Studies on the Dielectric Beheviour of Some Plant Fibers

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Abstract

The dielectric diffractogram of raw and chemically degummed ginger (*Zingiber officinale*), turmeric (*Curcuma longa*) and java galangal (*Alpinia galangal*) fibers are taken at different temperatures and at different frequencies. It is found that the dielectric constants of the plant fibers are changed due to degumming. Also the dielectric constants of the fibers decrease with the increase of frequency at temperature 30^0C. The variation of dielectric constant with change of frequency indicates that the plant fibers are hydrophilic in nature. The hydrophilic nature of the fibers has not been changed due to degumming. The glass transition temperature (T_g) has changed when the fibers are degummed by 2% NaOH. The dielectric loss tangent (tanδ) shows a linear relation with temperature in air and in vacuum. The tanδ changes due to degumming of the fibers at lower temperature but remain almost same at higher temperature. Further, the values of tanδ vary at different medium.

Key Words: Dielectric diffractogram, *Zingiber officinale*, *Curcuma longa*, *Alpinia galangal*, dielectric loss tangent.

1. Introduction:

The cellulose fibers such as ginger, turmeric and java galangal are semicrystalline and hygroscopic in nature. The dielectric properties of these fibers have great importance in textile technology. The dielectric properties of the cellulose materials by capacity measuring method have been reported by various workers[1-4]. The action of absorbed water and influence of gum on the dielectric properties of some cellulose fibers have been studied[5-7]. The dielectric behaviour of ginger, turmeric and java galangal have been observed at room temperature as well as at different temperatures and at different frequencies at which they are quenched and annealed. In present investigation, raw and degummed fibers of ginger, turmeric and java galangal are subjected to dielectric cell arrangement at different temperatures and at audio frequency range 20 Hz – 20 KHz. The measurements were carried out in this range which is a suitable range[8].

2. Sample Preparation:

Ginger (*Zingiber officinale*), turmeric (*Curcuma longa*) and java galangal (*Alpinia galangal*) plants, from the various parts of the chosen area of the north-east region of India, have been collected. The fibers are extracted from the stems of these plants. One part of each of the raw fibers of these plants were immerged in a mixture of Benzene and Alcohol (ratio 1:1) for six hours. These were then washed with distilled water, and then boiled with NaOH solutions at 2% concentration. The fibers were then again washed with distilled water and dried normally (at room temperature). Samples so prepared were then taken into the Dielectric cell arrangement for analysis the dielectric properties.

3. Experimental Arrangement:

The capacity measurement method is a suitable method to study the dielectric properties fibers. The arrangement mainly consisted of a dielectric cell, which is a combination of one outer cylindrical plate and one inner cylinder (both made of copper). They act as the outer and the inner electrodes of the cell. A copper wire was wielded to the plate. The fibers were wounded round the inner cylinder uniformly so as to form a thin layer of thickness of about 0.2 mm. The outer plate was then placed coaxially upon the inner cylinder completely covering the fiber layer. The thickness of the fiber layer was measured directly by a traveling microscope. The cell was mounted inside a glass tube assembly of high temperature resistance with cone socket arrangement. A vacuum arrangement is attached with the glass tube, with the help of a side tube, to study the fibers under vacuum condition. The lower part of the tube assembly with the cell was inserted vertically into a muffled furnace. The cavity dimension of the furnace was 14 cm. in depth and 11 cm in diameter. With the help of copper – constantan thermocouple, the temperature of the dielectric cell was measured. The closed end of the thermocouple of length 20 cm was kept very near to the cell and the open ends of the lead were connected to digital microvoltmeter of the type DMV – 010 (Scientific equipment, Roorkee) having an accuracy of ± 0.01 mV. An LCR bridge (Marconi TF 2700 universal LCR bridge) is used to measure the capacitance directly from 0.5 pfd to 1100 pfd. The frequency of the internal generator was fixed at 1 KHz. For other frequencies, an external audio frequency oscillator was used. This external source with an isolating transformer of type TM 7120 (Marconi) in series was connected to the bridge via a jacket plug.

4. Measurement:

The fibers were wounded round the inner cylinder of the dielectric cell uniformly so as to form a thin layer of thickness of about 0.2 mm. The dimensions of the capacitance cell were measured with the help of the travelling microscope. The values of the capacitance and dielectric loss tangent (tanδ) of the cell with the specimen were recorded directly from the bridge at temperature from 303 K to 573 K under frequency 1 KHz in both air and in vacuum. Also the capacitance and tanδ for the specimen were measured in the frequency range 20 Hz to 20 KHz at room temperature (at 308 K). From the data obtained, the values of dielectric constant and dielectric loss factor in each case were calculated. The formulae used to calculate the dielectric constant and dielectric loss factor are same as used by Talukdar et al[9].

5. Results and Discussion

The variation of dielectric constant with temperature for the three plant fibers viz. ginger, turmeric and java galangal fibers, in air and in vacuum, are shown in fig. 1. The observed values are shown in table1. No first step variation of dielectric curves is attributed in the samples kept in vacuum except a slight decrease is observed initially. This is attributed due to the decrease of water molecules in vacuum. The values of dielectric constant remain almost same in the temperature range 363 – 453 K. The transition up to which these values remain constant corresponds to the glass transition temperature[10] (T_g) of the plant fibers. This is in agreement with the result obtained earlier for some polymers[11]. The variation of dielectric constant with temperature for raw and degummed fibers is given by figure 2. From the figures it is observed that the peak areas of dielectric thermograms of ginger, turmeric and java galangal fibers at dehydrated and decomposition state are decreased remarkably. This may be due to the decrease of water molecules at dehydrated state and change of interfacial polarization effect in decomposition state.

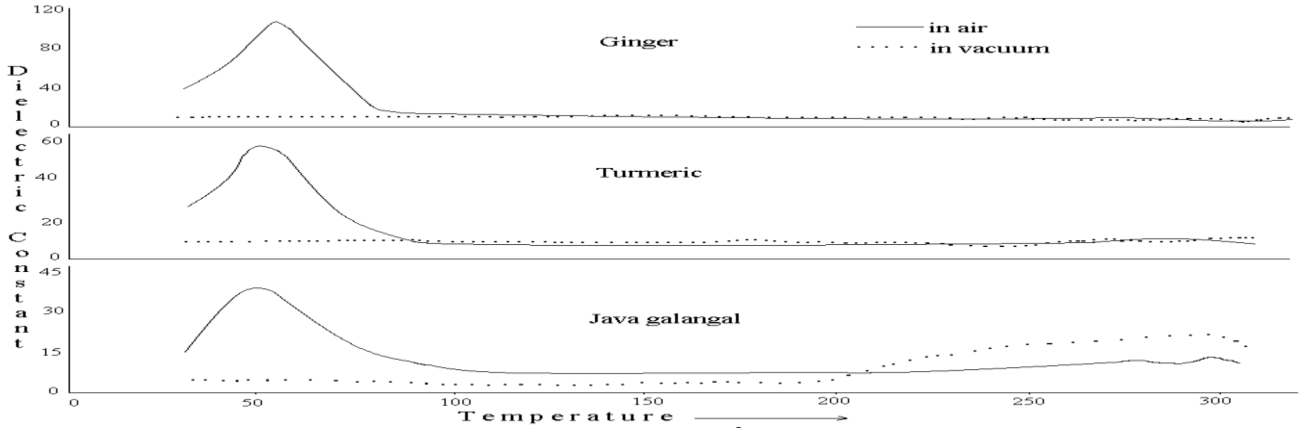

Fig.1-Variation of dielectric constant with temp. (^{0}C) of raw fibers in air & vacuum.

Table 1 - Dielectric constant (ε) of different plant fibers at different temperatures in air and in vacuum at frequency 1 KHz

(Samples : ra – raw in air, rv – raw in vacuum, da – degummed in air)

Temp.(K)	Ginger			Turmeric			Java galangal		
	ra	rv	da	ra	rv	da	ra	rv	da
303	45.83	4.07	44.67	23.54	5.17	17.15	22.78	8.68	7.49
323	80.43	4.07	50.61	36.56	5.17	18.76	38.34	6.17	8.83
423	3.87	4.07	3.95	4.78	5.17	3.89	7.12	4.23	5.27
543	11.78	10.59	11.18	8.13	10.11	4.95	16.43	22.12	8.73

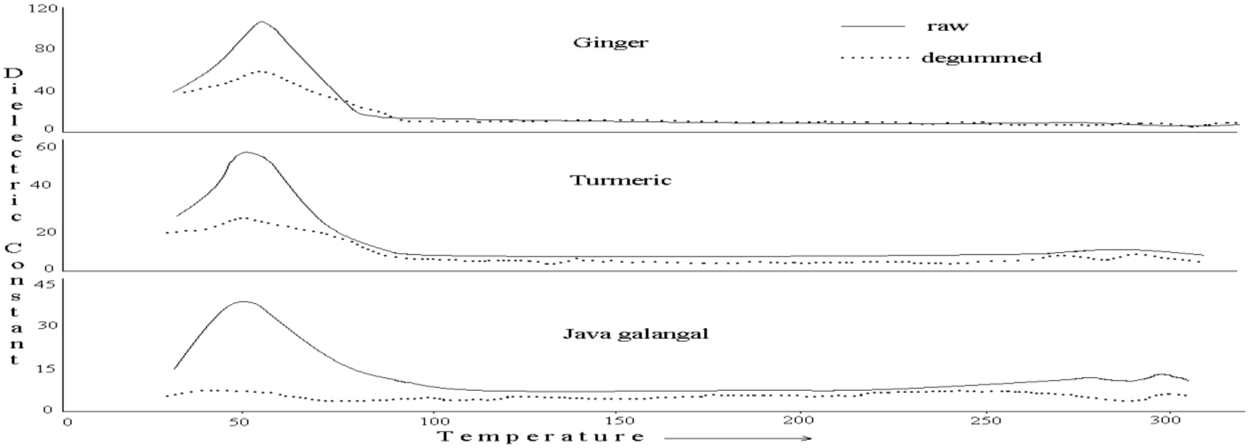

Fig.2- Variation of dielectric constant with temperature (^{0}C) of raw and degummed plant fibers

The variation of dielectric constant with change of frequency for the raw plant fibers are depicted in figure 3, from which it is observed that the dielectric constant of the fibers decreases with increase of frequency at temperature 303 K. This indicates that lower the frequency of the applied alternating field to the fibrous medium, greater is the dielectric constant due to moisture absorption. The same result was observed for polymeric fibers by some workers [12]. Thus it may be inferred that the plant fibers are hydrophilic in nature. The variation of dielectric constant with frequency for degummed plant fibers is found to be same as that for the raw fibers. This indicates that the hydrophilic nature of the fibers has not been changed due to degumming.

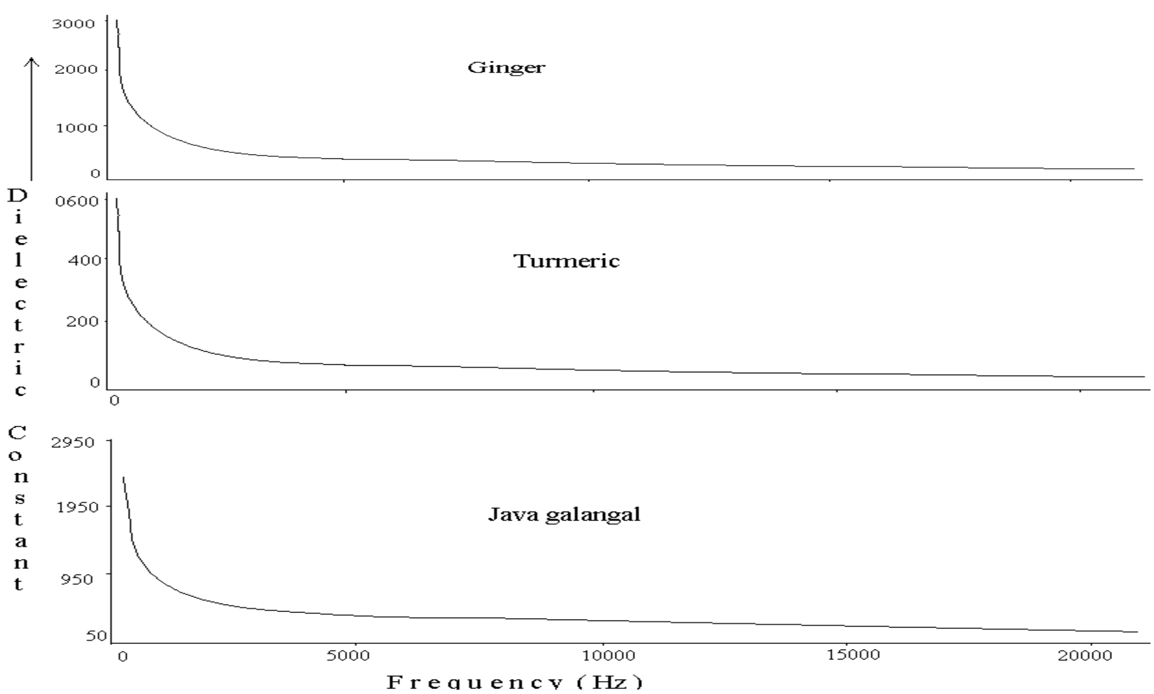

Fig. 3 - Variation of dielectric constant with frequency of some raw plant fibers.

The variation of dielectric constant with frequency for ginger fiber at different temperatures is shown in fig.4. From the figure it is observed that at higher temperature the dielectric constant decreases. This may be due to the change of interfacial polarization. This decrease in values of dielectric constant with increasing frequency at higher temperature may takes place due to influence of interfacial polarization during decomposition stage. Kitamara [13] obtained the same results for some plant fibers.

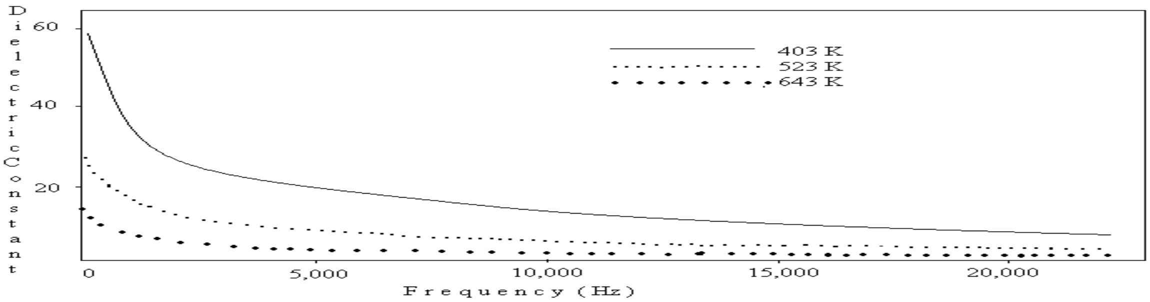

Fig.4 - Variation of dielectric constant with frequency for ginger fiber at different temperatures.

Table 2. Dielectric loss tangent (tan δ) of different raw and degummed fibers at different temperatures at frequency 1 KHz

(Samples : r – raw fibers, d – degummed fibers)

Temp. K	Ginger		Turmeric		Java galangal	
	r	d	r	d	r	d
303	0.12	0.13	0.12	0.12	0.15	0.19
363	2.20	0.21	2.20	2.20	2.24	2.28
423	4.65	4.65	4.65	4.65	4.69	4.83
483	7.16	7.16	7.16	7.16	7.20	7.24
573	10.34	10.34	10.34	10.34	10.39	10.45

In table 2, values of dielectric losses with temperature in air of the three plant raw and degummed fibers are displayed. From the table it is evident that the dielectric loss is gradually increased for all the fibers in the temperature range 303 – 573 K. This variation is due to the fact that due to increase of temperature the rotation of side groups and by segmental mobility of the fibers, which is agreed by I I Perepechko[14]. It is also inferred that the dielectric loss character of the observed plant fibers has not changed due to degumming.

6. Conclusion:

The dielectric constant of raw and degummed plant fibers is found to be different. It is noticed that the glass transition temperature (T_g) has changed when the fibers are degummed. These fibers are hygroscopic and hydrophilic in nature. The dielectric constant is highest for the ginger fiber and lowest for java galangal fiber amongst the observed fibers. The dielectric loss tangent changes due to degumming at lower temperature and remain nearly constant as the temperature rises. Further, the dielectric loss tangent changes its values at different medium, such as air, oxygen and vacuum.

References:

[1]. Bora M N, Saikia D, Saikia R, Talukdar C,1997, High Temp Phy. Vol.29, p.683-688.
[2]. Duswalt A A, 1974 Thermocimica Acta, 8, 57.
[3]. Bora M N, Baruah G C, Talukdar C, 1993, Thermocimica Acta, 218, 435 – 443.
[4]. Bora M N, Talukdar M, Talukdar C, 1999 Indian Journal of Fiber & Textile Research, Vol. 24, p. 172 – 176.
[5]. Physics of dielectric materials, Tareev B, Mir publishers, Moscow, 1978, p. 78.
[6]. An investigation on Thermophysical behaviour of some fibers readily available in the north east region of India by various physical methods, Gauhati University Ph D Thesis, Talukdar C, 1993, p. 67.
[7]. Boruah G C, Talukdar C, Bora M N, Gauhati University J Sci., 30 A, p.45.
[8]. Studies on the thermophysical properties of some organic complexes (fibers) by X-ray diffraction and other physical methods, Baruah G C, Gauhati University Ph.D. Thesis, 1991, p. 88.
[9]. Study of thermophysical and tensile properties of irradiated and chemically treated natural fibers available in north east India, Talukdar M, Gauhati University Ph.D. Thesis, 2003, pp. 46 – 50.
[10]. An introduction to polymer Physics, Perepechko I I, Mir publishers, Moscow, p.83.
[11]. Stetrovskii A P and Tarasova L V, Vysocomom Soedi A.20 (5), 1978, p. 1116.
[12]. Boruah G C, Talukdar C, Bora M N, Gauhati University J Sci., 30 A, p.45 -52.
[13]. Kitamara A I O, Nippon Sanshigaku Xasshi 39 (2), 1970, 119.
[14]. An Introduction to polym Phy, Perepechko I I, Mir publishers, Moscow,1981, p.162.