipal: Partial molar adiabatic compressibilities and viscosities of some amino acids in aqueous glycerol solutions at 298.15 K. Indian J. Chem. **47A** (2008) 1355–1364.

[30] S. V. Ranganayakulu, C. S. Reddy, D. L. Reddy: Ultrasonic studies of the binary mixtures of ethyl acetate and cresols-application of kosower and dimroth treatments. Mat. Chem. Phys. **90** (2005) 213–216.

[31] S. R. Kanhekar, P. Pravina, K. B. Govind: Thermodynamic properties of electrolytes in aqueous solutions of glycine at different temperatures. Indian J. Pure Appl. Phys. **48** (2010) 95–99.

[32] P. K. Banipal, A. K. Chakal, T. S. Banipal: Studies on volumetric properties of some saccharides in aqueous potassium chloride solutions over temperature range 288.15–318.15 K. J. Chem. Thermodynamic. **41** (2009) 452–483.

[33] S. Singh, I. Bahadur: Density and speed of sound of 1-ethyl-3-methylimidazolium ethylsulphate with acetic or propionic acid at different temperatures. J. Mol. Liq. **199** (2014) 518–523.

[34] B. V. Jahagirdar, B. R. Arbad, A. A. Walvekar, A. G. Shankarwer, M. Lande: Studies in partial molar volumes, partial molar compressibilities and viscosity B-coefficients of caffeine in water at four temperatures. J. Mol. Liq. **85** (2000) 361–373.

[35] A. K. Sharma, M. Saxena, R. Sharma: Ultrasonic studies of copper soaps urea complexes derived from mustard and soyabean oils. J. Phy. Sci. (2018) accepted.