International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

Determination of Wada Constant, Rao's Constant, Compressibility Andviscosity of A Cholesteric Liquid Crystal Solution at Various Temperatures

Anita Kanwar and Pritee Mhatre

VES College of Arts, Science and Commerce, Department of Physics, Sindhi society, Chembur, Mumbai 400071.

ABSTRACT:

The ultrasonic waves having different frequencies propagate through the liquid crystal solution with different velocities at various temperatures. This fact helps in studying physical and chemical properties of Cholesteric liquid crystal (CLC) of different concentration at various temperatures. We in our laboratory have found out Acoustic Impedance, Rao's constant, Adiabatic Compressibility,Wada constant,Van der Waals' constant, Free Volume, Internal pressure andClassical Absorption Co-efficientof CLC solutionof different concentration. The measurements were made at various temperatures using Ultrasonic interferometer working at the frequencies 3MHz and 5MHz. The results so obtained are analyzedto see the effect temperature, concentration and transition of CLC into various mesophases. It is observed that when the miscibility is high and the solution is highly homogeneousthe values of the parameters change drastically showing the change in the mesophases at phase transition temperatures.

INTRODUCTION:

Cholesteryl Pelargonate (CP) a CLC [1] having molecular formula $C_{36}H_{62}O_2$ and molecular weight of 526.88 g/mol as obtained from Sigma –Aldrich is used in preparation of the samples. The phase transition temperatures of CLC, CP were obtained using the Fabryperot scattering studies (FPSS) technique [2]. Homogeneous mixture of Toluene and CP [3] having various concentration is used as a sample to study the effect of temperature and concentration on the physical and chemical parameters. We have determined the Wada constant, Rao's constant, compressibility and viscosity [4-5] of the solution at various temperatures by varying concentration of the solution.

Ultrasonic velocities for the solutions of different concentrations were measured by varying the temperature using indigenously designed thermometer. The ultrasonic interferometer (Mittal enterprises, India; Model: F-80X) was used for the measurements of velocity of ultrasonic waves in the solvent and solution. It consists of a high frequency generator and a measuring cell and the measurements were made at two different frequencies viz3MHz and 5MHz. The least count of micrometer measuring cell is 0.01mm. The ultrasonic velocity has an accuracy of ± 0.5%. It is used to find the Acoustic Impedance, Rao's constant, Adiabatic Compressibility,and Wada constant. The viscosity was measured by Oswald'sviscometer. It is used to find Van der Waals' constant, Free Volume, Internal pressure andClassical Absorption Co-efficient of the five samples prepared in the laboratory.

Experimental details:

The phase transitions in CP using FPSS occurred at 331.6K, 337.8K, 344.5K and 357K respectively. Homogeneous mixture of Toluene and cholesteric liquid crystal Cholesteryl Pelargonate having various concentration is used as a sample to study the effect of temperature and concentration on the physical and chemical parameters. We have determined the Wada constant, Rao's constant, compressibility and viscosity of the solution at various temperatures by varying concentration of the solution. Indigenously designed temperature controller using transducer and a digital thermometer was used to maintain the temperature constant and for the measurement with accuracy of 0.1^0C.
The following formulae were used for the calculation of various parameters.

1) Acoustic Impedance (A)= Uρgm/cm^2.sec (where U is ultrasonic velocity and ρ is density)
2) Rao's constant or Molar sound velocity(R) = $\frac{M}{\rho} U^{1/3}$ $cm^{10/3}/sec^{1/3}$
   where $M=M_1W_1+M_2W2$ (M_1 and M_2 are molecular weights of CP and toluene respectively and W_1 and W_2 are weight fractions of CP and toluene respectively in the solution.
3) Adiabatic Compressibility (K) = $\frac{1}{U^2\rho}$ cm^2/dyne
4) Wada Constant or Molar compressibility (W) = $[\frac{M}{\rho}]$ x $K^{-1/7} cm^{19/7}/dyne^{1/7}$
5) Viscous relaxation time (T) =$\frac{4\eta}{3\rho U^2}$sec where $\eta$is viscosity.
6) Van der Waals' constant (b) = V $\left[1-\left(\frac{RT}{MU^2}\right)\left(1+\frac{MU^2}{3KT}\right)^{1/2}\right]$ cm^3/mole
   Where, R is the gas constant = $8.3143 \text{x} 10^7$ erg × mol^{-1} ×K^{-1}
7) Free Volume (V_f) = $\left[\frac{MU}{K\eta}\right]^{3/2}$
8) Internal Pressure $(\pi) = b'RT\left(\frac{K'\eta}{U}\right)^{1/2}\frac{\rho^{2/3}}{M^{7/6}}$ where b'=2 and K'= (93.875+0.375T)x 10^{-8}
9) Classical Absorption Co-efficient = $\frac{\alpha}{f^2} = \frac{8\pi^2\eta}{3U^3\rho}$

Observations:

The five sample solutions were prepared using Toluene (T) and Cholesteryl Pelargonate (CP) in the following proportionand analyzed to find above physical and chemical parameters. The Table 1 to Table 5 shows the calculated values of the parameters at 3MHz and 5MHz when the temperature is varied from 303K to 343K using above formulae.

i) 10ml T + 20 mg CP, Molecular Weight (MW)=710.2gm
ii) 10ml T + 40 mg CP, Molecular Weight =720.7gm
iii) 10ml T+ 60 mg CP, Molecular Weight =731.2 gm
iv) 10ml T+ 80 mg CP, Molecular Weight =741.8gm
v) 10ml+ 100 mg CP, Molecular Weight = 752.3 gm

ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

Table1 (a): Sample1: 10ml T + 20 mg CP, ρ =0.761gm/cc, η=1.206 dynes.sec/cm²

T(K)	Velocity (cm/s)	R ($cm^{10/3}/sec^{1/3}$)	K (cm^2/dyne)	W ($cm^{19/7}/dyne^{1/7}$)	A ($gm/cm^2.sec$)
Frequency: 3MHz					
303	129900	4.724E+04	7.784E-11	2.594E+04	9.889E+04
308	128700	4.710E+04	7.930E-11	2.587E+04	9.798E+04
313	129300	4.717E+04	7.857E-11	2.590E+04	9.844E+04
318	128700	4.710E+04	7.930E-11	2.587E+04	9.798E+04
323	129000	4.713E+04	7.893E-11	2.588E+04	9.821E+04
328	128100	4.702E+04	8.005E-11	2.583E+04	9.752E+04
333	128100	4.702E+04	8.005E-11	2.583E+04	9.752E+04
338	127500	4.695E+04	8.080E-11	2.580E+04	9.707E+04
343	127800	4.699E+04	8.042E-11	2.582E+04	9.729E+04
Frequency: 5MHz					
303	127900	4.700E+04	8.030E-11	2.582E+04	9.737E+04
308	129500	4.719E+04	7.833E-11	2.591E+04	9.859E+04
313	128500	4.707E+04	7.955E-11	2.586E+04	9.783E+04
318	130000	4.725E+04	7.772E-11	2.594E+04	9.897E+04
323	129000	4.713E+04	7.893E-11	2.588E+04	9.821E+04
328	129000	4.713E+04	7.893E-11	2.588E+04	9.821E+04
333	130000	4.725E+04	7.772E-11	2.594E+04	9.897E+04
338	129000	4.713E+04	7.893E-11	2.588E+04	9.821E+04
343	127900	4.700E+04	8.030E-11	2.582E+04	9.737E+04

Table 1(b)

T(K)	Viscous relaxation time	Van der Waals' constant	Free Volume	Internal Pressure	Classical Absorption Co-efficient
Frequency: 3MHz					
303	1.248E-10	9.100E+02	2.390E-03	3.948E+09	3.003E+04
308	1.272E-10	9.096E+02	2.357E-03	4.031E+09	3.220E+04
313	1.260E-10	9.096E+02	2.373E-03	4.087E+09	3.264E+04
318	1.272E-10	9.093E+02	2.357E-03	4.162E+09	3.433E+04
323	1.266E-10	9.092E+02	2.365E-03	4.223E+09	3.509E+04
328	1.284E-10	9.089E+02	2.340E-03	4.303E+09	3.721E+04
333	1.284E-10	9.087E+02	2.340E-03	4.369E+09	3.835E+04
338	1.296E-10	9.084E+02	2.324E-03	4.445E+09	4.026E+04
343	1.290E-10	9.083E+02	2.332E-03	4.505E+09	4.107E+04
Frequency: 5MHz					
303	1.288E-10	9.097E+02	2.335E-03	3.978E+09	3.195E+04
308	1.256E-10	9.098E+02	2.379E-03	4.019E+09	3.141E+04
313	1.276E-10	9.094E+02	2.351E-03	4.100E+09	3.346E+04
318	1.247E-10	9.095E+02	2.392E-03	4.141E+09	3.297E+04
323	1.266E-10	9.092E+02	2.365E-03	4.223E+09	3.509E+04
328	1.266E-10	9.090E+02	2.365E-03	4.288E+09	3.618E+04
333	1.247E-10	9.090E+02	2.392E-03	4.337E+09	3.616E+04
338	1.266E-10	9.087E+02	2.365E-03	4.419E+09	3.842E+04
343	1.288E-10	9.083E+02	2.335E-03	4.503E+09	4.095E+04

ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

Table2 (a): Sample2: 10ml T + 40 mg CP, ρ =0.763gm/cc, η=1.238 dynes.sec/cm^2

T(K)	Velocity (cm/s)	R (cm$^{10/3}$/sec$^{1/3}$)	K (cm^2/dyne)	W (cm $^{19/7}$/dyne $^{1/7}$)	A (gm/cm^2.sec)
Frequency: 3MHz					
303	127800	4.756E+04	8.021E-11	2.614E+04	9.755E+04
308	127200	4.748E+04	8.097E-11	2.610E+04	9.709E+04
313	127800	4.756E+04	8.021E-11	2.614E+04	9.755E+04
318	127800	4.756E+04	8.021E-11	2.614E+04	9.755E+04
323	127800	4.756E+04	8.021E-11	2.614E+04	9.755E+04
328	127500	4.752E+04	8.059E-11	2.612E+04	9.732E+04
333	127800	4.756E+04	8.021E-11	2.614E+04	9.755E+04
338	129000	4.771E+04	7.873E-11	2.621E+04	9.847E+04
343	128100	4.760E+04	7.984E-11	2.616E+04	9.778E+04
Frequency: 5MHz					
303	127000	4.746E+04	8.123E-11	2.609E+04	9.694E+04
308	126500	4.740E+04	8.187E-11	2.606E+04	9.656E+04
313	128500	4.765E+04	7.934E-11	2.618E+04	9.808E+04
318	127500	4.752E+04	8.059E-11	2.612E+04	9.732E+04
323	127000	4.746E+04	8.123E-11	2.609E+04	9.694E+04
328	120500	4.664E+04	9.023E-11	2.570E+04	9.198E+04
333	127000	4.746E+04	8.123E-11	2.609E+04	9.694E+04
338	123500	4.702E+04	8.590E-11	2.589E+04	9.427E+04
343	125500	4.727E+04	8.318E-11	2.600E+04	9.579E+04

Table 2(b)

T(K)	Viscous relaxation time	Van der Waals' constant	Free Volume	Internal Pressure	Classical Absorption Co-efficient
Frequency: 3MHz					
303	1.321E-10	9.209E+02	2.292E-03	3.970E+09	3.266E+04
308	1.333E-10	9.206E+02	2.276E-03	4.046E+09	3.439E+04
313	1.321E-10	9.206E+02	2.292E-03	4.102E+09	3.485E+04
318	1.321E-10	9.204E+02	2.292E-03	4.167E+09	3.598E+04
323	1.321E-10	9.202E+02	2.292E-03	4.233E+09	3.712E+04
328	1.327E-10	9.200E+02	2.284E-03	4.303E+09	3.864E+04
333	1.321E-10	9.199E+02	2.292E-03	4.364E+09	3.945E+04
338	1.296E-10	9.199E+02	2.325E-03	4.408E+09	3.915E+04
343	1.314E-10	9.196E+02	2.300E-03	4.489E+09	4.146E+04
Frequency: 5MHz					
303	1.337E-10	9.208E+02	2.271E-03	3.983E+09	3.349E+04
308	1.348E-10	9.205E+02	2.257E-03	4.057E+09	3.516E+04
313	1.306E-10	9.207E+02	2.311E-03	4.090E+09	3.410E+04
318	1.327E-10	9.203E+02	2.284E-03	4.172E+09	3.632E+04
323	1.337E-10	9.201E+02	2.271E-03	4.246E+09	3.806E+04
328	1.485E-10	9.187E+02	2.099E-03	4.426E+09	4.843E+04
333	1.337E-10	9.197E+02	2.271E-03	4.377E+09	4.045E+04
338	1.414E-10	9.189E+02	2.177E-03	4.506E+09	4.661E+04
343	1.369E-10	9.191E+02	2.231E-03	4.536E+09	4.501E+04

Table3(a): Sample3: 10ml T + 60 mg CP, ρ =0.765gm/cc, η=1.267 dynes.sec/cm²

T(K)	Velocity (cm/s)	R ($cm^{10/3}/sec^{1/3}$)	K (cm^2/dyne)	W ($cm^{19/7}/dyne^{1/7}$)	A ($gm/cm^2.sec$)
Frequency: 3MHz					
303	128100	4.817E+04	7.963E-11	2.648E+04	9.803E+04
308	128100	4.817E+04	7.963E-11	2.648E+04	9.803E+04
313	128100	4.817E+04	7.963E-11	2.648E+04	9.803E+04
318	127500	4.809E+04	8.038E-11	2.645E+04	9.758E+04
323	128400	4.820E+04	7.926E-11	2.650E+04	9.826E+04
328	128100	4.817E+04	7.963E-11	2.648E+04	9.803E+04
333	128400	4.820E+04	7.926E-11	2.650E+04	9.826E+04
338	128400	4.820E+04	7.926E-11	2.650E+04	9.826E+04
343	128700	4.824E+04	7.889E-11	2.652E+04	9.849E+04
Frequency: 5MHz					
303	141000	4.973E+04	6.572E-11	2.722E+04	1.079E+05
308	128500	4.822E+04	7.913E-11	2.650E+04	9.834E+04
313	131500	4.859E+04	7.556E-11	2.668E+04	1.006E+05
318	127500	4.809E+04	8.038E-11	2.645E+04	9.758E+04
323	133500	4.883E+04	7.332E-11	2.679E+04	1.022E+05
328	129500	4.834E+04	7.792E-11	2.656E+04	9.911E+04
333	128500	4.822E+04	7.913E-11	2.650E+04	9.834E+04
338	134500	4.896E+04	7.223E-11	2.685E+04	1.029E+05
343	129000	4.828E+04	7.852E-11	2.653E+04	9.872E+04

Table 3(b)

T(K)	Viscous relaxation time	Van der Waals' constant	Free Volume	Internal Pressure	Classical Absorption Co-efficient
Frequency: 3MHz					
303	1.342E-10	9.321E+02	2.271E-03	3.952E+09	3.279E+04
308	1.342E-10	9.320E+02	2.271E-03	4.017E+09	3.388E+04
313	1.342E-10	9.318E+02	2.271E-03	4.082E+09	3.499E+04
318	1.354E-10	9.315E+02	2.255E-03	4.157E+09	3.680E+04
323	1.335E-10	9.315E+02	2.279E-03	4.207E+09	3.691E+04
328	1.342E-10	9.313E+02	2.271E-03	4.278E+09	3.842E+04
333	1.335E-10	9.312E+02	2.279E-03	4.338E+09	3.924E+04
338	1.335E-10	9.310E+02	2.279E-03	4.403E+09	4.042E+04
343	1.329E-10	9.309E+02	2.287E-03	4.463E+09	4.124E+04
Frequency: 5MHz					
303	1.107E-10	9.341E+02	2.622E-03	3.766E+09	2.234E+04
308	1.333E-10	9.320E+02	2.281E-03	4.010E+09	3.346E+04
313	1.273E-10	9.323E+02	2.362E-03	4.029E+09	3.151E+04
318	1.354E-10	9.315E+02	2.255E-03	4.157E+09	3.680E+04
323	1.235E-10	9.323E+02	2.416E-03	4.126E+09	3.159E+04
328	1.313E-10	9.315E+02	2.308E-03	4.254E+09	3.679E+04
333	1.333E-10	9.312E+02	2.281E-03	4.336E+09	3.911E+04
338	1.217E-10	9.320E+02	2.443E-03	4.302E+09	3.357E+04
343	1.323E-10	9.309E+02	2.295E-03	4.458E+09	4.086E+04

Table 4(a): Sample4: 10ml T + 80 mg CP, ρ =0.767gm/cc, η=1.273 dynes.sec/cm^2

T(K)	Velocity (cm/s)	R (cm$^{10/3}$/sec$^{1/3}$)	K (cm^2/dyne)	W (cm $^{19/7}$/dyne $^{1/7}$)	A (gm/cm^2.sec)
Frequency: 3MHz					
303	128100	4.873E+04	7.942E-11	2.680E+04	9.829E+04
308	127500	4.866E+04	8.017E-11	2.677E+04	9.783E+04
313	127500	4.866E+04	8.017E-11	2.677E+04	9.783E+04
318	127800	4.869E+04	7.979E-11	2.678E+04	9.806E+04
323	127500	4.866E+04	8.017E-11	2.677E+04	9.783E+04
328	128100	4.873E+04	7.942E-11	2.680E+04	9.829E+04
333	127800	4.869E+04	7.979E-11	2.678E+04	9.806E+04
338	127800	4.869E+04	7.979E-11	2.678E+04	9.806E+04
343	127800	4.869E+04	7.979E-11	2.678E+04	9.806E+04
Frequency: 5MHz					
303	126000	4.846E+04	8.209E-11	2.668E+04	9.668E+04
308	125000	4.834E+04	8.341E-11	2.662E+04	9.591E+04
313	126500	4.853E+04	8.144E-11	2.671E+04	9.706E+04
318	128500	4.878E+04	7.893E-11	2.683E+04	9.860E+04
323	128500	4.878E+04	7.893E-11	2.683E+04	9.860E+04
328	123500	4.814E+04	8.545E-11	2.652E+04	9.476E+04
333	127500	4.866E+04	8.017E-11	2.677E+04	9.783E+04
338	127500	4.866E+04	8.017E-11	2.677E+04	9.783E+04
343	127000	4.859E+04	8.080E-11	2.674E+04	9.745E+04

Table 4(b)

T(K)	Viscous relaxation time	Van der Waals' constant	Free Volume	Internal Pressure	Classical Absorption Co-efficient
Frequency: 3MHz					
303	1.345E-10	9.433E+02	2.303E-03	3.902E+09	3.205E+04
308	1.357E-10	9.430E+02	2.287E-03	3.976E+09	3.374E+04
313	1.357E-10	9.428E+02	2.287E-03	4.041E+09	3.485E+04
318	1.351E-10	9.427E+02	2.295E-03	4.100E+09	3.563E+04
323	1.357E-10	9.425E+02	2.287E-03	4.170E+09	3.711E+04
328	1.345E-10	9.424E+02	2.303E-03	4.224E+09	3.756E+04
333	1.351E-10	9.422E+02	2.295E-03	4.294E+09	3.907E+04
338	1.351E-10	9.420E+02	2.295E-03	4.358E+09	4.026E+04
343	1.351E-10	9.418E+02	2.295E-03	4.423E+09	4.146E+04
Frequency: 5MHz					
303	1.390E-10	9.429E+02	2.247E-03	3.935E+09	3.424E+04
308	1.412E-10	9.425E+02	2.220E-03	4.016E+09	3.652E+04
313	1.379E-10	9.426E+02	2.260E-03	4.056E+09	3.596E+04
318	1.336E-10	9.428E+02	2.314E-03	4.089E+09	3.486E+04
323	1.336E-10	9.426E+02	2.314E-03	4.153E+09	3.597E+04
328	1.447E-10	9.416E+02	2.180E-03	4.302E+09	4.347E+04
333	1.357E-10	9.421E+02	2.287E-03	4.299E+09	3.944E+04
338	1.357E-10	9.419E+02	2.287E-03	4.363E+09	4.064E+04
343	1.368E-10	9.417E+02	2.274E-03	4.437E+09	4.251E+04

Table 5(a): Sample5: 10ml T + 100 mg CP, ρ =0.769gm/cc, η=1.298 dynes.sec/cm^2

T(K)	Velocity (cm/s)	R (cm$^{10/3}$/sec$^{1/3}$)	K (cm^2/dyne)	W (cm $^{19/7}$/dyne $^{1/7)}$	A (gm/cm^2.sec)
Frequency: 3MHz					
303	128400	4.933E+04	7.885E-11	2.714E+04	9.878E+04
308	129300	4.945E+04	7.775E-11	2.719E+04	9.947E+04
313	128700	4.937E+04	7.848E-11	2.716E+04	9.901E+04
318	129000	4.941E+04	7.811E-11	2.718E+04	9.924E+04
323	128100	4.930E+04	7.921E-11	2.712E+04	9.855E+04
328	128100	4.930E+04	7.921E-11	2.712E+04	9.855E+04
333	128100	4.930E+04	7.921E-11	2.712E+04	9.855E+04
338	128400	4.933E+04	7.885E-11	2.714E+04	9.878E+04
343	125700	4.899E+04	8.227E-11	2.698E+04	9.670E+04
Frequency: 5MHz					
303	127000	4.915E+04	8.059E-11	2.706E+04	9.770E+04
308	123000	4.863E+04	8.592E-11	2.681E+04	9.462E+04
313	134000	5.004E+04	7.239E-11	2.747E+04	1.031E+05
318	128000	4.928E+04	7.934E-11	2.712E+04	9.847E+04
323	139500	5.072E+04	6.680E-11	2.779E+04	1.073E+05
328	140500	5.084E+04	6.585E-11	2.785E+04	1.081E+05
333	135000	5.017E+04	7.132E-11	2.753E+04	1.039E+05
338	129000	4.941E+04	7.811E-11	2.718E+04	9.924E+04
343	130000	4.954E+04	7.692E-11	2.724E+04	1.000E+05

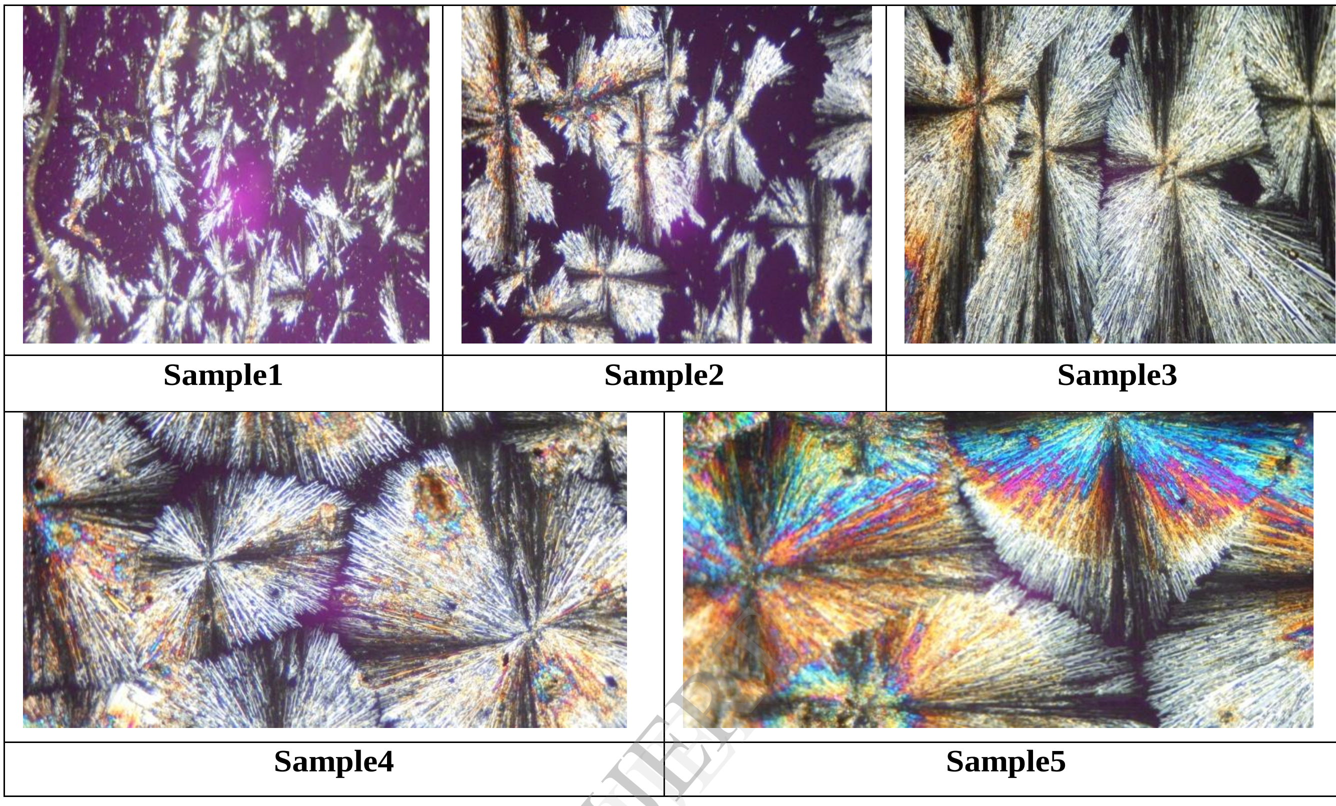
Table 5(b)

T(K)	Viscous relaxation time	Van der Waals' constant	Free Volume	Internal Pressure	Classical Absorption Co-efficient
Frequency: 3MHz					
303	1.361E-10	9.544E+02	2.293E-03	3.878E+09	3.196E+04
308	1.342E-10	9.543E+02	2.318E-03	3.928E+09	3.211E+04
313	1.355E-10	9.541E+02	2.301E-03	4.001E+09	3.378E+04
318	1.348E-10	9.539E+02	2.310E-03	4.060E+09	3.455E+04
323	1.367E-10	9.536E+02	2.285E-03	4.139E+09	3.666E+04
328	1.367E-10	9.534E+02	2.285E-03	4.203E+09	3.780E+04
333	1.367E-10	9.533E+02	2.285E-03	4.267E+09	3.896E+04
338	1.361E-10	9.532E+02	2.293E-03	4.326E+09	3.977E+04
343	1.420E-10	9.525E+02	2.221E-03	4.437E+09	4.459E+04
Frequency: 5MHz					
303	1.391E-10	9.541E+02	2.256E-03	3.899E+09	3.339E+04
308	1.483E-10	9.532E+02	2.150E-03	4.028E+09	3.921E+04
313	1.250E-10	9.549E+02	2.445E-03	3.921E+09	2.875E+04
318	1.369E-10	9.538E+02	2.283E-03	4.076E+09	3.564E+04
323	1.153E-10	9.555E+02	2.597E-03	3.966E+09	2.606E+04
328	1.137E-10	9.554E+02	2.625E-03	4.013E+09	2.612E+04
333	1.231E-10	9.544E+02	2.473E-03	4.156E+09	3.159E+04
338	1.348E-10	9.533E+02	2.310E-03	4.316E+09	3.903E+04
343	1.328E-10	9.533E+02	2.336E-03	4.363E+09	3.897E+04

ISSN: 2278-0181
Vol. 3 Issue 1, January - 2014

Figure1 shows the Optical Polarizing Microscope images of the sample1 to sample5 respectively at room temperature.

Figure1: Optical Polarizing Microscope images



Sample1 **Sample2** **Sample3**

Sample4 **Sample5**

Figure2 to Figure6 showsvariation of ultrasonic velocity with temperature at two different frequencies viz 3MHz and 5 MHz for sample1 to sample5 respectively.

Figure2: Sample1

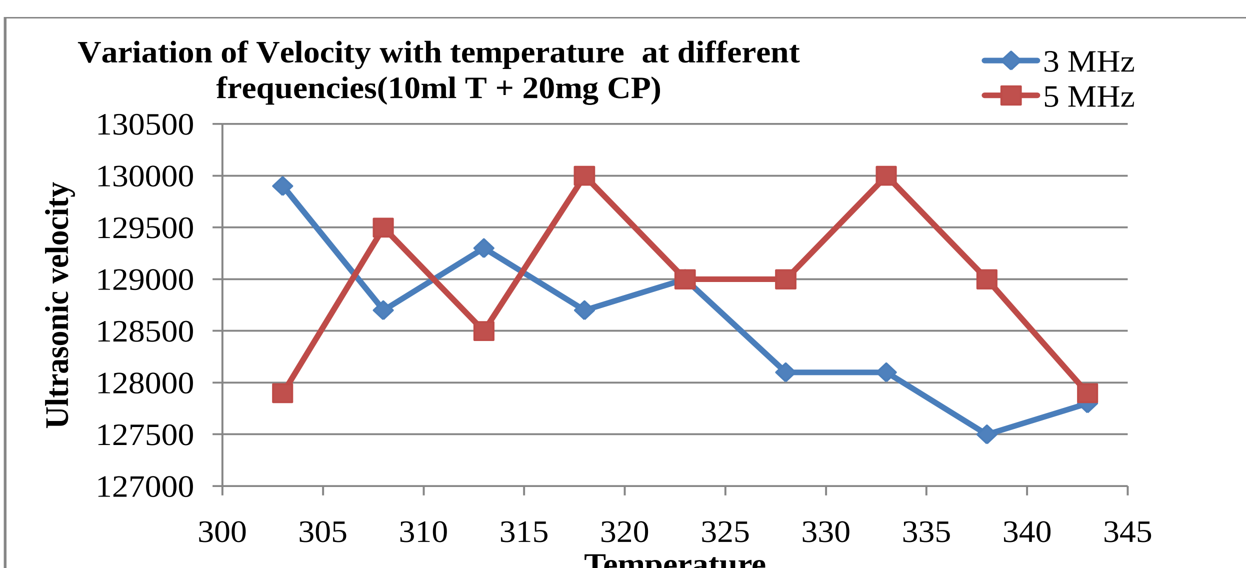


Figure3: Sample2

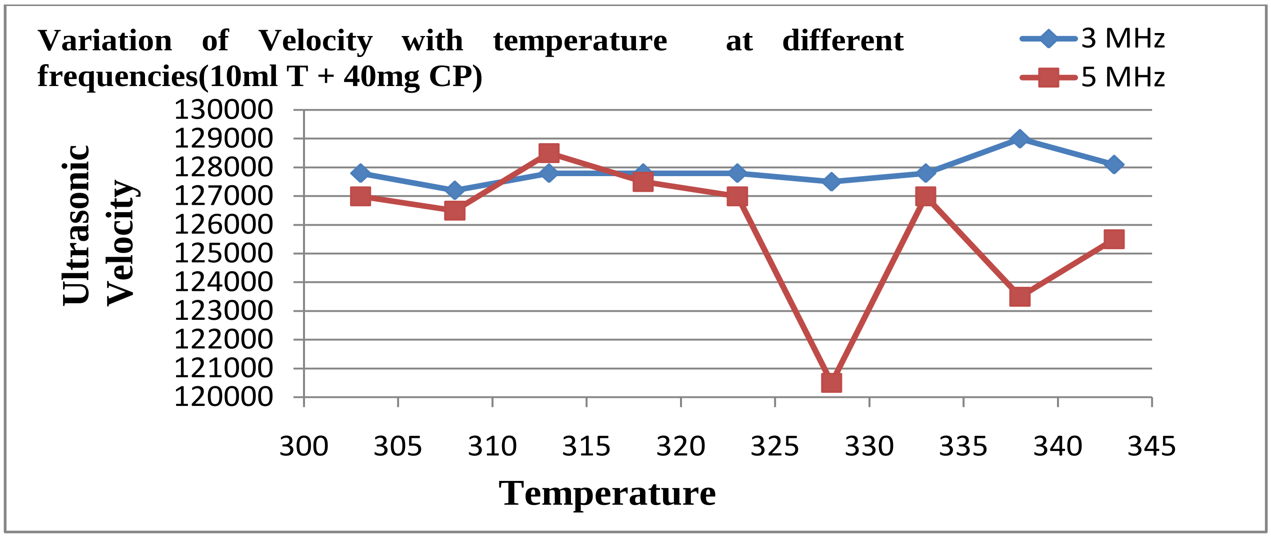


Figure4: Sample3

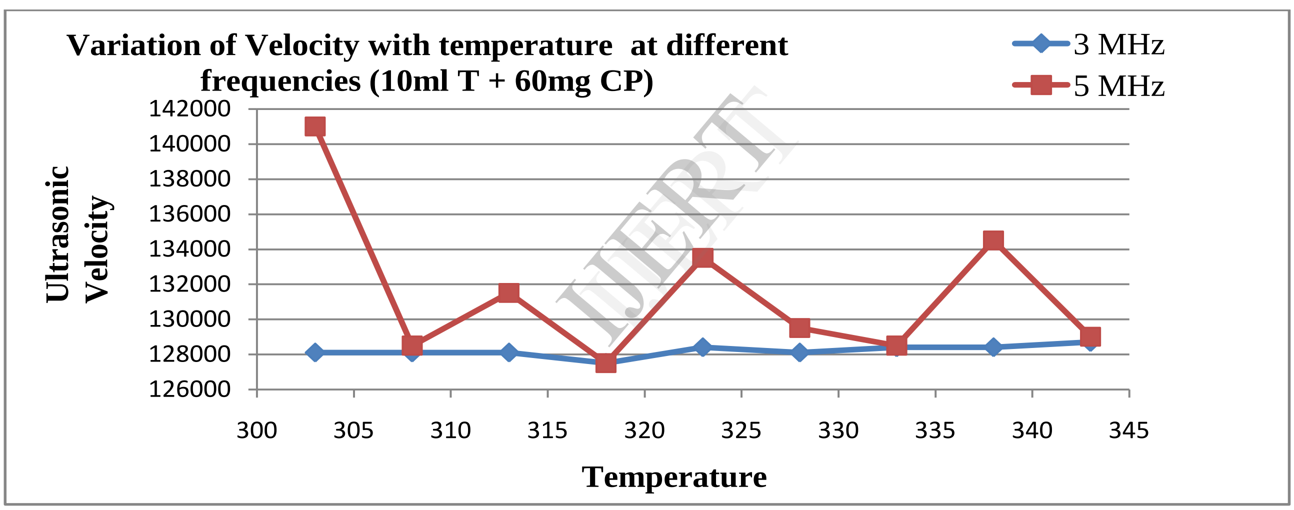


Figure5: Sample4

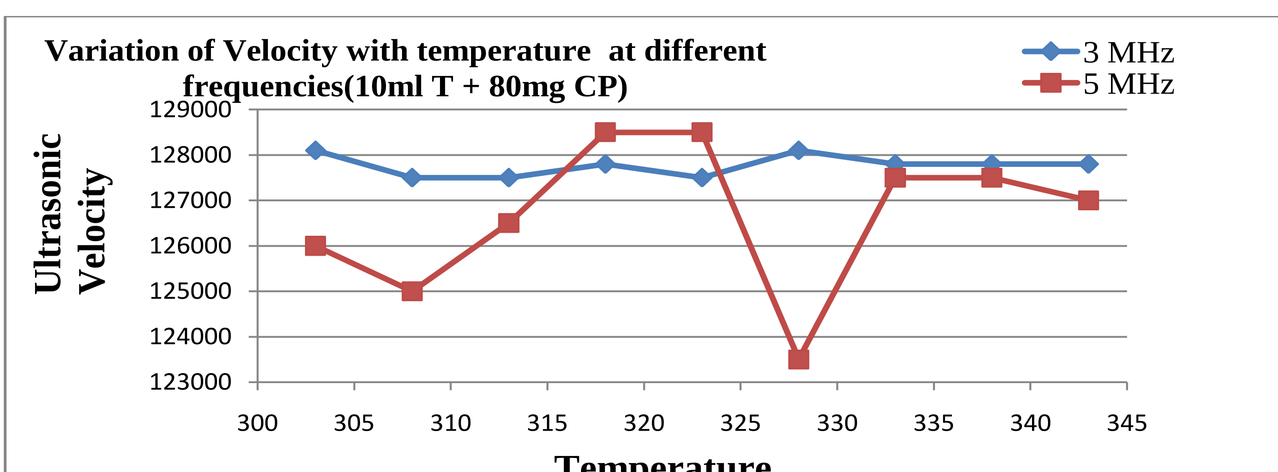


Figure6: Sample5

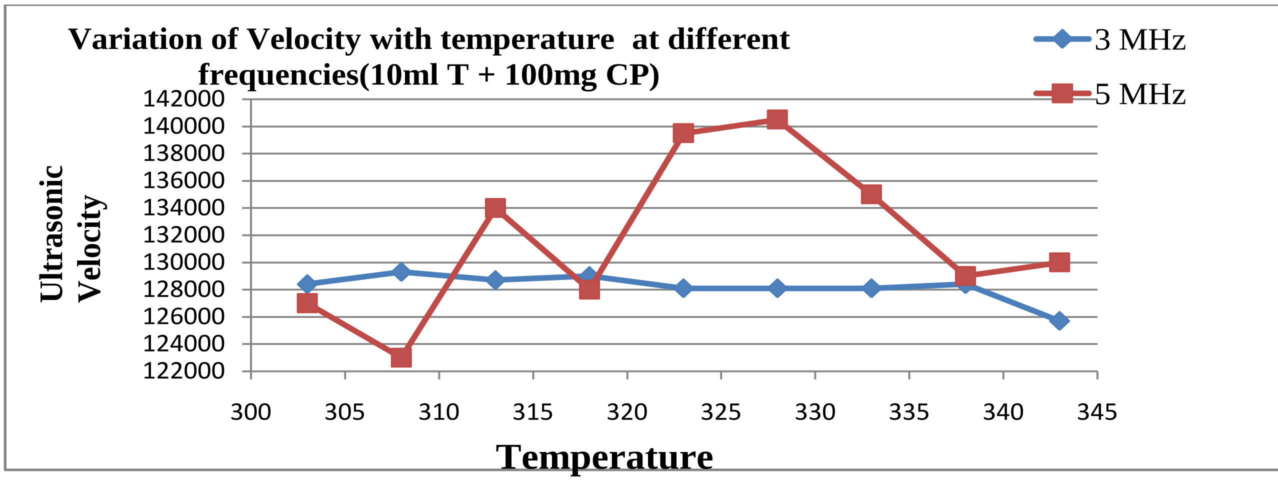


Figure7 to Figure11 shows variation of Viscosity with temperature at two different frequencies viz 3MHz and 5 MHz for sample1 to sample5 respectively.

Figure7: Sample1

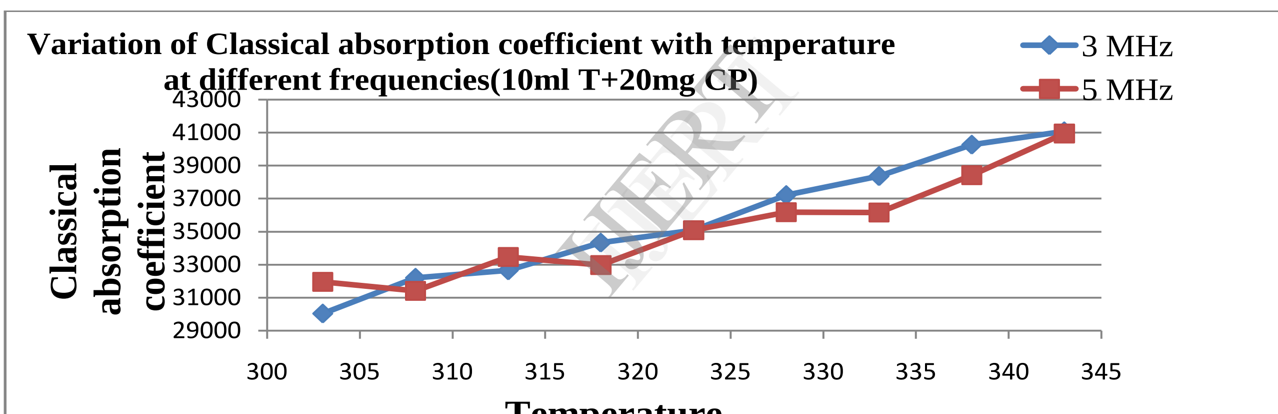


Figure8: Sample2

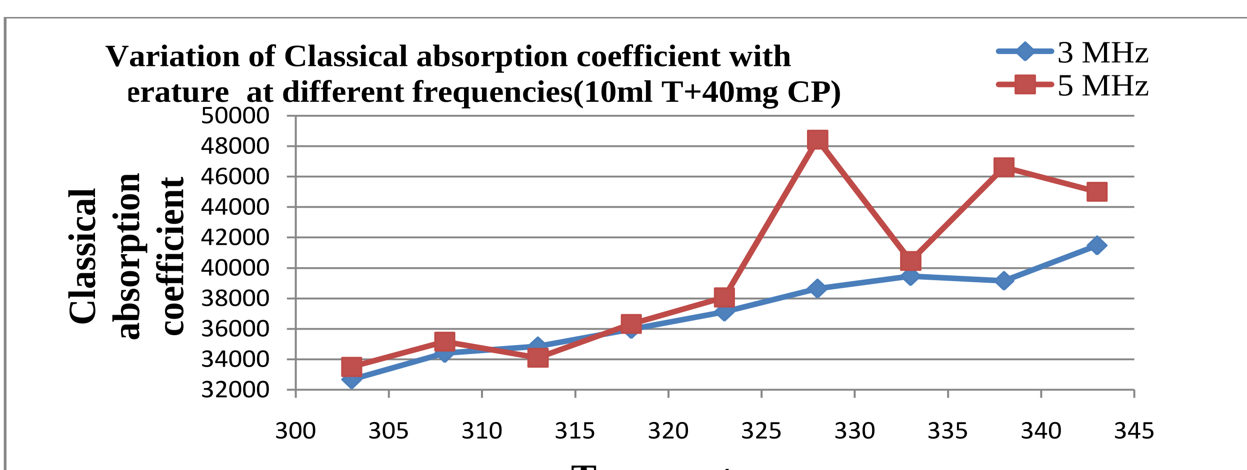


Figure9: Sample3

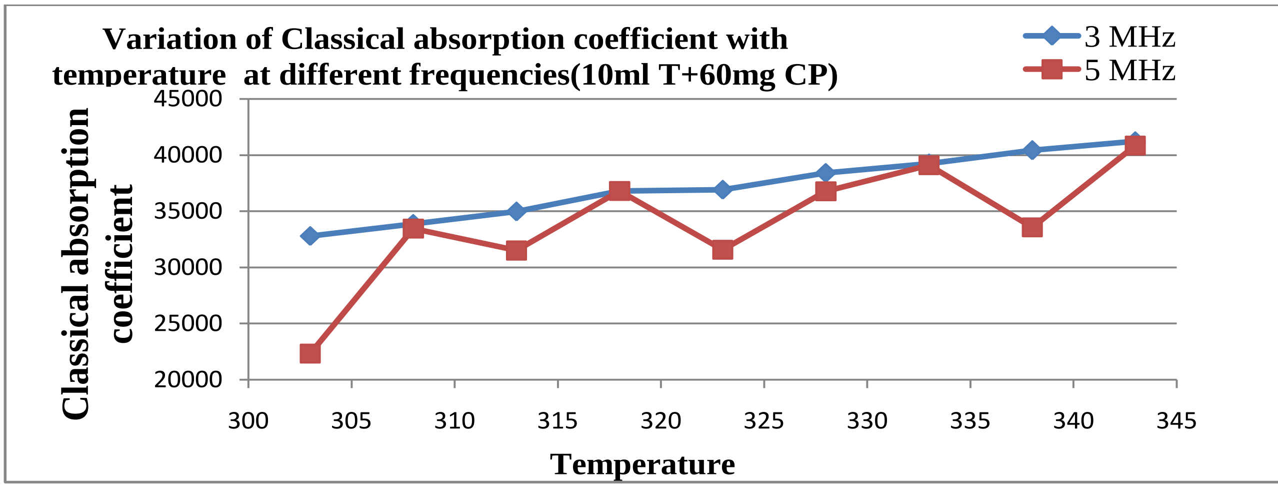


Figure10: Sample4

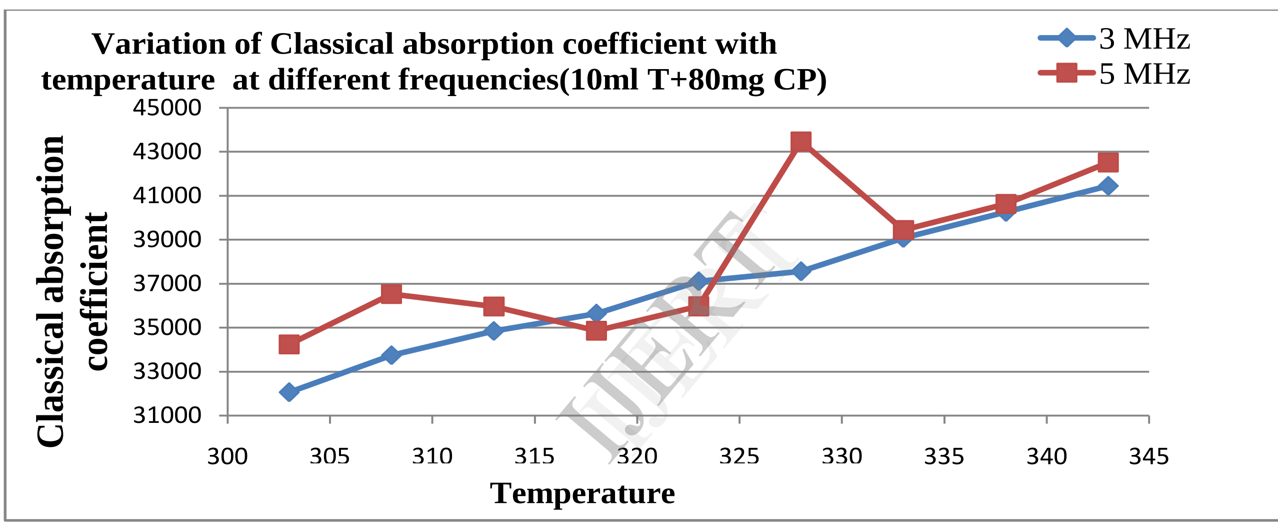
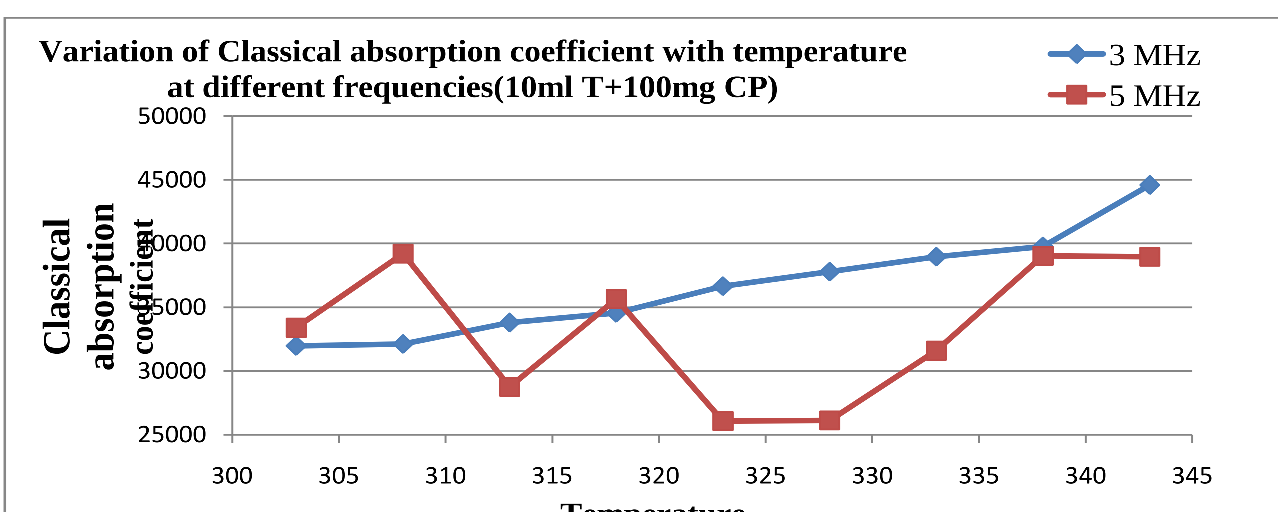


Figure11: Sample5



Results and Discussions:

Figure1 shows that as the amount of solute (CP) increases in the solvent (T) the density increases [6] and the effect of CP becomes more prominent in the solution. Table1 to Table5 and Figure2 to Figure6 show that ultrasonic velocity varies with temperature and variation is non linear. The non-linear variation in ultrasonic velocity and other acoustical parameters indicates that there is a strongmolecular interaction between CP in Toluenesolution [1, 4].The variation is much more prominent in case of 5MHz frequency than 3MHz. Acoustic impedance is directly proportional to ultrasonic velocity. Acoustic compressibility and viscous relaxation time varies inversely with square of ultrasonic velocity. These all nonlinear behaviour with molar concentration is may be attributed to molecular association and complex formation. This indicates that the solution is becoming more homogeneous with increasing temperature and such solution generally absorbs more ultrasonic energy [7-9]. The non linear variation in the parameters with temperature can also be related to mesophases of CP, because of which orientation and arrangement of the molecule changes. Internal pressure increases with increasing temperature here the variation is nearly linear [10, 11].Thisshows that binding forces between the CP and toluene insolution are becoming stronger which shows thatthere exists a strong molecular interaction.
Data above Table1 to table5 show that viscosity increases with rise in concentration. This indicates that there exists a stronginteraction between solute and solvent which is alsosupported by ultrasonic velocity [12].
It is found that vanderwalls constant [13] is decreasing with increasing temperature as shown in Table2 to table6. This shows that binding forces between the CP and solvent in solution are becoming weaker as the CP goes from Cholesteric phase to liquid phase.

Acknowledgement
The author is grateful to University grant commission, New Delhi for providing financial support to this work through Major research project letter F.No.41-836/2012 (SR)2012.

References:

1. P. G. de Gennes and J. Prost, The Physics of Liquid Crystals (Oxford University Press, 1993).
2. Gupta S J and et. al., "Liquid Crystal Phase Transition using Fabry-Perot Etalon" *Journal of Optics*, India, Vol.29 No.2 pp.53-62 (2000).
3. Anita Kanwar and Gupta Sureshchandra J, "Extended blue phases in Polymer Dispersed Cholesteric Liquid Crystals",Journal of Optics Vol. 37, No. 1, Pages 09-15, (2008)..
4. PriyankaTabhane, Omprakash P. Chimankar, Chandragupt M. Dudhe and Vilas A.Tabhane, "Ultrasonic studies on molecular interaction in polyvinyl chloride solution"Pelagia Research Library, Der ChemicaSinica, *2012, 3(4):944-947*.
5. P J Vasoya, N M Mehta, V A Patel, P H Parsania, "Effect of temperature on ultrasonic velocity and thermodynamic parameters of cardo aromatic polysulfonate solutions", Journal of Scientific & Industrial Research, Vol.66, pp 841-848, 2007.
6. V.A. Tabhane, S. Agrawal, K.G.Rewatkar, J. Acous. Soc. of Ind., 28, 369, 2000.
7. O.P.Chimankar, D.V. Nandanwar, K.G. Rewatkar& V.A. Tabhane, 18th National Symp. On Ultrason.,2009, 1(107), 353.
8. V.A. Tabhane, S. Agrawal, K.G.Rewatkar, J. Acous. Soc. Of Ind., 2000, 28, 369.

9. V.A. Tabhane, O.P. Chimankar, S. Manjha and T.K. Nambinarayanan, J. Pure Appl. Ultrson., 1999, 21, 67.
10. A. Abubaker, RFort, Trans. Faraday. Soc,61,2102 (1965).
11. M.Thirunavukkarasu, N.Kanagathara, "Ultrasonic Studies on Non-Aqueous solutionsof Toluene in Carbon Tetra Chloride", International Journal of ChemTech ResearchIJCRGG ISSN: 0974-4290, Vol.4, No.1, pp 459-463, 2012.
12. C. M. Dudhe, K. C. Patil, "Viscosity, Free volume and Internal pressure of aqueous PromethazineHydrochloride", International Journal of Pharmacy and Pharmaceutical Science Research, 2012, 2(4), 76-78.
13. Jatinder Pal Singh, Rajesh Sharma, "Variation of Wada Constant, Raos Constant and Acoustic Impedance of Aqueous Cholesteryl Oleyl Carbonate with Temperature", International Journal of Engineering Research and Development, e-ISSN: 2278-067X, p-ISSN: 2278-800X, Volume 5, Issue 11 (February 2013), PP. 48-51.