Indian Journal of Fibre & Textile Research
Vol. 42, March 2017, pp. 64-71

Mechanical, thermal and dynamic mechanical analysis of jute fibre reinforced epoxy composite

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Received 12 April 2015; revised received and accepted 10 June 2015

The aim of the present study is to investigate the mechanical, thermal and water absorption properties, and to perform dynamic mechanical analysis of jute fibre reinforced epoxy composite. The mechanical properties of the jute composites such as tensile, flexural and impact are investigated in this study. The dynamic mechanical analysis has been done in terms of storage modulus, loss modulus and damping parameter within the temperature range 30° - 200° C. The thermogravimetric analysis is used to measure the weight loss as a function of temperature. Thermal properties such as glass transition temperature, crystallization temperature, decomposition temperature, and enthalpy are obtained from differential scanning calorimetry studies. It is observed that the addition of jute fibre up to 30 wt. % in epoxy matrix increases the mechanical, thermal and water absorption properties.

Keywords: Dynamic mechanical analysis, Jute fibre, Mechanical properties, Thermal properties, Water absorption properties

1 Introduction

Nowadays natural fibres are used in place of glass and other synthetic fibres due to many advantages such as low cost, low density, abundance, environmental friendly, non-toxicity, high flexibility, renewability, biodegradability, relative non-abrasiveness, high specific strength and ease of processing. Natural fibres also have some limitations such as lower impact strength and higher moisture absorption[1-5].

Most of the studies are focused on mechanical properties of natural fibre reinforced polymer composite. The mechanical properties such as tensile strength, tensile modulus, flexural strength, flexural modulus and impact strength have been evaluated by different researchers. Prasad and Rao[6] studied the mechanical properties of jowar, sisal and bamboo reinforced polyester composite. They observed that tensile strength of jowar fibre composite was almost equal to bamboo fibre composite but 1.9 times more than sisal fibre reinforced polyester composite. The flexural strength of jowar composite was found 4% and 35 % greater than those of bamboo and sisal fibre reinforced polyester composites respectively. Bakare *et al.*[7] developed and characterized the unidirectional sisal fibres reinforced rubber seed oil based polyurethane composites and observed that tensile and flexural properties of composite were increased with fibre loading up to 30 wt %.

Dynamic mechanical and thermal analysis has become a far used technique to determine the interfacial characteristics of natural fibre reinforced polymer composite. Many researchers have reported studies on thermal and dynamic mechanical analysis of natural fibres reinforced polymer composites. Pothan *et al.*[8] investigated the dynamic mechanical analysis of banana fibre reinforced polyester composites and highlighted that the composite with 40 vol% fibre fraction shows the maximum value of storage modulus, whereas lower value of loss modulus and damping parameters. Nair *et al.*[9] presented studies on thermal and dynamic analysis of short sisal fibres reinforced polystyrene composites. They observed that the sisal fibre reinforced composite shows the higher thermal stability as compared to neat polystyrene and sisal fibres. The storage modulus decreases upon increasing the temperature and the glass transition temperature of composite shifts towards lower temperature compared to neat polystyrene.

The mechanical properties in terms of tensile, flexural and impact tests, and water absorption behavior in terms of sorption, diffusion and permeability coefficient are investigated. In addition,

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thermal property of prepared jute composites are studied using Thermogravimetric Analysis(TGA) and Differential Scanning Calorimetry (DSC). Moreover, Dynamic Mechanical Analysis (DMA) in terms of storage modulus $(E^{'})$, loss modulus $(E^{''})$ and damping parameter $(Tan\delta)$ are also studied in this investigation.

2 Materials and Methods

Jute fibre reinforced epoxy composite was prepared in the laboratory. The specification of materials and fabrication process are described below.

2.1 Materials

Jute fibres were used as reinforcement and epoxy (AY 105) as a matrix. Jute fibre and epoxy matrix were purchased from local resource.

2.1.1 Matrix

Epoxy resin is made by reacting epichlorohydrin with bis-phenol A. The reaction between these two compounds removes unreacted phenol, acetone and attached two glycidyle groups, producing diglycidyl ether of bisphenol A (DGEBA). The standard name of diglycidyl ether of bisphenol A is epoxy resin.

Various molecular weights of epoxy resin can be obtained by varying relationship between epichlorohydrin and bis-phenol A. In formula of epoxy resin, if $n = 0$, molecular weight of epoxy resin is 340, for $n = 1$ molecular weight is 624, whereas for $n = 2$ molecular weight is found 908.

To convert epoxy resin to epoxy plastic, a reaction with suitable material is required. Such type of material is called hardener (curing agent). The most widely used curing agent is primary and secondary amines such as diethylene triamine.

Epoxy is a thermosetting polymer that cures when mixed with a hardener. Epoxy resin of grade AY105, having 1.11 g/cm^3 density and 11.79 Pa.s dynamic viscosity at 25 ºC, was used in this work. Epoxy was cured with hardener HY951. The matrix materials were prepared with a mixture of epoxy and hardener at a ratio of 10:1 as recommended[10].

2.1.2 Reinforcement

Jute (*Corchorus capsularis*) was used as reinforcement. The physical and mechanical properties of jute fibre are density (1.3g/m^3), diameter (25-200 µm), elongation at break (1.5-1.8 %), tensile strength (393-773MPa) and young's modulus (26.5 GPa), and chemical composition is cellulose (61-71%), lignin (12-13%), microfibrillar angle (8^0), wax (0.5%) and hemi-cellulose (14-20%)[11-13]. Jute fibre burns without melting at high temperature. The thermal properties of jute fibre are ignition temperature (193°C) and specific heat (1360 J/kg/K), which shows good thermal insulation of jute.

2.2 Fabrication of Composites

The composites were fabricated by reinforcing jute fibres with unidirectional alignment in epoxy matrix by hand-lay-up technique followed by static compression. A stainless steel mould having dimensions of 500 × 300 × 3 mm^3 was used. A releasing agent was used to facilitate easy removal of the composite from the mould after curing. The cast of each composite was cured under a load of 50 kg for 24 h before it was removed from mould. Dimension of specimens was cut as per ASTM standard using a diamond cutter. The composites manufactured with varying wt % of fibres are designated as J15 (15 wt % of jute fibre), J20 (20 wt % of jute fibre**)**, J25 (25 wt % of jute fibre) and J30 (30 wt % of jute fibre).

2.3 Characterizations of Composites

The fabricated composites were tested for mechanical, thermal, water absorption properties and dynamic mechanical analysis.

2.3.1 Tensile Test

Tinius Olsen H 10 K-L (Bi-axial testing machine) was used to obtain tensile properties of the composite samples with a crosshead speed of 2 mm/min, operated at room temperature. Tests were conducted as per ASTM D638 with dimension 165mm × 20 mm × 3mm. Five specimens of each composite were tested and average values were reported.

2.3.2 Flexural Test

Flexural properties of the composites were measured using a three point bending test on Tinius Olsen H10 K-L (Bi-axial testing machine). The sample was prepared for the flexural test with dimensions (80mm × 12.7mm × 3mm) as per ASTM D790. The flexural test was carried out at room temperature with the crosshead speed of 2 mm/min. Flexural strength and flexural modulus were calculated using the following equation [6]:

$$\text{Flexural strength} = \frac{3FL}{2bd^2} \text{ and flexural modulus} = \frac{mL^3}{4bd^3} \quad \ldots (1)$$

where F is the ultimate failure load (N); L, the span length (mm); b and d, the width and thickness of specimen in (mm) respectively; and m, the slope of tangent to the initial line portion of the load-displacement curve. Five specimens of each composite were tested and average values were reported.

2.3.3 Impact Test

Tinius Olsen Impact 104 machine was used to obtain impact properties of jute fibre composite samples. The sample was prepared for the impact test with dimensions 65mm × 12.7mm × 3mm and 2.5 mm notch thickness as per ASTM D 256. Five specimens of each composite were tested and average values were reported.

2.3.4 Statistical Analysis

Statistical analysis is required to know that test is significant or not. Null hypothesis shows that there is no difference between samples. If p value, calculated from T-test or ANOVA is less than 0.05, then null hypothesis can be rejected, however it is considered if p value is greater than 0.05. T-test and analysis of variance (ANOVA) were used to find out the statistical analysis of tensile, flexural and impact test. Probability value p =0.05 was considered as an analytical of significance compared to the control composite (J15).

2.3.5 Water Absorption Properties

Water absorption behavior of jute fibre reinforced polymer composite was investigated as per ASTM D 570. The specimens were submerged in water at room temperature to study the kinetics of water absorption behavior. The samples were taken out periodically with period of 12 h and weighed immediately. The content of water absorption by sample was observed using a precise 4-digit balance. The percentage of water absorption was calculated using the following equation:

$$\text{Water absorption (\%)} = \frac{w_2 - w_1}{w_1} \times 100 \quad \ldots (2)$$

Where w_1 is the weight before soaking into water (g); and w_2, the weight after soaking into water (g). Diffusion coefficient is generally prescribed for a given pair of species. The kinetic parameter, diffusion coefficient (mm^2/s) was calculated by the following equation[10]:

$$\text{Diffusion coefficient } (D) = \pi \left(\frac{t^2 m^2}{16 W_\infty^2} \right) \quad \ldots (3)$$

where m is the slope of linear portion of the sorption curve; and t, the initial sample thickness in (mm).

The permeability of water molecules through the composite sample depends on the sorption of water by the fibres. Therefore, the sorption coefficients which are related to the equilibrium sorption, was calculated by the following equation[10]:

$$\text{Sorption coefficient } (S) = W_\infty / W_t \quad \ldots (4)$$

where W_∞ and W_t are the percentage of water uptake at infinite time and at time t.

The permeability coefficient P (mm^2/s), which implies the net effect of sorption and diffusion, was calculated by the following equation[10]:

$$\text{Permeability coefficient } (P) = D \times S \quad \ldots (5)$$

2.3.6 Thermogravimetric Analysis

Thermal stability of the composite was assessed using the thermogravimetric Perkin Elmer TGA 4000 apparatus. TGA measurements were carried out on 15-25 mg sample placed in a platinum pan, heated from 30º-800 ºC at a heating rate of 10 ºC / min in a nitrogen atmosphere with a flow rate of 20 mL/min to avoid unwanted oxidation.

2.3.7 Differential Scanning Calorimetry

The thermal properties i.e. glass transition temperature (T_g), crystallization temperature (T_c), decomposition temperature (T_d) and enthalpy of epoxy and jute composites were studied by using differential scanning calorimetry (Perkin Elmer model DSC 4000). The experiments were carried out in the temperature range 30° – 400 °C at heat flow rate of 10 °C/min under nitrogen atmosphere purged at 20 mL/min and using aluminum pan. Nitrogen was used for the efficient heat transfer and removal of volatiles from the samples.

2.3.8 Dynamic Mechanical Analysis

Viscoelastic properties of fibre reinforced polymer composites depend on the nature of the matrix, reinforcement and fibre–matrix interfaces. The viscoelastic properties of epoxy and jute composites were studied by using the dynamic mechanical analyzer (Seiko instruments DMA 6100). The viscoelastic properties were determined in 3 point bending test at 1 Hz frequency as a function of temperature. The composites are cut into samples having dimensions of 50 mm ×13 mm × 3 mm according to ASTM D 5023. Experiments were carried out in the temperature range 30°–200° at heating rate of 10°/min. The viscoelastic properties such as storage modulus, loss modulus and damping parameter of the specimens were measured.

3 Results and Discussion

3.1 Mechanical Properties

The tensile, flexural and impact properties of epoxy and jute fibre reinforced epoxy composite are given in Table 1.

3.1.1 Tensile Properties

Variation in tensile strength and tensile modulus on increasing the jute fibre content are given in Table 1. Tensile properties of jute fibre reinforced epoxy composite increases with increasing jute fibre content up to 30 wt % in epoxy matrix. The composite J30 offers the maximum value of tensile strength and tensile modulus due to strong adhesion between fibres and epoxy matrix which causes uniform transfer of stress from matrix to fibres. Tensile strength (78.21 MPa) and tensile modulus (1.52 GPa) are found maximum for the composite J30, which are found more than 131% and 114% respectively as compared to epoxy. It is observed that tensile strength of composite J30 is more than 41, 27 and 1.4% and tensile modulus is more than 35, 24 and 7% as compared to composites J15, J20 and J25 respectively. According to statistical analysis, the values of tensile strength and modulus are found to be significant as compared to the J15 composite. The results of ANOVA also show the significant difference between composites (Table 1). The results of tensile properties of present composite as compared to other composites are given in Table 2.

3.1.2 Flexural Properties

Variation in flexural strength and flexural modulus on increasing the jute fibre content are given in Table 1. Flexural properties of epoxy and jute composite are also found to be increased with increasing jute fibre content in epoxy matrix. The composite J30 offers the maximum value of flexural strength and flexural modulus due to strong fibre-matrix adhesion and minimum possibility of voids in the composite. Flexural strength (203.48 MPa) and flexural modulus (9.76 GPa) are found maximum for the composite J30, which are higher than 71% and 69% respectively as compared to epoxy. It is seen that flexural strength of composite J30 is more than 105, 39 and 23% and flexural modulus is more than 70, 32 and 3% as compared to composites J15, J20 and J25 respectively. According to statistical analysis the values of flexural strength and modulus are found to be significant as compared to the J15 composite. The results of ANOVA also show the significant difference between composites (Table 1). The results of flexural properties of present composite as compared to other composites are given in Table 2.

3.1.3 Impact Properties

Variations in impact strength and impact energy on increasing the jute fibre content are given in

Table 1—Tensile, flexural and impact properties of epoxy and jute composites

Composite	Tensile strength MPa	Tensile modulus GPa	Flexural strength MPa	Flexural modulus GPa	Impact strength kJ/m^2	Impact energy J
Epoxy	33.86 ± 3.59	0.71 ± 0.06	118.73 ± 10.49	5.78 ± 0.48	5.67 ± 0.35	0.14 ± 0.01
J15	55.33 ± 3.34	1.13 ± 0.06	99.36 ± 8.30	5.73 ± 0.32	8.79 ± 0.70	0.28 ± 0.02
J20	61.78 ± 3.86	1.23 ±0.15	146.23 ± 11.94	7.37 ± 0.53	9.02 ± 0.67	0.29 ± 0.03
J25	77.15 ± 5.13	1.42 ± 0.13	165.35 ± 6.79	9.73 ± 0.50	9.92 ± 0.87	0.34 ± 0.03
J30	78.21 ± 6.12	1.52 ± 0.13	203.48 ± 17.34	9.76 ± 0.82	13.89 ±0.98	0.35 ± 0.02

Table 2—Comparison of mechanical properties of some natural fibre polymer composites from published work

Reinforcement	Matrix	Tensile strength, MPa	Tensile modulus, GPa	Flexural strength, MPa	Flexural modulus GPa	Impact strength J/m	Ref.
Pineapple leaf fibre	Polyester	52.90	2.29	80.20	2.76	80.30	14
Kenaf	Polypropylene	26.90	2.70	43.10	2.30	43.80	15
Borassus fruit fibre	Polypropylene	29.29	2.58	45.34	1.46	28.61	16
Coir	Polypropylene	26.14	2.21	42.67	1.83	21.99	16
Jute	Polypropylene	29.40	2.49	48.76	1.70	22.53	16
Sisal	Polypropylene	28.05	2.64	48.77	1.43	25.98	16
Banana	Epoxy	16.12	0.64	57.33	8.92	39.75	10
Sisal	Epoxy	21.20	0.72	62.04	9.34	67.62	10
Jute	Epoxy	78.21	1.52	203.48	9.76	44.41	Present work

Table 1. Similar to tensile and flexural tests results, impact properties of jute fibre reinforced epoxy composites are found to be increased with increasing jute fibre content up to 30 wt %, in epoxy matrix. Impact strength (13.89kJ/m^2) and impact energy (0.35J) are found maximum for the composite J30, which are more than 145% and 150% respectively as compared to epoxy. The composite J30 shows the maximum impact strength and impact energy due to strong adhesion between jute fibres and epoxy matrix. The impact strength is found 58, 54 and 40% higher and impact energy is found 25, 21 and 3 % higher than composites J15, J20 and J25 respectively. According to statistical analysis, the values of impact strength and impact energy are found to be significant as compared to the J15 composite. The results of ANOVA also show the significant difference between composites (Table 1). The results of impact properties of present jute fibre reinforced epoxy composite are also compared with other composites (Table 2).

3.2 Water Absorption Properties

The water absorption (%) of jute fibre reinforced epoxy composite is plotted against the square root of time (Fig. 1). The water absorption increases with increasing fibre content in all cases. The composite J30 shows water absorption i.e. 4.8, 36 and 6.2% more than composites J15, J20 and J25 respectively. The increasing water absorption in jute fibres is due to its hydrophilic nature and greater interfacial area between fibre and matrix. The water absorption by epoxy is almost negligible due to its hydrophobic nature. The water absorption for all composites is linear in beginning and then slows down till it approaches saturation point. This process is very similar to Fickian diffusion process. The sorption, diffusion and permeability coefficient of jute fibre reinforced epoxy composite are calculated and tabulated in Table 3. The composite J20 shows the lowest sorption coefficient and J30 shows the lowest diffusion and permeability coefficient due to strong adhesion between fibres and matrix.

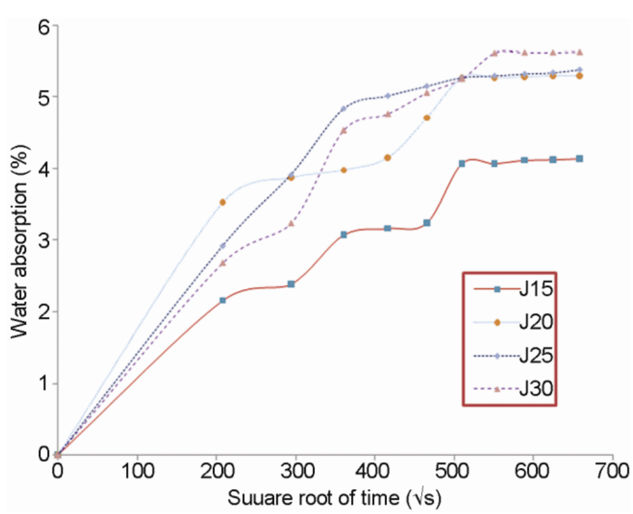

Fig. 1—Water absorption of jute composites as a function of square root of time

3.3 TGA of Jute Composite

Figure 2 shows the TGA results of jute fibre reinforced epoxy composite. There are three significant regions of weight loss due to rise in temperature. The initial low temperature weight loss of composites is due to the removal of moisture from composite, major weight loss due to degradation and volatization of epoxy along with jute fibres present in composites and the residue that are formed after degradation requires higher temperature for subsequent degradation. The initial, major and final weight loss and their corresponding temperature are given in Table 4. The major weight loss of the composite J30 occurs at 510 ºC. Here degradation is shifted to higher temperature which shows increased thermal stability due to stronger adhesion between fibres and matrix as compared to all other composites.

Table 3—Sorption, diffusion and permeability coefficient of jute composites

Composites	Water uptake at infinite time, %	Sorption coefficient (S)	Diffusion coefficient (D), mm^2/s	Permeability coefficient (P) mm^2/s
J15	4.14	1.91	1.242E-5	2.372E-05
J20	5.30	1.50	2.039E-5	3.058E-05
J25	5.37	1.84	1.361E-5	2.504E-05
J30	5.63	2.10	1.058E-5	2.217E-05

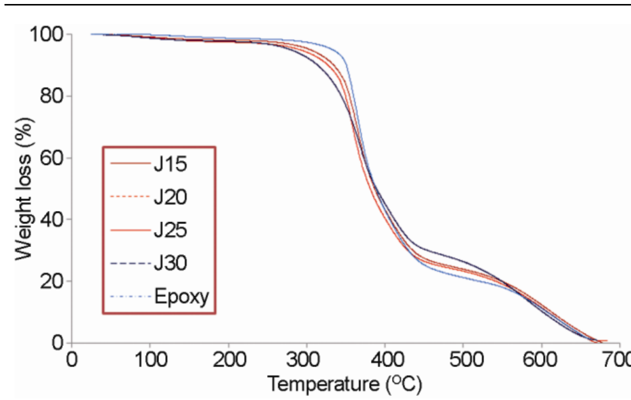

Fig. 2—Variation in weight loss of epoxy and jute composites with temperature

Table 4—Initial and final weight loss and temperature of epoxy and jute composite

Composites	Initial weight loss %	Initial weight loss temperature, ºC	Major weight loss, %	Major weight loss temperature, ºC	Final weight loss temperature, ºC
Epoxy	5	330	75	450	679
J15	5	305	75	481	668
J20	5	293	75	468	671
J25	5	280	75	513	683
J30	5	286	75	510	698

3.4 Differential Scanning Calorimetry

Thermal properties of epoxy and jute fibre reinforced epoxy composites such as glass transition temperature (T_g), crystallization temperature (T_c), decomposition temperature (T_d) and enthalpy are obtained from DSC studies and summarized in Table 5. The corresponding data are plotted in Fig. 3. During analysis, composite absorbs heat when being melted and release heat during degradation. The results suggest that glass transition temperature (T_g) lies between 64 °C and 69 °C, crystallization temperature lies between 111 °C and 116 °C, whereas decomposition temperature lies between 335 °C and 345°C. The composite J30 shows the higher melting point due to strong adhesion between fibres and matrix. There is no significant change in the value of enthalpy for epoxy and jute composites. The measured enthalpy of epoxy and jute composites are 28.45 and 28.46 J/g respectively.

Table 5—DSC results for epoxy and jute composites

Composite	T_g, °C	T_c, °C	T_d,°C
Epoxy	65.16	110.53	345-350
J15	67.18	115.70	343-346
J20	66.15	113.67	344-350
J25	66.98	109.00	348-354
J30	69.17	110.38	352-357

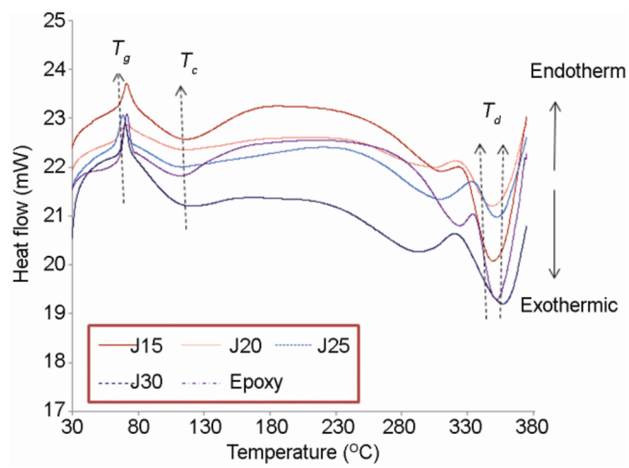

Fig. 3—Variation in heat flow with temperature of epoxy and composites

3.5 Dynamic Mechanical Analysis

The DMA was performed on the composite samples to study its viscoelastic properties. Figure 4-6 show the variation in E', E'' and $Tan\delta$ of the epoxy and jute composites as a function of temperature at a frequency of 1 Hz.

3.5.1 Storage Modulus

The maximum energy stored by material during one cycle of oscillation is known as storage modulus (E'). It also gives an idea of temperature-dependant stiffness behaviour and load-bearing capability of the composite material[17]. Figure 4 shows the variation in storage modulus of epoxy and jute composites as a function of temperature. On comparing different composites it is found that the value of E' an increases with increase in the weight fraction of jute fibres in the composites up to 25 wt%. The value of E' is found 3.65 GPa for epoxy in the glassy region but this value is found to increase up to 4.87 GPa for the composite J25. This may be due to reinforcement of jute fibres in epoxy matrix. The storage moduli of

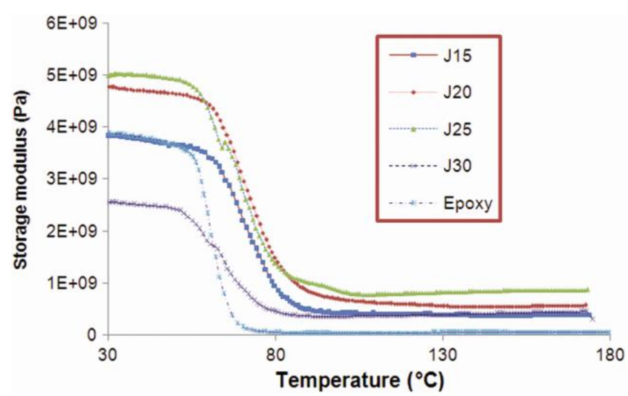

Fig. 4—Variation in storage modulus with temperature of epoxy and jute composites

the epoxy and jute composites decrease as temperature is increased due to loss in stiffness of fibres. It can be seen from Fig. 4 that the jute composites have a gradual fall in the value of E' when temperature is increased as compared to the neat epoxy which has a very steep fall

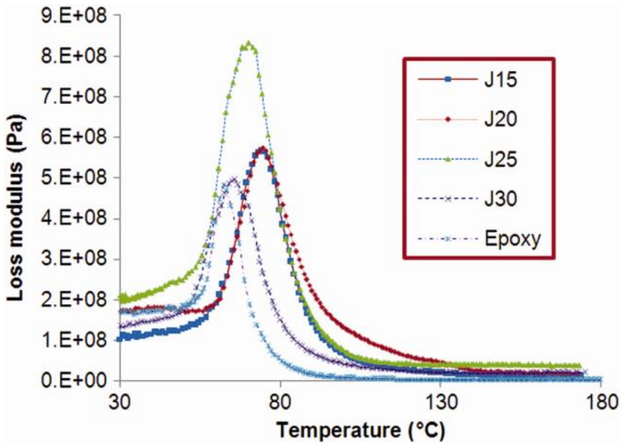

Fig. 5—Variation of loss modulus with temperature of epoxy and jute composites

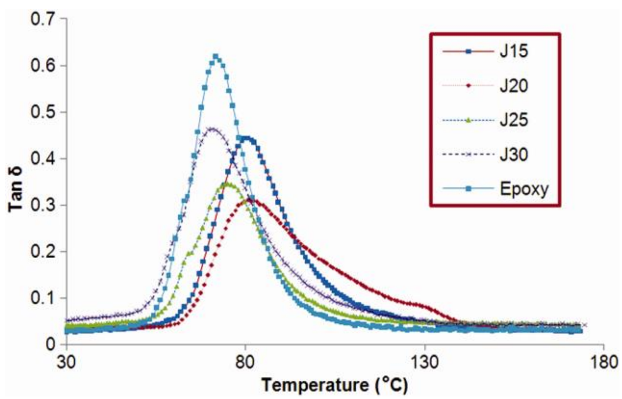

Fig. 6—Variation of Tan δ with temperature of epoxy and jute composites

Table 6—Peak height and T_g from loss modulus and tan delta, and value of $\in$ for jute composites

Composite	Peak height of loss modulus curve, GPa	Peak height of tan delta curve	T_g, °C (from loss modulus curve)	T_g, °C (from tan delta curve)	$\in$
Epoxy	0.48	1.30	62.17	73.81	-
J15	0.57	0.44	74.32	79.86	0.32
J20	0.57	0.31	74.44	80.68	0.29
J25	0.83	0.35	70.15	75.14	0.28
J30	0.49	0.46	65.84	70.86	0.24

in the value of E'. In the rubbery region, storage modulus of epoxy is much lower than those in jute composites. The value of E' of epoxy is 0.23 GPa whereas with incorporation of jute fibre the value is increased to 1.07 GPa for jute composite J25. This is attributed to the reinforcement of fibres which allow proper stress transfer from the matrix to the fibres[18]. The effectiveness constant of reinforcement $(\in)$ can be calculated by using the following equation[19]:

$$\in = \frac{\left(\frac{E'_g}{E'_r}\right)_{Composite}}{\left(\frac{E'_g}{E'_r}\right)_{Epoxy}}$$

where E'_g is the storage modulus in the glassy region; and E'_r, the storage modulus in the rubbery region. The higher value of $\in$ shows lower efficiency of the reinforcement and lower value shows higher efficiency of reinforcement. The effectiveness constant is given in Table 6. The composite J30 shows the lowest value (0.24) of effectiveness constant of reinforcement, whereas composite J15 shows its highest value (0.32). The lowest value of effectiveness constant for composite J30 shows the better fibre-matrix adhesion. It may be due to addition of high strength jute fibre including better stress transfer from matrix to fibres.

3.5.2 Loss Modulus

Loss modulus is the amount of dissipated energy/cycle in the form of heat under deformation from sample. For the polymer system the dynamic glass transition temperature is defined as the peak of either E'' or Tanδ curve. The variation in loss modulus as a function of temperature is shown in the Fig. 5. It can be observed that the value of E'' increases and then decreases with the increase in temperature. The value of E'' is found 0.48 GPa for epoxy but this value is found to increase up to 0.83 GPa for the composite J25. The glass transition temperature of composites J15 and J20 have shifted towards higher temperature. The shifting of T_g towards higher temperature can be associated with the decrease in mobility of matrix due to incorporation of jute fibres[18]. The value of glass transition temperature for epoxy and jute composites obtained from loss modulus curve is given in Table 6.

3.5.3 Tan Delta

Damping parameter is the ratio of loss modulus and storage modulus which shows the impact properties of material. The higher value of Tanδ shows the better impact properties[17]. The effect of damping parameter on epoxy and jute composites as a function of temperature is shown in Fig. 6. The peak of Tanδ curve occurs in glass transition region, where composite changes from rigid to more elastic state due to the movement of molecules in polymer structure. The maximum value of Tanδ is found

(1.30) for epoxy as expected. The value of tan delta peak and glass transition temperature of epoxy and composites are given in Table 6. The value of T_g obtained from tan delta curve is higher than T_g from loss modulus curve.

4 Conclusion

Mechanical, thermal, water absorption properties and dynamic mechanical analysis of jute fibre reinforced epoxy composite are studied. It can be seen that increasing the jute fibre content up to 30 wt. % in epoxy matrix results in increase in mechanical, thermal and water absorption properties. The composite J30 offers the lower value of diffusion and permeability coefficient but higher value of sorption coefficient. The value of storage modulus for epoxy and jute composites are found to be less at higher temperature but these values are increased on increasing the jute fibre content. Similarly, loss modulus is observed to increase on increasing the jute fibre content due to uniform stress transfer from matrix to fibres. The effectiveness constant of reinforcement is calculated for jute composites and its lower value is found for composite J30. The T_g is obtained from loss modulus and tan delta curve and it is seen that the value of T_g from loss modulus curve is lower than that obtained from tan delta curve.

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