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PHYSICO-ACOUSTIC INVESTIGATION OF BIOACTIVE SCHIFF BASE: N-((2-CHLORO-6,8-DIMETHYLQUINOLIN-3-YL)METHYLENE)-3-(5-METHYL-1H-TETRAZOL-1-YL)BENZENAMINE IN WATER-DMF AT DIFFERENT TEMPERATURES

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ABSTRACT
A novel Schiff Base, N-((2-Chloro-6,8-dimethylquinolin-3-yl)methylene)-3-(5-methyl-1*H*-tetrazol-1-yl)benzenamine were synthesized from the condensation reaction of 3-(5-methyl-1*H*-tetrazol-1-yl)benzenamine and 2-chloro-6,8-dimethylquinoline-3-carbaldehyde and elemental analysis, infrared, ^{1}H-NMR and ^{13}C-NMR spectroscopic techniques were used to establish the formation of Schiff bases. To understand molecular interactions in solutions, physico-acoustic properties such as density, viscosity and ultrasonic velocity have been measured for the synthesized Schiff base in DMF and $CHCl_3$ solutions of various concentrations at 300.15 ºK, 305.15 ºK, and 310.15 ºK. The experimental result data have been used to calculate various acoustic parameters, which are interpreted in terms of solute–solute and solute–solute interactions in these solvents.

KEYWORDS: Acoustical Parameters, DMF, Temperature, Viscosity, Water.

INTRODUCTION
Schiff bases, condensation compounds containing azomethine groups (-CH=N-) have a wide range of applications as catalysts,[1] dyes and pigments,[2] polymer stabilizers,[3] and intermediates in organic synthesis.[4] Schiff bases with di- or tridentate ligands form very stable complexes with transition metals.[5] Schiff bases are important intermediates in many enzymatic reactions involving the interaction of the enzyme with the amino or carbonyl group of the substrate. Apart from this, numerous Schiff bases exhibits a wide range of biological activities such as antibacterial,[6] antifungal,[7] analgesic,[8] anti-inflammatory,[9] anti-HIV,[10] anticancer,[11] antiparasitic,[12] antioxidant,[13] antimatarial,[14] and antiviral agents,[15] etc.

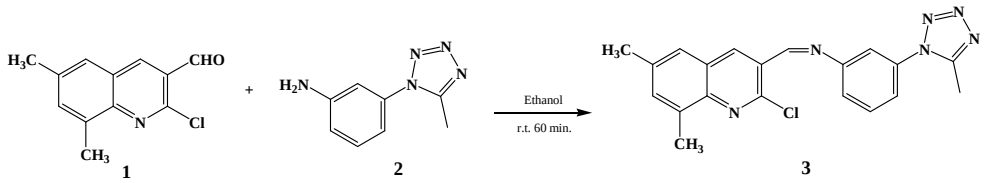
The interaction between solvents and solutes is one of the most important processes in organic chemistry that controls solubility, reactivity, and structure.[16] They also play an important role in the outcome of common processes such as annealing, molding and electro-spinning. Solute-solvent interactions are also important in biology. Although different solvents are used every day to dissolve molecules in the laboratory, the choice of solvent for each solute is predictable. The role of individual solvents with solutes is well documented, but solvent combinations require special attention. The solution-state conformations of heterocyclic compounds are strongly determined by the quality of the solvent. Theta solvents occupy a special position because the interactions between the solvent and solute i.e. heterocyclic compounds are of the same energy as solvent-solute interactions.

Solubility of active pharmaceutical ingredients is an important parameter used in the pharmaceutical industry, but its inadequate data records remain a major obstacle in the development of new drugs. For example, according to BCS criteria, as many as 40% of drugs can be regarded as practically insoluble in water and this number is even higher for newly developed drugs.[17] Owing to the above problem, herein, we have synthesized a quinoline-tetrazole hybrid Schiff base, N-((2-Chloro-6,8-dimethylquinolin-3-yl)methylene)-3-(5-methyl-1*H*-tetrazol-1-yl)benzenamine and evaluated for their physico- acoustic parameters intensively with solute-solvent interaction.

MATERIAL AND METHODS

2.1. Reagents

All the chemicals used were of AR grade and were purchased from sd-Fine chemicals. The melting points were determined in open capillaries using melting point apparatus (Model MP-96) and were uncorrected. The progress of reaction and purity of the product were monitored by thin layer chromatography using precoated Silica 60/UV254 (SDFCL). ^{1}H-NMR spectra and ^{13}C-NMR spectra were recorded in $CDCl_3$ using 400 MHz Varian Mercury plus 400 MHz FT-NMR spectrometer. The ^{1}H chemical shift values were reported on δ ppm scale relative to TMS (δ = 0.00 ppm). FT-IR were recorded and reported in cm^{-1}.



Scheme.1 Synthesis of *N*-((2-Chloro-6,8-dimethylquinolin-3-yl)methylene)-3-(5-methyl-1*H*-tetrazol-1-yl)benzenamine 3

2.2. Synthesis of *N*-((2-Chloro-6,8-dimethylquinolin-3-yl)methylene)-3-(5-methyl-1*H*-tetrazol-1-yl) benzenamine (3)

A mixture of 3-(5-methyl-1*H*-tetrazol-1-yl)benzenamine **1** (1 mmol, 2.19 g), 2-chloro-6,8-dimethylquinoline-3-carbaldehyde **2** (1 mmol, 1.75 g) and 20 ml ethanol was taken in 50 ml round bottom flask. The resultant reaction mixture was stirred for 1 hr. at room temperature. The progress of the reaction was monitored by TLC. After completion of reaction, the reaction mixture was poured on 50 ml cold water, filtered, dried and recrystalized from 1:1 ethanol/water. Pale yellow solid; (3.3 g, 88%) yield; mp 231–232 ºC; IR (KBr, νmax, cm^{-1}): 1611 (C=N azomethine), 1576 (C=N tetrazole ring), 1469 (N=N tetrazole ring), 1091 and 990 (N-N=N); ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 2.53 (s, 3H, CH_3-tetrazole); 2.71 (s, 3H, CH_3- quinoline); 2.77 (s, 3H, CH_3- quinoline); 7.40-7.41 (dd, 2H, quinoline H-5, H-7); 7.42-7.43 (dd, 2H, Ar-H); 7.48-7.57 (m, 1H, Ar-H); 7.66-7.70 (m, 1H, Ar-H); 8.93 (s, 1H, quinoline H-4); 9.04 (s, 1H, N=CH); ^{13}C NMR: δ ppm: 9.93 (CH_3-tetrazole), 17.65 (CH_3-quinoline, C-8), 21.58 (CH_3-Quinoline, C-6), 117.77 (C, tetrazole), 122.15 (1C), 122.46 (1C), 125.61 (1C), 126.39 (1C), 127.2 (1C), 130.81 (1C),134.72 (1C), 134.96 (1C), 136.35 (1C), 137.63 (1C), 137.73 (1C), 146.81 (1C), 148.25 (Ar C-1), 151.56 (quinoline C-2), 153.13 (quinoline C-9), 158.53 (N=CH); MS (ESI) m/z: 377.04 $(M+1)^{+}$. Anal. calcd. (%) for $C_{20}H_{17}ClN_6$: C, 63.74; H, 4.55; Cl, 9.41; N, 22.30; Found: C, 63.91; H, 4.56; Cl, 9.43; N, 22.26.

2.3. Choice of Solvents for physico-acoustic parameters

N,*N*-Dimethylformamide (DMF) and chloroform ($CHCl_3$) were chosen as solvents for the present investigation. Density, viscosity and ultrasonic velocity of solvents and solutions of different concentrations were measured using pycnometer, Ubbelohde suspended level viscometer and ultrasonic interferometer, respectively at temperatures of 300.15 ºK, 305.15 ºK and 310.15 ºK.

Initially, all required concentrations for the synthesized compounds were prepared in DMF and $CHCl_3$ using calibrated volumetric flasks. All prepared samples were kept at the desired temperature for 24 hours to ensure their solubility at temperature.

Density (ρ) and its measurement

Density is a measure of the "compactness" of a substance and is defined by the equation

$$\text{Density } (\rho) = \frac{\text{mass (m)}}{\text{volume (v)}}$$

The density was experimentally calculated by the equation.

$$\text{Density} = \frac{\text{weight of solvent/solution x density of water}}{\text{weight of water}}$$

$$\text{g/cm}^3$$

Viscosity (η) and its measurement

Viscosity expresses the resistance of a liquid to flow. It describes the internal friction of a moving fluid. Due to molecular structure, a fluid with high viscosity resists movement due to high internal friction while a fluid with low viscosity flows easily due to very low friction.

The determination of the viscosity of liquids or solutions is more accurately carried out by using Ubbelohde viscometer. Using the time taken for the distilled water and solution, the viscosity of unknown solutions is determined.

$$\frac{\eta_s}{\eta_w} = \frac{t_s \rho_s}{t_w \rho_w}$$

Where η_w, ρ_w and t_w are the viscosity, density and time flow of distilled water respectively and η_s, ρ_s and t_s are the viscosity, density and time flow of unknown liquid or solution respectively.

Ultrasound velocity (U) and its measurement

The measuring cell of the quartz crystal was filled with solvent/solution and then the micrometer was fixed. Circulation of water was started from the thermostat of required temperature and the test solvent/solution was allowed to thermally equilibrate in the cell. The

micrometer was rotated very slowly to obtain the maximum or minimum anode current (n). A number of maximum reading of anode current were counted. The total distance (d) traveled by the micrometer was read for n=10. Finally the wavelength (λ) was determined by the equation,

$$\lambda = \frac{2d}{n}$$

The sound velocity (U) of the solvent and solution was calculated from wavelength and frequency (F) according to equation.

$U = \lambda F$

Experimentally calculated data of density (ρ), viscosity (η) and ultrasound velocity (u) of pure solvents and solutions of the synthesized compounds in DMF and $CHCl_3$ at three different temperatures are reported in Table. 1 to 6 as follows:

Table 1: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrationsin DMF at 300.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	0.9349	0.6596	1401.5
2	2.0	0.9361	0.6843	1408.7
3	4.0	0.9366	0.7143	1419.4
4	6.0	0.9370	0.7235	1428.2
5	8.0	0.9377	0.7391	1436.7
6	10	0.9380	0.7596	1448.2

Table 2: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrations in DMF at 305.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	0.9343	0.6056	1383.3
2	2.0	0.9344	0.6515	1390.1
3	4.0	0.9349	0.6868	1389.5
4	6.0	0.9363	0.7037	1409.7
5	8.0	0.9358	0.7202	1427.0
6	10	0.9374	0.7427	1429.8

Table 3: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrationsin DMF at 310.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	0.9337	0.5739	1363.9
2	2.0	0.9347	0.6235	1370.9
3	4.0	0.9353	0.6531	1379.5
4	6.0	0.9360	0.6720	1391.3
5	8.0	0.9364	0.6821	1397.3
6	10	0.9370	0.7016	1409.5

Table 4: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrationsin Chloroform at 300.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	1.4773	0.5303	986.65
2	2.0	1.4783	0.5340	988.97
3	4.0	1.4790	0.5361	990.58
4	6.0	1.4791	0.5371	992.33
5	8.0	1.4799	0.5380	994.00
6	10	1.4803	0.5383	995.62

Table 5: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrationsin Compound 3 at 305.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	1.4714	0.5111	965.64
2	2.0	1.472o	0.5131	967.90
3	4.0	1.4737	0.5140	969.64

4	6.0	1.4739	0.5155	971.36
5	8.0	1.4745	0.5164	972.80
6	10	1.4756	0.5190	974.45

Table 6: Experimental data of density (ρ), viscosity (η) and ultrasonic velocity (U) of Compound 3 with different concentrationsin Chloroform at 310.15 ºK.

Sr. No.	Concentration (x 10^{-3} M)	Density (x 10^{-3} kgm^{-3})	Viscosity (x 10^{-3} Nsm^{-2})	Sound Velocity (ms^{-1})
1	00	1.4684	0.4966	943.46
2	2.0	1.4690	0.4987	945.63
3	4.0	1.4700	0.4993	947.09
4	6.0	1.4705	0.4995	948.73
5	8.0	1.471	0.5001	950.43
6	10	1.4720	0.5020	952.01

RESULTS AND DISCUSSION

Physicochemical properties of pure and mixtures of solute Viscosity measurements can be useful for finding fluids of various types mainly on molecular and atomic basis. The temperature dependence of the viscoelastic/viscous behavior of inorganic mixtures plays an important role in material characterization.

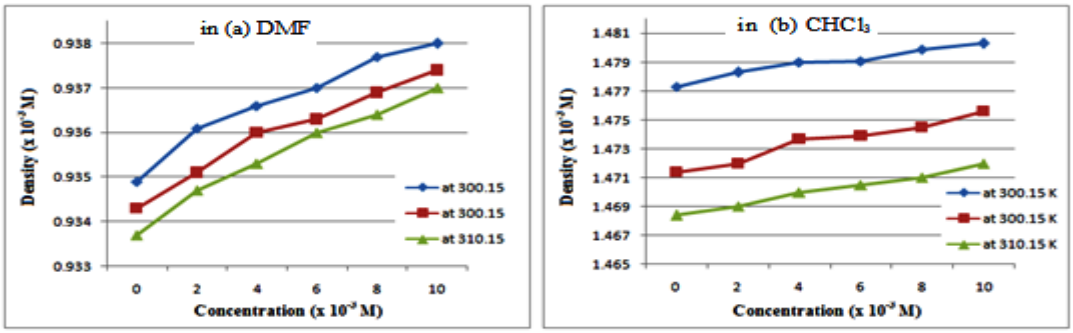


Figure 1: Variation of density with concentrations at different temperature of compound 3 in (a) DMF and (b) $CHCl_3$.

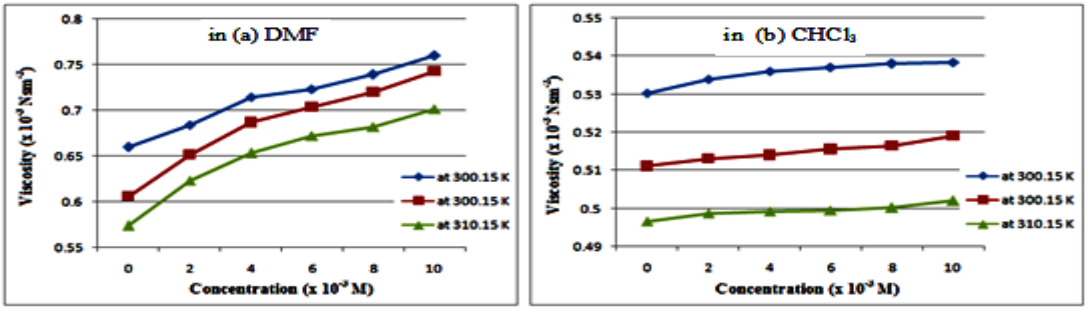


Figure 2: Variation of viscosity with concentrations at different temperatures of compound 3 in (a) DMF and (b) $CHCl_3$.

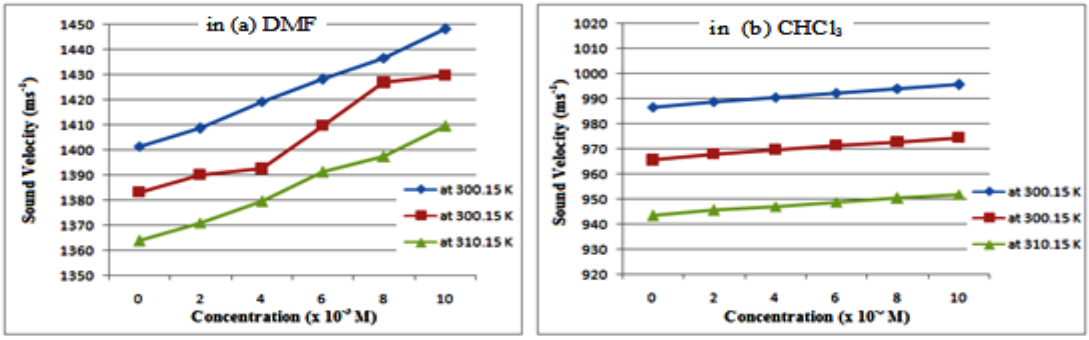


Figure 3: Variation of sound velocity with concentrations at different temperature of Compound 3 in (a) DMF and (b) $CHCl_3$.

In the present work, density, viscosity and ultrasonic sound velocity have been studied for different concentrations of compound 3 in DMF and CHCl3 at 300.15 ºK, 305.15 ºK and 310.15 ºK. From experimental data, Tables 1 to 6 and Figures 1 to 3 show the differences in density (ρ), viscosity (η) and ultrasonic sound velocity (u) between pure solvents (DMF and CHCl3) and solutions of the synthesized compound. It is observed that density, viscosity and ultrasonic velocity (U) increases with increase in concentration of the compound due increase in amount of compounds. An increase in temperature causes the solute molecules to move faster and separate further, causing the density to decrease. An increase in temperature increases the kinetic or thermal energy and the molecules become more mobile, which lowers the attractive bond energy and thus lowers the viscosity. Temperature variation of solutions shows that the strength of intermolecular nitration increases with increasing temperature.

CONCLUSION

In conclusion, the ultrasonic velocity, density and viscosity of the title compound **3** were measured in DMF and $CHCl_3$ at various temperatures. Trends and deviations in derived parameters were confirmed with the existence of strong interactions and dipole-dipole interactions. Linearity in properties infers specific interactions between solute and solute molecules. Strong intermolecular interactions through H-bonding at low values were observed. It is confirmed that at low value of concentration weak interaction is observed in solute-solute interaction. This indicates that solute-solute and solute-solvent interactions exist in these systems.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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