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A comparative study of dielectric behaviours of pineapple, dagger and sisal fibre at different temperature readily available in North-East India

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ABSTRACT
The dielectric behaviours of some raw and degummed plant fibres such as pineapple (Ananas comosus) dagger (Agave americana) and sisal (Sansevieria trifascicata) are studied in 1 KHz frequency and in the temperature range between 303K and 573K.
The dielectric behaviours at different temperature of the fibres has not changed due to the degumming. It is observed that the dielectric constant (ε′) has changed due to the degumming. The dielectric loss tangent (ε″) are almost same in air medium at the same temperature for raw and degummed fibre.
The dielectric constant (ε′) of raw pineapple fibre at the temperature 303, 323, 423, 473,and 523 K are 47.73, 83.53, 4.77, 4.77, 6.14 and 8.52 respectively. These values for raw dagger and raw sisal fibres are 12.2, 13.31, 2.42, 2.42, 3.03, 5.45 and 16.66, 21.42, 4.28, 3.33, 3.33, 6.19 accordingly.
The dielectric loss tangent (ε″) in air for raw pineapple, dagger and sisal fibres at the temperature 373 K are 2.82 and 2.86 respectively. It is also found that the glass transition temperature has changed due to the degumming for all the three fibres.
Keywords: *dielectric constant, dielectric loss, degumming, glass transition temperature, plant fibre.*

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I. INTRODUCTION

The pineapple, dagger and sisal fibres are semi crystalline and hygroscopic in nature [1]. They are organic polymer. The study of the thermal behavior of these fibres has great importance in textile technology as well as in the electrical and other industries.
The common character and properties such as thermal, chemical and physical of organic industrial fibredepends on the high polymeric compounds that constitute the fibre. Organic fibre uses in textile technology are mainly composed of compounds belonging to the class of high polymers. The vigorous development of polymer science and the extensive utilization of polymeric materials in technology have led to the increase interest to the various problems of the physics of polymers. Polymer Physics is highly important for the understanding of many scientific and practical problems associated with the use of polymeric materials in modern engineering.
One of the main objectives of polymer Physics is the elucidation of interconnection between the structure and the physical properties of polymers. A profound knowledge of the interconnection between the structure and the physical properties make it possible to control the production and quality of industrial fibre and regulate their specific consumption depending upon the conditions for their use or processing.
The natural fibres are increasingly being use as reinforcement of polymer matrix composites and are gaining acceptance as glass fibres replacements in composite manufacturing [2,3]. In order to use natural fibres as the best alternative materials for glass-fibre reinforced composites in structural applications, their structural characteristics, thermal effect and chemical effect must be well known so that one can predict the properties of the final product [4,5].
Some investigators [6,9] have made studies on thermophysical properties of some natural fibres. The effect of heating rate and chemical treatment on the glass transition temperature of pineapple leaf fibrereinforced P F composites were studied by Bhandari et.al.[10]. Some investigators[11,15] have studied dielectric properties of polymeric and cellulosic yarn and fabrics. However, no investigations notice to study the dielectric properties of dagger and sisal fibre of North-East Indian region.

Thus, attempts have been made to study the dielectric properties of these natural raw and degummed plant fibres in audio frequency range available in North-East India.

II. MATERIALS AND METHODS

SAMPLE PREPARATION

The fibres collected from different localities of North-East India were processed by usual methods. In order to degumming the sample, one part of these raw fibres were immersed into 1:1 Alcohol and Benzine solution for 24 hours and then it was washed several timesby distilled water and then dried it in room temperature. The dried samples were boiling for half an hour at 6% Sodium Hydroxide (NaOH). After boiling, the samples were cooling in normal atmosphere. Then the sample was washing several times with hot and cold distilled water to neutralize the fibres. After making the samples free from alkali, those were allowed to dry in open air [16].

METHODS

The experimental arrangement for dielectric measurements consist of a beat frequency oscillator (Agronic), an insulating transformer of type TM7120 (Marconi) and a universal bridge of type TF2700 (Marconi). With the help of a copper-constantan thermocouple, the temperature of the dielectric cell was measured with the help of a digital micro voltmeter of type DMV-010 (Scientific equipments, Roorkee) having an accuracy of measurement ± 0.01 mV. For conversion of the voltmeter records into temperature, standard calibration data for copper-constantan thermocouple was adopted. A cylindrical cell made of copper was used for capacity measurement. The dimensions of the capacitance cells were measured with the help of a travelling microscope having an uncertainty of ±0.001cm. The experimental arrangement and measurement were taken by the method describe elsewhere [17].

III. RESULTS AND DISCUSSION

The variation of dielectric constant (ε′) with temperature of different raw fibres such as pineapple, dagger and sisal are shown in figure 1.

From the figure it is seen that the dielectric constant for all the raw fibres under study increase from room temperature to near about 333K where it reaches the maximum value. This may be attributed to the decrease in electrical conduction due to the removal of the surface water molecule absorbed by the hygroscopic fibre. The height of the peak indicates a measure of hygroscopicity of the fibres.

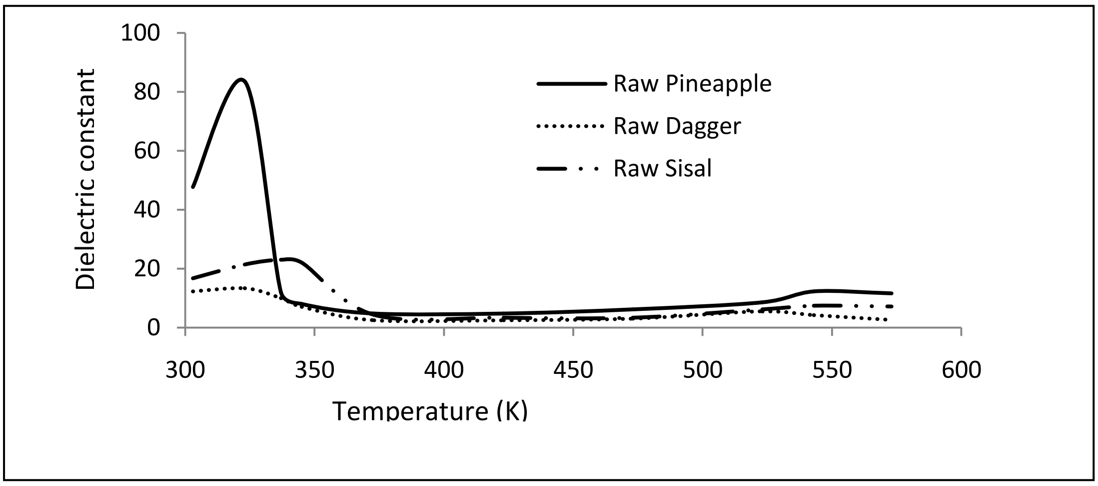

Figure1: Dielectric constant (ε′) of different raw fibres at different temperature in air at the frequency 1KHz.

The electric field applied by means of condenser plate causes relative displacement of the electrons and atomic nuclei, thus polarizing the atoms of the fibres. Hence, the electrical conduction in the fibres, to a greater extent, is ionic [18] which remain constant in the temperature ranges 373-453 K for pineapple, 383-473 K for sisal and 373-463 K for dagger. Beyond this range, the conduction decreases and as a result the dielectric constant increases for all the fibres. The temperature up to, which the dielectric constant remains invariable, corresponds to the glass transition temperature (T_g) of the fibre. At this point the inset motion of the chain segments in the amorphous region of the fibre takes place. This change in phase contributes to the orientational polarization due to which the dielectric constant increases.

As the temperature is increased, another effect, viz, interfacial polarization may occur due to void in the fibres. The conducting charge carriers may be trapped at these defects inducting opposite charges and thus polarizing the fibre molecules. The anomalous rise in the dielectric constant value with the increase in temperature may be attributed to this effect.
Beyond 473 K, the decomposition of the fibres starts. Thus abnormal values of the dielectric constant in this range of temperature can arise because of the decomposition of the organic molecules of the fibres.
From the figure, it is also observed that the first peak height of pineapple raw fibre is highest while that of dagger fibre is the lowest. This indicates that the pineapple fibre is more hygroscopic among the observed fibres.

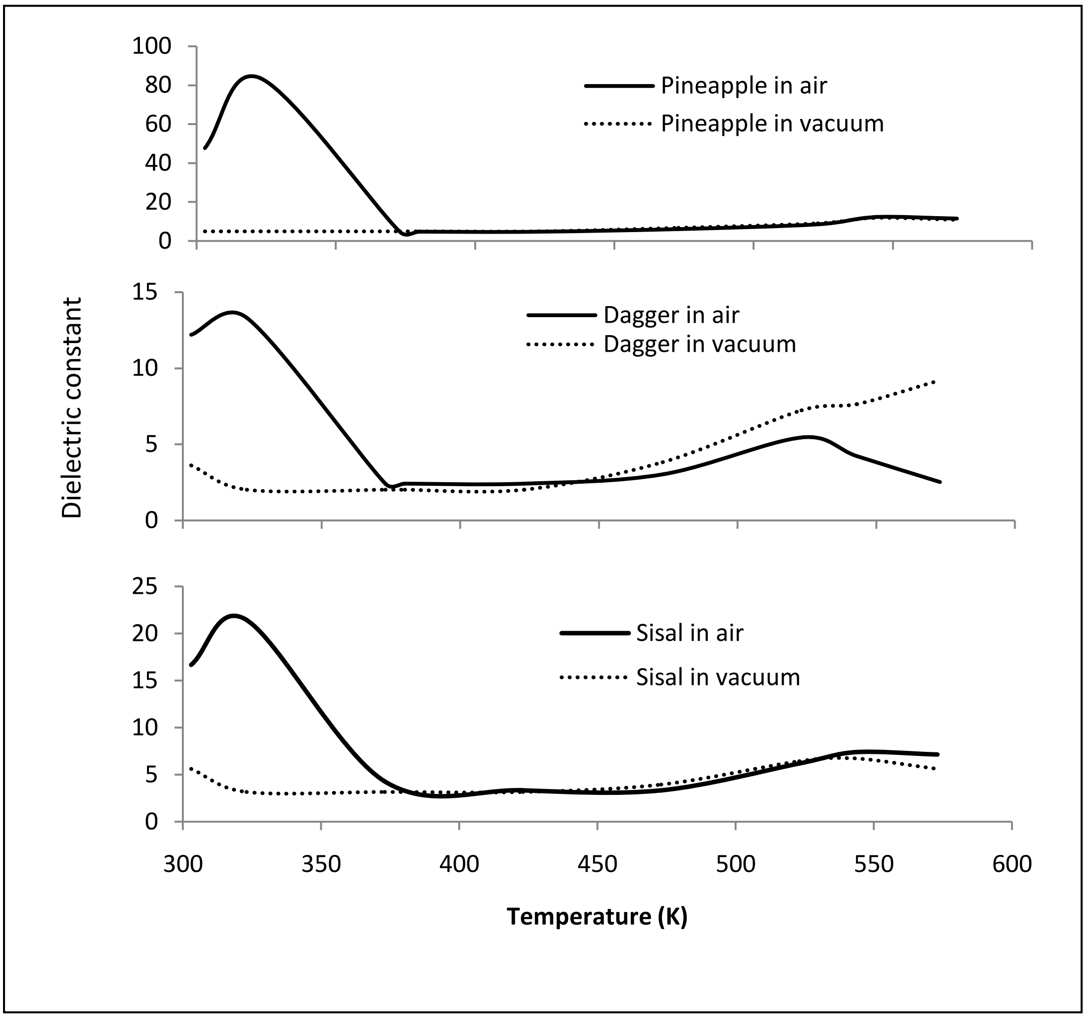

Figure2 Dielectric constant(ε′) of different fibres at different temperature in air and vacuum at the frequency 1KHz

The dehydration and decomposition peaks for pineapple, dagger and sisal fibres were also observed almost at the same temperature range by some observer [19] by thermo-gravimetry (TG) and differential thermo gravimetry (DTG) curve. They also found that amongst the three fibres the activation energy at temperature near about 353 K is highest for pineapple and lowest for dagger, which support our works.
Our study on the dielectric properties of these fibres in vacuum confirms the effects of surface water molecules as no such rise in value of dielectric constant is observed under vacuum condition in this range of temperature which is shown in the figure 2. No first step variation of dielectric curve is attributed in the samples kept in vacuum except a slight decrease is observed initially. This indicates that surface water molecules are not completely evaporated at room temperature under vacuum condition.
The observed values of dielectric constant (ε′) of different fibres at different temperature in air (raw and degummed fibres) and vacuum (raw fibres) at the frequency 1 KHz are displayed in table I. From the table we observe that the dielectric constant decreases after degumming the fibres. This may be due to the increase of degree of crystallinity after degumming the fibres for which degree of orderliness increase. This causes the

increase of conductivity and thus decrease of dielectric constant. The increase of degree of crystallinity due to degumming the fibrewas confirmed in our earlier XRD studies [20].

TABLE I – The dielectric constant (ε′) of different fibres at different te mperature in air and vacuum at 1 KHz frequency. (Sample a- Raw in air, b- Raw in vacuum, c- Degummed in air)

Temperature (K)	Pineapple Dielectric constant (ε′)			Dagger Dielectric constant (ε′)			Sisal Dielectric constant (ε′)		
	a	b	c	a	b	c	a	b	c
303	47.73	5.01	46.67	12.2	3.62	11.7	16.66	5.60	15.15
323	83.53	5.01	51.86	13.31	2.02	2.15	21.42	3.14	20.86
373	4.77	5.01	4.52	2.42	2.02	2.15	4.28	3.14	14.51
423	4.77	5.01	3.56	2.42	2.02	2.38	3.33	3.14	3.19
473	6.14	6.83	3.56	3.03	3.83	2.38	3.33	3.93	3.19
523	8.52	9.11	9.85	5.45	7.23	11.01	6.19	6.43	8.75
543	12.27	11.85	12.02	4.23	7.64	4.15	7.38	6.71	13.77
573	11.59	10.8	11.67	2.52	9.22	4.15	7.14	5.59	6.01

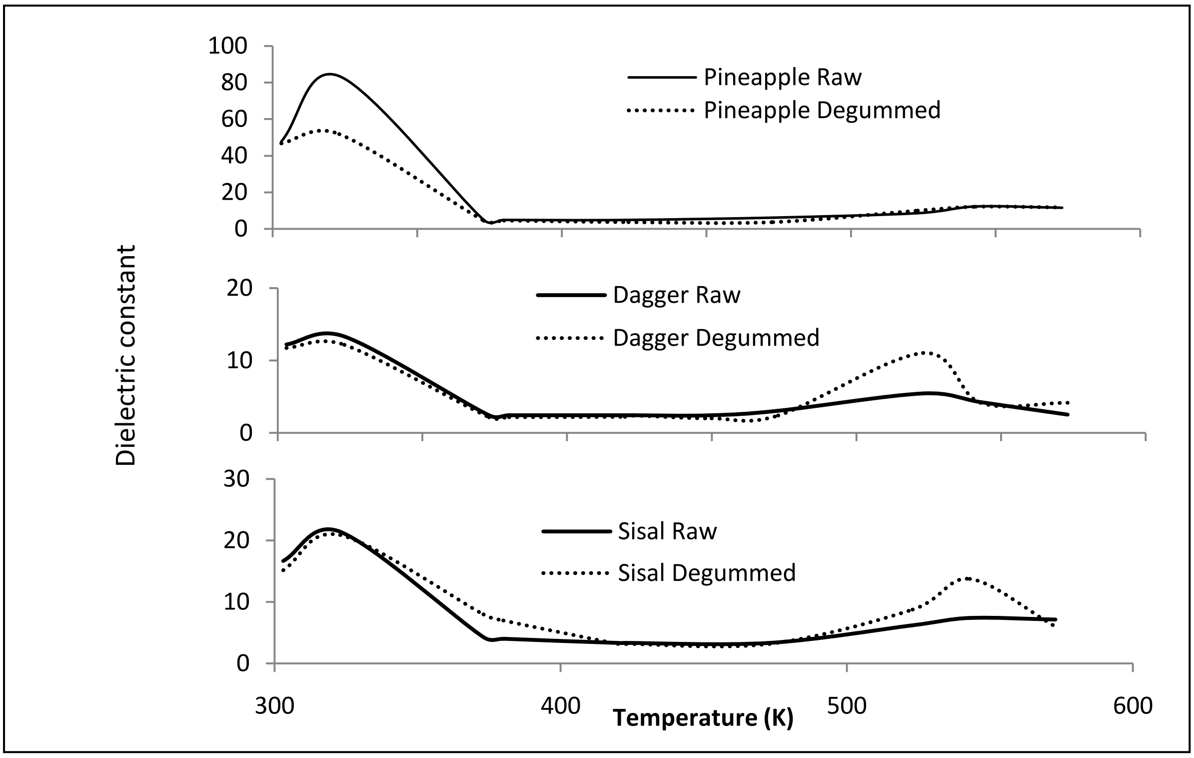

Figure3 Dielectric constant of different raw and degummed fibre at different temperature in air at frequency 1 KHz.

The variation of dielectric constant (ε′) with temperature for the raw and degummed fibres are depicted in figure 3. From figure 3 it is observed that the peak areas of the dielectric thermo grams of pineapple, dagger and sisal at dehydrated and decomposition state changes remarkably due to degumming. This may be due to the decrease of water molecule at dehydration state for increase of crystallinity and change of interfacial polarization effect in decomposition state for degumming. From the figure it also observe that the hygroscopicity of all the observed fibres are decreases due to degumming.

The steady value of dielectric constant of raw and degummed pineapple, dagger and sisal fibres are displayed in Table II. From the table it is inferred that the glass transition temperature has increased for all the fibres after degumming. This is in agreement with the result obtained earlier for some polymers.

TABLE II – Measurement of steady values of dielectric constant (ε′) for different fibres at 1 KHz in air medium.

Samples	Temperature range (K)	dielectric constant (ε′)
Pineapple raw	373-453	4.77
Pineapple degummed	383-498	3.56
Sisal raw	383-473	3.33
Sisal degummed	383-483	3.19
Dagger raw	373-463	2.42
Dagger degummed	383-478	2.38

TABLE III – The dielectric loss (ε″) of different fibres at different temperature in air at 1 KHz frequency. (Sample a- Raw, b- Degummed)

Temperature (K)	Pineapple Dielectric loss (ε″)		Dagger Dielectric loss (ε″)		Sisal Dielectric loss (ε″)	
	a	b	a	b	a	b
303	0.12	0.13	0.16	0.16	0.16	0.12
363	2.40	2.41	2.44	2.44	2.44	2.40
373	2.82	2.82	2.86	2.86	2.86	2.82
423	4.85	4.85	4.89	4.89	4.89	4.85
483	7.26	7.26	7.30	7.30	7.30	7.26
573	10.93	10.93	10.97	10.97	10.97	10.93

The observed values of dielectric loss (ε″) of different raw and degummed fibres at different temperature in air at the frequency 1 KHz are displayed in Table III. From the Table III it is observed that the variation of dielectric losses of the degummed fibres at different temperatures are almost same with the value of raw fibres. The variation of dielectric losses (ε″) with temperature in air at the frequency 1 KHz of the three raw fibres are displayed in figure 4. It is evident from the figure that dielectric loss gradually increases for all the fibres in the temperature range 303-573 K. This may be due to the increase of internal friction and thus decrease of electrical conduction for rise of temperature. The same result also observed for some samples by some observers at this range of temperature [21].

IV. CONCLUSION

Two-step variation of dielectric values are observed for all the three fibre samples. The natural fibres do not lose their dielectric characters due to degumming. All the three plant fibres are hydrophilic in nature. All the three fibres show almost similar dielectric behaviours with change in temperature at constant frequency, which indicates, the fibres posses identical molecular set up. The glass transition temperature has increased after degumming all the three fibres. The observed steady values of dielectric constant in a wide range of temperature indicate their stability to use as electrical appliances in the high temperature range.

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REFERENCE

[1] M. N. Bora, G.C. Baruah, D saikia, M. Talukdar and C. Talukdar, 1998, 'A review on the thermophysical properties of silk, plant and polyester fibres under different conditions', The 5th Asian thermophysical properties conference proceedings, August 30- sept 2, 1998, Seul, Koria, p. 77.

[2] Merish I.B. Abderahim . L Umadevi , I. Lorent, C. Yves, and T Sabu, 2006, 'Thermophysical properties of natural fibres reinforced polyester composites', Compos Science Technol., Vol. 66, No. 15, 2719-2725.

[3] J.B. Naik, S. Mishra, 2005, 'Studies of electrical properties of natural fibre : HDPE Composites', Polym. Plast Technol. Eng., Volume 44, No. 4, 687-693.

[4] E.A. turi, M. Jaffe, 1981,Fibres, Thermal characterization of polymeric materials, second edition, Academic press Ins, London Chapter 7, p. 709.

[5] D.J. Vaughan, 1998, Fibre glass reinforcement (Hand book of composites), 2nd edition, Chamman and Hall, London, pp. 131-154.

[6] M.N. Bora, G.C. Baruah, C. Talukdar, 1993, ' Studies on the dielectric propertiesof some natural (Plant) and synthetic fibresin audio frequency rangeand their D.C. conductivity at elevated temperature,' Thermochimica acta, 218, 435-443.

[7] C. Talukdar, M. Talukdar, D. Talukdar, S. Bardaloi and M. N. Bora, ' XRD studies of some cellulose fibre at different temperatures,' 8th ATPC Proc., Fukuoka, Japan, Paper no. 042, p. 21-24, August 2007.

[8] M. Talukdar, C. Talukdar, S. Bardaloi, D. Talukdar and M.N. Bora, ‘The investigation of thermal behavior of raw and degummed muga fibreinduced by heat treatment,’ 8^{th} ATPC Proc., Fukuoka, Japan, Paper no. 041, pp. 21-24, August 2007.

[9] D. Saikia, ‘The effect of heat on structural characteristics of crude and chemically treated agave fibres,’ 8^{th} ATPC Proc., August 2007, Fukuoka, Japan, Paper no. 160, pp. 21-24.

[10] D. Bhandari, R.K. Mangal, N.S. Saxena, S. Thomas and M.S. Sreekala, ‘Effect of heating rate and and chemical treatment on the glass trasition temperature of a pineapple leaf fibre reinforced P F composites,’ 2000, Indian J Phy, 74A(3),p. 243-244.

[11] W.L. McCubbin, 1970, J. Polym. Sci., 30, 181.

[12] T.J. Lewis and P.J. Bowen, ‘Electronic process in biopolymer system,’ IEEE trans, Electr. Insul, El 19(3) 254.

[13] N.M. Abdel Moteleb, M.M. Naoum, H.G. Shirouda and H.A. Rizk, ‘Some of the dielectric properties of cotton cellulose and viscose,’ 1982, J. Polym. Sci., 20(3), 765.

[14] G. N. Sarma, M. Talukdar, ‘Studies on the dielectric behavior of some plant fibres,’ January 2013, IJCER, vol.3, issue 1, pp.184-187.

[15] M. Talukdar, ‘Dielectric properties of irradiated and non irradiated Muga (Antheraea assama) silk fibre in presence of Oxygen at elevated temperature,’ April 2013, vol. 03, issue 4, pp. 218-221.

[16] C. Talukdar, ‘ An investigation on thermophysical behavior of some fibre readily available in the North-Eastern region of India by various physical method,’ 1993, A thesis of Gauhati University.

[17] M. Talukdar, Study of the thermophysical and tensile properties of irradiated and chemically treated natural fibres available in North-East India, A thesis of Gauhati University.

[18] S. Satio, H. Sesabe, Electrical conduction in polymers, 1968, J. Polym. Sci. A2(6) 1297

[19] M.N. Bora , D. Saikia, and C. Talukdar, ‘Thermophysical properties of some natural plant fibre by thermogravimetric and derivative thermogravimetric methods,’1997, High Temperature High Pressure, vol. 29, p. 683.

[20] M.N. Bora C. Talukdar and M. Talukdar, ‘Tensile properties of plant fibres readily available in North-Eastern region of India,’ Indian J. Fibre and Textile Research, 1999, Vol. 24, pp. 172-176.

[21] B. Tareev, ‘Physics of Dielectric material, 1979, (Moscow, Mir Publishers) p.158.

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