ICA –POSTER 406

Acoustics and Dielectric properties of Borassus Flabellifier 'BF' with frequency at 308K.

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ABSTRACT:

Dielectric properties of Borassus Flabellifier 'BF' wood were carried out by authors with frequency at room temperature 308K. The wood section is taken from male BF tree and female BF tree from where the natural juice is collected over night. A large variation occurs at frequencies less than 10 Hz. at room temperature 308K.The dielectric constant decreased as frequency increased from 1 Hz to 4.0 x10^7 Hz. The minimum peak value of the dielectric loss tangents shifted towards higher frequencies at room temperature 308K. Very low dielectric conductivity has been observed. Characterization of the samples was made by scanning electron microscope (SEM) Model JEOL JSM5400. Results shows that the dielectric properties are slight different in male and female BF wood considerably. The variation of the dielectric constant in different wood structures is correlated at room temperature with the frequency variations in a way the received signal strength. Acoustics measurement were carried out in our laboratory using Ultrasonic Interferometer by NDT technique and the dielectric measuring device used in this study at UGC-DAE Consortium for Scientific Research Centre Indore (M.P.) India. In this study the drying of wood done by microwave energy using a continuous microwave drier was compared to that by conventional method.

Key words: NDT technique Dielectric constant, Dielectric loss tangents, dielectric conductivity, non- destructive, microwave, and scanning electron microscope.

Introduction:

The main aim of the present study is that untreated wood had higher dielectric constant than their polymer composites. Electric conductivity of wood is an important property. For good electric insulating property a substance should be porous, good strength properties on the other hand demand a compact structure. Structural and insulating materials should therefore satisfy both the requirements. Wood in this respect is in an especially advantageous position, for, in its case, the relation between electric insulation and strength is extra ordinarily favourable. Its low electrical conductivity makes it an ideal material for house construction, water pipes, tanks, casings, railway and other carriages, drying chambers, cold rooms etc. Further, electrical conductivity in conjunction with volumetric specific heat determines the rate of temperature change in wood when it is heated or cooled. Knowledge of this is of interest and importance for studies in preservation, sterilisation, and fire resistance, the drying of wood and in the making of plywood. Dielectric properties of wood have both theoretical and industrial applications. They also provide a better understanding of the molecular structure of wood and wood-water interactions [1]. The behaviour of water with the constituents of wood such as cellulose and lignin can be understood more clearly by studying dielectric properties. BF tree is natural lignocelluloses based composite material and is an abundant natural resource in Dhar and Jhabua tribal district of M.P. India and has been used traditionally for fabrication of village houses as a structural material. Massive use of BF tree is possible if it can be used as a reinforcing constituent in a composite material. Different types of lignocelluloses and fibrous materials such as wood are being increasingly used for insulation and lamination applications. Dielectric constant of wood increases significantly with moisture content. The presence of polymers leads to decrease in the number of polarisable units to use BF tree for insulating applications. Among the natural fibre which have been used as reinforcement in plastics. Natural fibres have found use as potential resources for making low cost composite material. Composites as a dielectric are becoming more popular and studies of electrical properties of natural fibres reinforced polymer composites are, therefore, very important. Knowledge of A.C. conductivity [2] behaviour of the wood of BF (Figure 1 & 2) is indispensable for finding its proper application. A.C. conductivity values have been determined different frequencies at room temperature and analysed based on the structure available in different parts of BF tree. The utilization of high frequency and microwave techniques are also of growing importance for heating, gluing, drying, as well as improving the quality of wood and wood based product [3]. When wood is placed in an electric field, the current-carrying properties of the wood are governed by certain properties, such as moisture content, density, grain direction, temperature; and by certain components such as cellulose, hemicelluloses, and the lignin of wood. They also vary in an extremely complicated fashion with frequency. The overall effects of these parameters interact with each other and add to the complexities of the dielectric properties. In last years great efforts have been made on the development of measurement and testing techniques for wood and wooden structures with the aim of predicting their characteristics and ensuring their performances. Many experimental methods have been investigated and among the different approaches, Particulars attention has been developed to ultrasonic measurement. Non-Destructive Testing of Material is an important part of Engineering Education as it gives information without deformation in the shape and size of the material. One of the NDT techniques, Piezoelectric Technique is widely used for the measurement of composition dependent properties such as ultrasonic velocity, compressibility, elastic constant**,** Young's modulus and Bulk modulus. Its suitability for metals, plastics, polymers and crystals etc makes it versatile tool for Engineering Physics, Material Science and Polymer Science. Characterization of the samples also done by scanning electron microscope (SEM) Model JEOL JSM5400.

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Figure 2 Wood section of female BF tree

Figure 1 Wood section of male BF tree.

Experimental Procedure:

The wood part of Female BF tree and male BF tree is taken from Kukshi, District Dhar (M.P.) India from where the natural juice is collected overnight. The cutting of wood part in small pieces along the direction of its fibre and along the perpendicular direction of its fibre. The wood part is cut in to small parts of size thickness 3mm, length 8mm and breath 5 mm. The small parts of this sample material is placed in shade to dry for reduce its moisture contained. The samples are further dried by irradiate with microwaves in a modified microwave oven for 20 minute at 373K to reduce its moisture contained up to o.1%, by Ken star India Limited, Aurangabad, India Model No.OM-29 ECF, microwave 1000W, input range190-250V-a.c., 50Hz, microwave frequency 2450MHz).Oven temperature was displayed in the front panel with an accuracy of $\pm 1^0$C.All the four sample material surfaces is polished by silver coating paint. Dielectric constant and dielectric loss tangents were measured in the frequency range 1 Hz. to 10^7 Hz using four probe methods at UGC-DAE Consortium for Scientific Research Centre Indore (M.P.) India.

Table 1 List of samples used in our studies.

S.NO.	Name of the specimens/Sample material	Abbreviations
1	Rectangle pallets of female BF tree parts from where the natural juice collected over night in the perpendicular direction of fibre.	FBF_1
2	Rectangle pallets of female BF tree parts from where the natural juice collected over night in the direction of fibre	FBF_2
3	Rectangle pallets of male BF tree parts from where the natural juice collected over night in the perpendicular direction of fibre.	MBF_1
4	Rectangle pallets of male BF tree parts from where the natural juice collected over night in the direction of fibre	MBF_2

Theory and calculation:

The Dielectric conductivity (σ) [4] was calculated by the relation

$$\sigma = \varepsilon_0 \omega \varepsilon' \tan\delta = \varepsilon'' \varepsilon_0 \omega \quad \text{------------------------ (1)}$$

Where ε_0, ε', ε'' is the dielectric constant of free space (8.85 x $x10^{-12}$F/m), real and imaginary part of dielectric constant with the sample and angular frequency $\omega = 2\pi f$, f the applied frequency. The loss tangent $\tan\delta$ is given by the relation.

$$\tan\delta = \varepsilon''/\varepsilon' \quad \text{-------------------------- (2)}$$

From the knowledge of f_q, f_c and the masses of the quartz (m_q) and the specimen (m_s), the resonant frequency of the specimen fs is evaluated using the relation

$$f_s = fc + (m_q/m_c)\,[f_c - f_q] \quad \text{--------------------------(3)}$$

Using the value of f_s, the length of the specimen (*L*) and the density of the specimen, the velocity [5] of the ultrasonic waves in the specimen (v) can be calculated using relations

$$v = 2.f_s.L \quad \text{------------------------ (4)}$$

Result and Discussion:

The Table 3 shows Dielectric data for frequencies from 1.0 Hz to 10^7 Hz at room temperature 308K are presented in Fig. 3 and 4.The dielectric constant decreases nearly up to 10^2 Hz for all the four samples at room temperature 308K.Also it was observed that by varying the frequencies in all the samples the dielectric constant nearly remain same between 10^2 Hz to 10^6 Hz. after this the dielectric constant increases and decreases abruptly with frequency. The increase in dielectric constant at low frequency can be explained by the fact that the dipolar groups are bound in the solid structures so that the dipole is a structural element of the solid lattice and rigidity of the lattice hinders the orientation of the dipoles .It is assumed that the fixed dipole moment of the cellulose molecules and the interfacial polarization at lower frequencies are both activated by thermal energy Nanassy et al [6]. Inhomogeneties likes defects, space charge formation , lattice distortions etc. in the interfacial layers together produce an absorption current resulting in dielectric loss. , Fig.5 and Fig 6 shows that a large increase in the dielectric loss tangent at low frequency range 10^2Hz to 1.0 Hz.

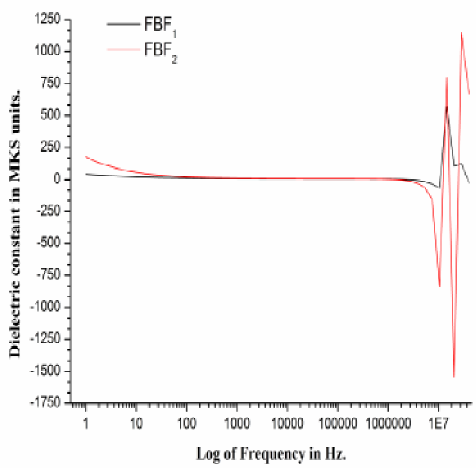

Figure 3 Variation of dielectric constant with frequency in Hz.

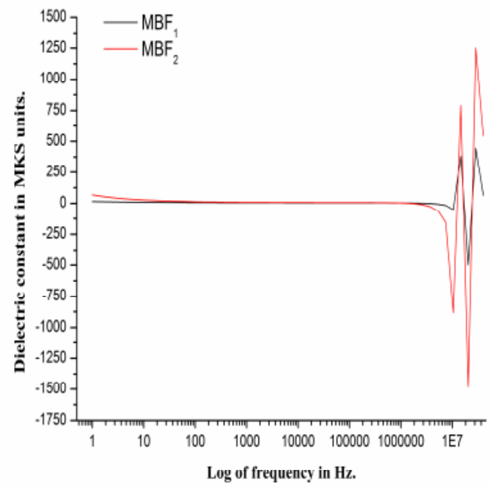

Figure 4 Variation of dielectric constant with frequency.

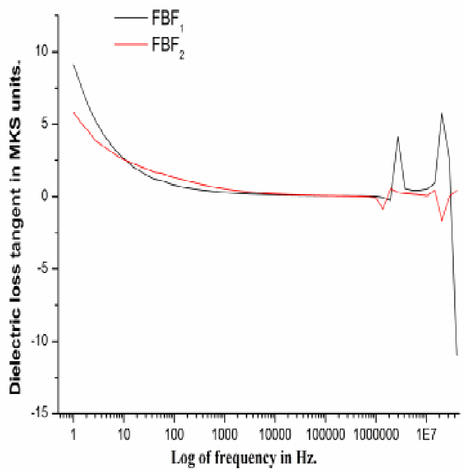

Figure 5 Variation of dielectric loss tangent with frequency.

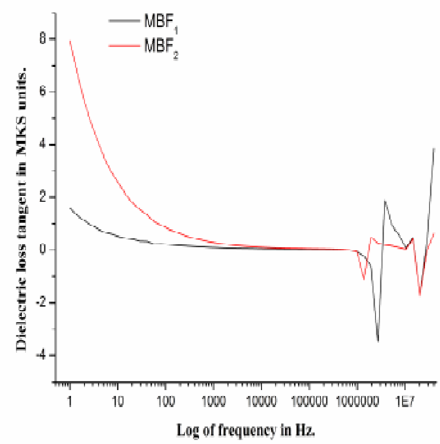

Figure 6 Variation of dielectric loss tangent with frequency

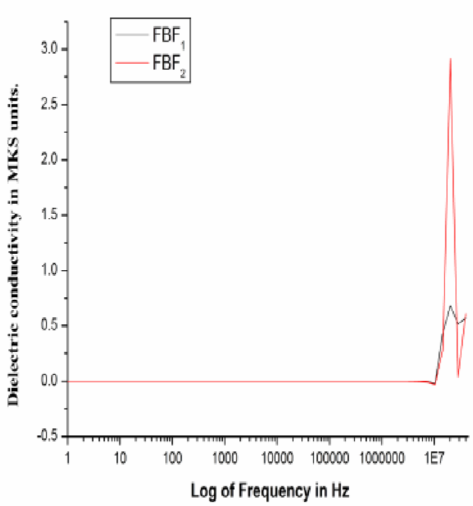

Figure 7 variation of dielectric conductivity with frequency.

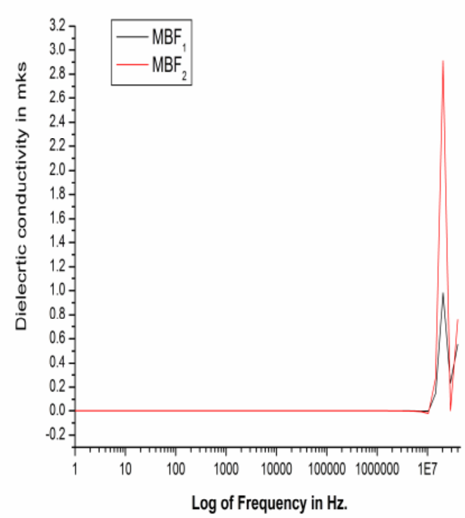

Figure 8 Variation of dielectric conductivity with frequency

Table 2 The calculated values of dielectric conductivity σ.

S.No.	Frequency in Hz	FBF_1	FBF_2	MBF_1	MBF_2
1	4.00E+07	0.570195679	0.603554474	0.552960394	0.75469813
2	2.86E+07	0.514243226	0.035676073	0.233777752	0.001938195
3	2.04E+07	0.684086562	2.912601337	0.9801195	2.909731028
4	1.46E+07	0.430848571	0.279978018	0.149094639	0.273956536
5	1.04E+07	-0.020511074	-0.029259953	-0.002636341	-0.021164506
6	7.44E+06	-0.006193484	-0.007472284	-0.003989919	-0.00679015
7	5.31E+06	-0.001903917	-0.003182841	-0.001826014	-0.003065504
8	3.79E+06	-0.000652136	-0.001290257	-0.00081614	-0.001259461
9	2.71E+06	-0.000209135	-0.000497121	-0.000341381	-0.000488351
10	1.94E+06	-6.63854E-05	-0.000193401	-0.000137595	-0.000190333
11	1.38E+06	-1.6914E-05	-7.15572E-05	-5.029E-05	-7.02051E-05
12	9.88E+05	5.25551E-06	-1.12909E-05	-1.15378E-05	-1.16258E-05
13	7.06E+05	7.31392E-06	1.34255E-06	-8.58833E-07	9.48645E-07
14	5.04E+05	7.06492E-06	5.40338E-06	2.28557E-06	5.01455E-06
15	3.60E+05	5.70073E-06	5.29168E-06	2.47175E-06	4.89085E-06
16	2.57E+05	4.51967E-06	4.62842E-06	2.11154E-06	4.21337E-06
17	1.84E+05	3.53217E-06	3.84485E-06	1.65836E-06	3.41101E-06
18	1.31E+05	2.7517E-06	3.13658E-06	1.2646E-06	2.69545E-06
19	9.37E+04	2.14093E-06	2.5178E-06	9.53914E-07	2.11079E-06
20	6.69E+04	1.68342E-06	2.09141E-06	7.30352E-07	1.68137E-06
21	4.78E+04	1.33034E-06	1.73048E-06	5.59387E-07	1.34068E-06
22	3.41E+04	1.02937E-06	1.37664E-06	4.07465E-07	1.00816E-06
23	2.44E+04	8.16017E-07	1.14851E-06	3.11614E-07	8.01912E-07
24	1.74E+04	6.51853E-07	9.67086E-07	2.39241E-07	6.42717E-07
25	1.24E+04	5.23323E-07	8.1889E-07	1.84914E-07	5.20705E-07
26	8.89E+03	4.23457E-07	7.02464E-07	1.43408E-07	4.24534E-07
27	6.35E+03	3.44663E-07	6.03015E-07	1.12398E-07	3.49814E-07
28	4.54E+03	2.80763E-07	5.19197E-07	8.7228E-08	2.87642E-07
29	3.24E+03	2.31616E-07	4.51E-07	6.9141E-08	2.42005E-07
30	2.31E+03	1.91892E-07	3.95775E-07	5.52464E-08	2.04804E-07
31	1.65E+03	1.61534E-07	3.4769E-07	4.44369E-08	1.75601E-07
32	1.18E+03	1.36832E-07	3.07474E-07	3.56939E-08	1.50776E-07
33	8.43E+02	1.16018E-07	2.74008E-07	2.87441E-08	1.31451E-07
34	6.02E+02	9.96779E-08	2.44566E-07	2.33964E-08	1.14952E-07
35	4.30E+02	8.59863E-08	2.19413E-07	1.89762E-08	1.00889E-07
36	3.07E+02	7.51595E-08	1.97362E-07	1.54324E-08	8.89269E-08
37	2.20E+02	6.61037E-08	1.78293E-07	1.27861E-08	7.94392E-08
38	1.57E+02	5.84533E-08	1.61578E-07	1.04345E-08	7.18064E-08
39	1.12E+02	5.21815E-08	1.4617E-07	8.76387E-09	6.38008E-08
40	8.00E+01	4.69177E-08	1.3378E-07	7.07762E-09	5.76123E-08
41	5.71E+01	4.45707E-08	1.24281E-07	5.11678E-09	5.40612E-08
42	4.08E+01	3.88865E-08	1.10212E-07	5.42695E-09	5.05226E-08
43	2.92E+01	3.59672E-08	1.02103E-07	4.20194E-09	4.62755E-08
44	2.08E+01	3.3285E-08	9.37435E-08	3.86044E-09	4.27962E-08
45	1.49E+01	3.12881E-08	8.72967E-08	3.15769E-09	4.05451E-08
46	1.06E+01	2.94378E-08	8.12353E-08	2.74053E-09	3.82749E-08
47	7.59E+00	2.78934E-08	7.6015E-08	2.50587E-09	3.63591E-08
48	5.42E+00	2.6599E-08	7.17718E-08	2.14206E-09	3.47813E-08
49	3.87E+00	2.52441E-08	6.80623E-08	1.91306E-09	3.36661E-08
50	2.77E+00	2.40447E-08	6.4575E-08	1.73094E-09	3.25718E-08
51	1.98E+00	2.3096E-08	6.20725E-08	1.57678E-09	3.16906E-08
52	1.41E+00	2.22417E-08	5.96463E-08	1.45871E-09	3.09607E-08
53	1.01E+00	2.09492E-08	5.75349E-08	1.35711E-09	3.02819E-08
54	1.00E+00	2.05072E-08	5.73285E-08	1.34832E-09	3.026E-08

Table 2 and Graphs for dielectric conductivity are shown in Fig. 7 and 8 respectively. Very low conductivity has been observed for the all four samples, it basically decreases with the increased frequency. Earlier reported values of ultrasonic velocity in different wood and BF liquid are given in the table -3. This study was helpful in to know the wood structure. The given results were same for experimental and theoretical values. SEM studies [Figure 9 and 10] reveal change in the structure and homogeneity of the wood samples collected from the female and male BF tree part. Some irregular size particle and different layers formation of thin crystals are seen on the surface of the rectangle crystal in both BF sample.

Table 3 Earlier reported value of density and ultrasonic velocity in different wood samples.

S. No.	Sample	Density Kg/m3	Ultrasonic Velocity in m/s	Reference No.
1	Olive	720.2	2300.0	[7]
2	Yellow pine	587.9	2400	[7]
3	China fir	Between 460.0to 470.0	Between 5738 to 6129	[8]
4	Japanese cedar	Between 462.0to 486.0	Between 4882 to 5196	[8]
5	Brazilian Jatoba	880.0	Between 4000 to 5100	[9]
6	Borassus Flabellifier 'BF' Liquid	0.9975	Between 1640 to 1648	[10], [11]

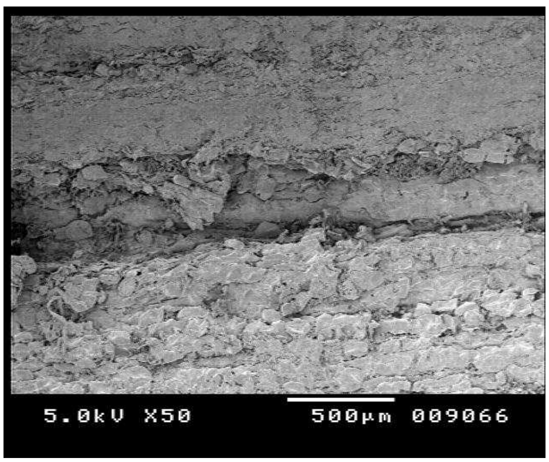

Figure 9 SEM of female BF wood at 5.0kvx50 & 500μm.

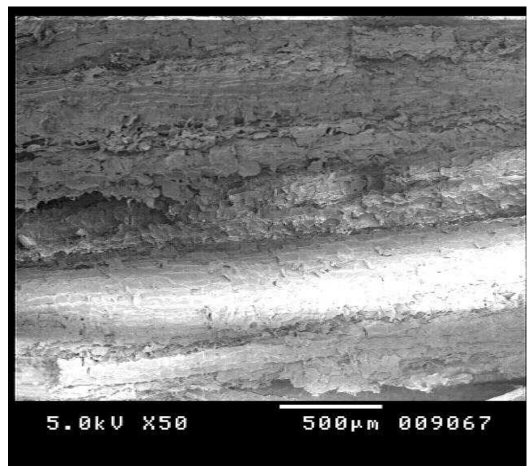

Figure 10 SEM of male BF wood at 5.0kvx50 & 500μm

Conclusion:

In summery female and male BF tree wood were characterised for their dielectric and electrical properties at room temperature. The dielectric constant remain approximately same in the frequency range 10^2Hz to 10^6Hz.Similarly dielectric tangents remain approximately same in the frequency range 10^3Hz to 10^6Hz.Condutivity was very low in all the four samples. These could be promising material for application in technology. The ultrasonic velocity of BF has been measured in liquid form in our laboratory. Preliminary analysis indicates that in all form of BF shows its importance. The Measurements of ultrasonic velocity in different parts of BF tree is in progress and will be presented else where.

Acknowledgement:

One of the authors (Sushil Phadke) is highly thankful to University Grants Commission, New Delhi for awarding a Minor Project. Our sincere thanks to Dr. U.C. Jain Principal Govt. P.G. College, Dhar (MP), Dr. R.K. Dave Principal Govt. Girls College Dhar (MP) and Dr. Nagesh Dagaonkar HOD, Physics Govt. P.G. College, Dhar (MP) for providing lab facility and maximum cooperation. We are very thankful to Mr. Ritusing Kalesh for providing samples and Mr. Gurudatt V Kate for providing photographs of Dist. Dhar (M.P.) India. We are also thankful of Dr. A.M. Awasthi and Dr. S. Bharadwaj for providing their lab facility to measure dielectric constant at UGC-DAE Consortium for Scientific Research Centre Indore (M.P.) India.

Reference:

1. M.D. Wan, B. Kaida, and A.A. Sidek, Temperature dependence of the dielectric properties of rubber wood. Wood and Fibre Science, *Vol. 33(2) 2001*, pp. 233-238.

2. N. Chand, D. Jain, and A Nigrawal, Investigation on gradient a. c. conductivity characteristics of bamboo (Dendrocalamus *strictus*). Bull. Mater Science, *Vol. 29, No.2, April 2006*, pp. 193-196.

3. H. S. Kol, Thermal and dielectric properties of pine wood in the transverse direction.Bio Resources *Vol 4 (4),* 2009, pp. 1663-1669.

4. Dalveer Kaur, Sukhleen Bindra Narang and Kulwant S. Thind, Processing, dielectric behaviour and conductivity of some complex tungsten – bronze dielectric ceramics. Journal of Ceramic Processing Research *Vol., 7, No.1*, pp. 31-36 (2006).

5.Solunke M.B.,Modi K.B.,Lakhani V.K., Zankat K.B.,Sharma P.U., Reddy P.V. and Shah S.S. Effect of Ag+-addition on elastic behaviour of Bi-2212 superconductors. Indian Journal of Pure & Applied Physics, *Vol.45 (2007*), 764-766.

6. A.Z. Nanassy, Electric polarization measurement on yellow birch. Can. J. Physics 42: 1964, pp1270-1281.

7. B. Marchetti, R. Munaretto, G.M. Revel, E. Primo Tomasini. The forest products society proceeding No. 7246, *ISBN 1-892529-31-9*, 2003.

8. M. C. Yeh, C. K, Liu, Y. L. Lin, Effects of ultrasonic detection modes on the longitudinal ultrasonic wave transmission in domestic plantation lumber. Taiwan J For Sci.22 (1); 57-68, 2007.

9. F.G.R. Oliveira, A Sales, Relationship between density and ultrasonic velocity in Brazilian tropical woods. Bio resource Tech. *Vol., 97* (2006) pp 2443-2446.

10. S.Phadke, B.D. Shrivastava & A. Mishra, Thermodynamic, Acoustic, Volumetric & Viscometric study of Borassus Flabellifier BF at 313.15K. Ultra Scientist of Physical Science *ISSN 0970-9150, Vol.21, No. 3,* pp 499-504, Dec. 2009.

11. S.Phadke, B.D. Shrivastava & A. Mishra. Role of frequency in studying intermolecular interactions in binary liquid mixtures of Borassus Flabellifier BF and ethanol. ISBN: 978-81-8424-555-4, NSU-XVIII National Conference at VIT University, Vellore (T.N.) India, pp. 119-123, 21-23 Dec. 2009.