Dynamic Mechanical Analysis of Asian Palmyra Sprouts fiber Reinforced Epoxy Composites

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Abstract – *The dynamic mechanical analysis of asian palmyra sprouts fiber reinforced epoxy composites was done with effect of fibre loading, frequency and temperature. In this borassus flabellifer (Asian palmyra) sprouts were used as natural fiber reinforcement. DMA is done at three different fibre loading (20%, 30% and 40%) at three different frequencies (1, 3 and 5 hz). The graphical representation of storage modulus (E'), loss modulus (E") and damping factor are obtained from Dynamic mechanical analysis. The values of storage modulus decreased with increase in fibre loading. This shows that effectiveness of fibre is highest at 40% fiber loading. The loss modulus and damping peaks decreased with increase of fibre loading. The decrease in tanδ peak at higher fiber loading represents better interfacial bonding. This shows that at 40% fibre loading better results are obtained compared to lower fiber loadings and 40% fibre loading is considered as effective fibre loading. Loss modulus and damping factor (tanδ) peaks increased with increase of frequency.*

Key Words: **Storage modulus, Loss modulus, damping factor, Natural fiber.**

1. INTRODUCTION

In the last few years, there has been prominent importance for natural materials which cause no harm to the environment. This led to the replacement of synthetic fibers with natural fibers. This reduces solid waste in material manufacturing. Natural fiber reinforced polymer composites are emerging as new eco-friendly polymeric composite materials.

Dynamic mechanical test methods have been widely employed for investigating the structures and viscoelastic behaviour of polymeric materials for determining their relevant stiffness and damping characteristics for various applications. The dynamic properties of polymeric materials are of considerable practical significance when determined over a range of temperature and frequencies. [1]

The importance of dynamic mechanical analysis (DMA) as a tool in the study of the behaviour of composite structures is paramount. It has been proved to be an effective method to study the relaxations in polymers and thereby the behaviour of the materials under various conditions of stress, temperature and phase composition of fibre composites and its role in determining the mechanical properties. [2]

Natural fiber has been in a wide use since the evolution of the human race. They had got wide acceptation in communities for their flexibility and strength. Recent trends in the area of fiber rein-forced composites have drawn a string in using these natural fibers as their reinforcement. The natural fiber imparts lower durability and lower strength compared to glass fibers. However, low specific gravity results in a higher specific strength and stiffness. Natural fibers offer good thermal, dielectric and acoustic insulation properties along with ease in processing technique without wearing of tools. [3]

Palmyra fiber is obtained from the palmyra (palm) tree, which is 10 to 15 metre high plant. It is used as natural reinforcing fiber. It is cost-effective and eco-friendly. It is having high specific strength. Due to its low specific weight, it can be a better alternative to existing synthetic fibre reinforced composites. In present work, we use Asian palmyra sprouts fiber.

2. EXPERIMENTAL PROCEDURES

2.1 Materials

- Fibers - Asian Palmyra sprouts fiber
- Matrix - General purpose epoxy resin
- Accelerator - cobalt naphthenate
- Hardener - Methyl ethyl ketone peroxide

2.2 Extraction of fibers

Borassus flabellifer (Asian palmyra) sprouts were purchased from local sellers. Hand peeling technique is used for getting thin layers of sprouts. The thin layers of sprouts were treated with 1% Naoh solution. Distilled water is used to remove unwanted particles. Then fibers are dried for 20 h at regular room temperature. Further, fibers are heated in air oven for 2 h at 70 ^{0}c to remove any moisture from it.

Figure 1: Asian Palmyra sprouts fiber

2.3 Fabrication of composites Polymer

Hand layup method was used to prepare the composite polymer. Borassus flabellifer (Asian palmyra) sprouts fiber were used to know the reinforcing capability of fibre on epoxy resin. Accelerator and catalyst are added to resin at the room temperature. Moulds were used prepare Asian palmyra sprouts fiber reinforced epoxy composites. A pressure of 0.05Mpa was applied and composites specimen were allowed to cure for 1 day. Specimens are removed from moulds and again cured at 70^{0}c for 2h. fibre loading of three different percentages (20%,30% and 40%) are prepared.

2.4. Experimental conditions

In dynamic mechanical analysis a small cyclic load is applied on the sample at varying temperatures.

Instrument	-	Dynamic mechanical analyzer
Heating rate	-	3^{0}C/min
Temperature range	-	Room temperature to 150^{0}c
Frequencies	-	1,3 and 5 Hz
Maximum load range	-	up to 18 N
Deformation mode	-	Three point bending
Sample dimensions	-	Length (l)-50 mm, Width (w)-10 mm, Thickness (t)-3 mm.
Deformation amplitude	-	40 µm
Cooling	-	Liquid nitrogen with Automated Cooling Accessory

Figure 2: Dynamic mechanical analyzer

2.6 Test procedure:

The sample of known fiber loading is taken and placed inside environmental chamber. Cyclic load is applied on the sample at varying temperature at the rate of 3^{0}c. The process is repeated until 150^{0}c. It will take nearly 50 minutes for each sample.

3. RESULTS AND DISCUSSION

The graphical representation of storage modulus (E'), loss modulus (E") and mechanical loss factor (tanδ) are obtained from dynamic mechanical analysis. These are dependent on fiber loading, frequency and temperature. Graphs are obtained for three different fiber loadings (20%, 30% and 40%) at three different frequencies (1,3 and 5 hz). Heating rate of 3^{0}c is maintained throughout process. Dimensions of specimens should be 50 x10 x 3 mm3 according to the DMA equipment.

Glass transition (t_g) is a sudden noticeable peak in elastic modulus and tanδ curves. This helps in finding material property. This is important factor for finding the properties of composite polymer. The peak height of tanδ and loss modulus gives glass transition (t_g).

The variation of storage modulus, loss modulus and damping factor as a function of temperature and frequencies of asian Palmyra sprouts fiber reinforced epoxy composites are as shown in figures 3 to 11.

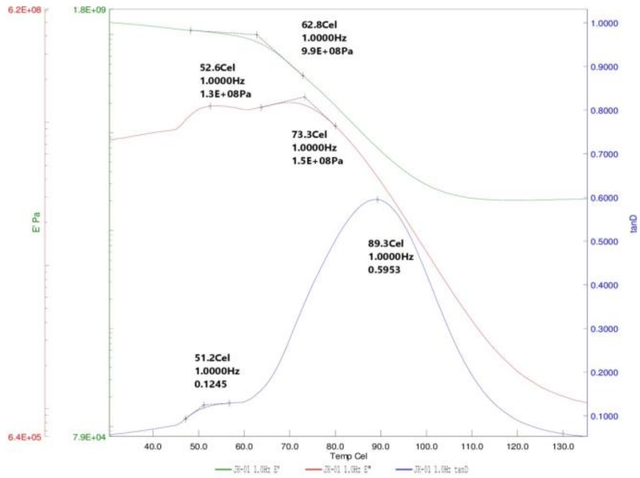

Figure 3: shows DMA results of 40% Asian Palmyra fiber epoxy composites at 1 hz

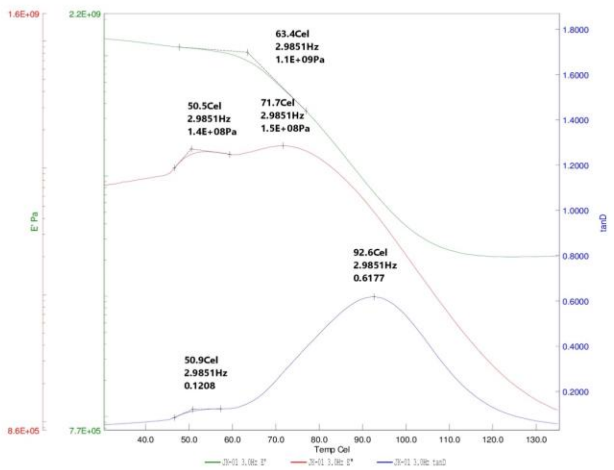

Figure 4: shows DMA results of 40% Asian Palmyra fiber epoxy composites at 3 hz

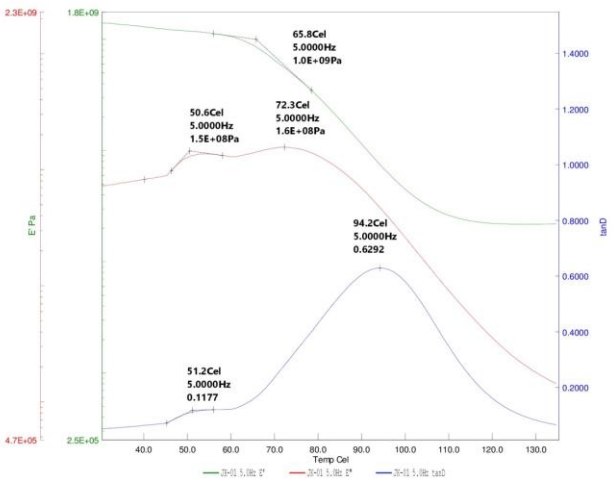

Figure 5: shows DMA results of 40% Asian Palmyra fiber epoxy composites at 5 hz

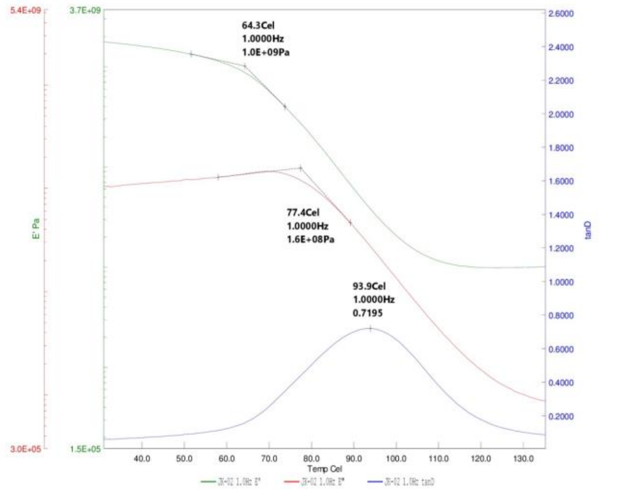

Figure 6: shows DMA results of 30% Asian Palmyra fiber epoxy composites at 1 hz

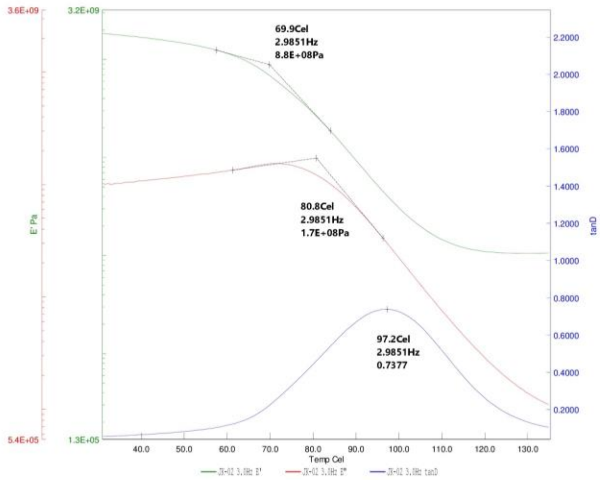

Figure7: shows DMA results of 30% Asian Palmyra fiber epoxy composites at 3 hz

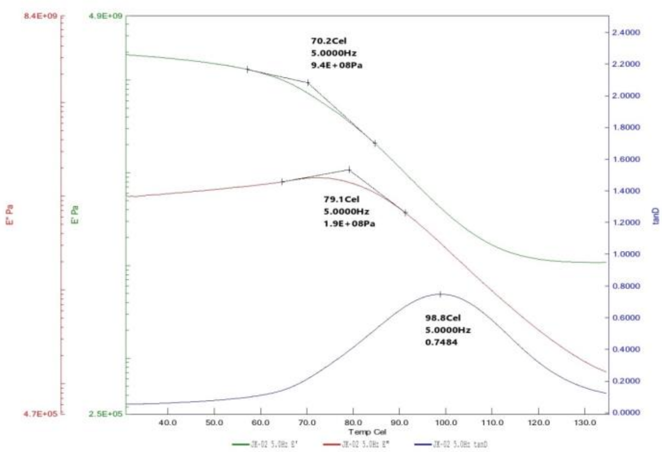

Figure 8: shows DMA results of 30% Asian Palmyra fiber epoxy composites at 5 hz

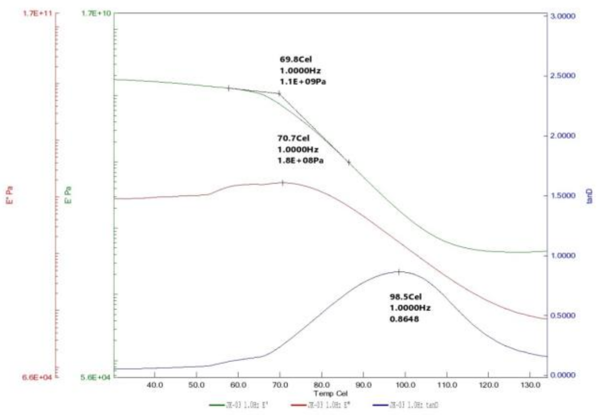

Figure 9: shows DMA results of 20% Asian Palmyra fiber epoxy composites at 1 hz

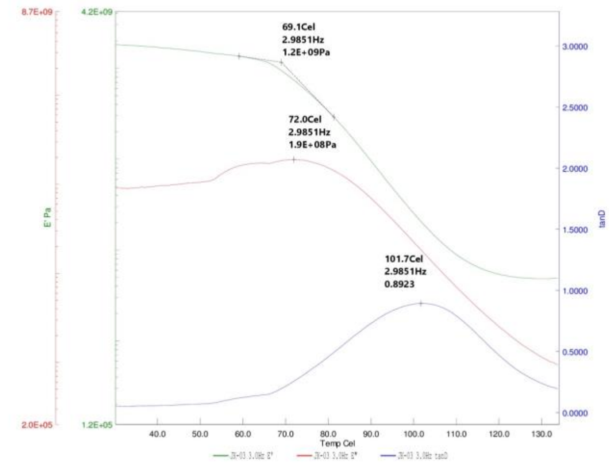

Figure 10: shows DMA results of 20% Asian Palmyra fiber epoxy composites at 3 hz

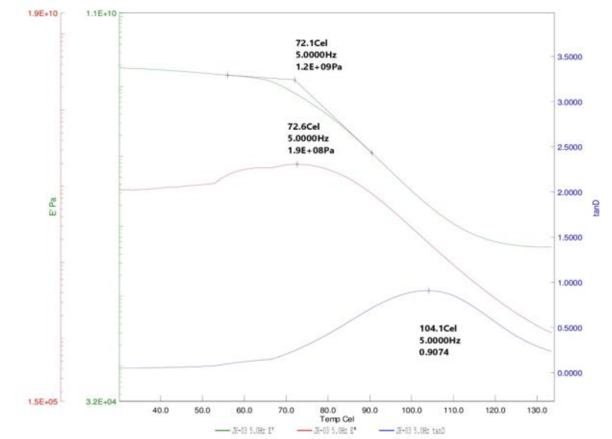

Figure11: shows DMA results of 20% Asian Palmyra fiber epoxy composites at 5 hz

3.1 Effect of fiber loading on dynamic storage modulus (E'):

Dynamic storage modulus (E') is the most important property to know the load bearing capacity of a composite material. The variation of storage modulus as a function of temperature of asian Palmyra fiber reinforced epoxy composites is shown in Figures 3 to 11.

The storage modulus values for different fiber loading (20%, 30% and 40%) at three different frequencies (1,3and 5 Hz) are given in figures 3 to 11. The values of storage modulus decreased with increase in fibre loading. Stiffness of the material increased with increase in fiber loading. At 40% fiber loading storage modulus is better than at lower fiber loadings.

3.2 Effect of fiber loading on mechanical loss factor (tan δ):

The values of mechanical loss factor (tan δ) decreased with increase in fiber loading. The decrease in tanδ peak with increase in fiber loading represents better fiber and matrix interfacial interaction at higher fiber loading. When the fiber concentration is lower, fibers act ineffectively.

3.3 Effect of fiber loading on loss modulus:

Loss modulus (E") is a measure of the energy released as heat per cycle under deformation. From the above figures it shows that values of loss modulus decreased with increase in fibre loading. From the figures 3 to 11, it is clear that increase in fiber loading causes broadening of the loss modulus peak.

3.4 Effect of frequency:

The storage modulus, loss modulus and damping peaks have been found to be affected by frequency. With increase of frequency there is increase in values of damping factor (tan δ) and loss modulus. Frequency has direct impact especially at higher temperatures but there is no prominent use of finding results at different frequencies.

4. CONCLUSIONS

Dynamic mechanical properties of asian Palmyra fiber reinforced epoxy composites are greatly dependent on the percentage of fiber loading.

* Dynamic storage modulus (E') is the most important property to know the load bearing capacity of a composite material. The effectiveness of the fiber is better at 40% fiber loading.

* The advancement in properties is observed for composites with 40% fiber loading, which is chosen as the effective fiber loading. At this maximum fiber loading, better stress transfer takes place fibre and matrix.

* Increase in fiber loading decreases the tan δ peak height, which represents the improved fiber/matrix adhesion at higher fiber loading.

*With the increase in frequency there is increase in values of damping factor and loss modulus. There is no prominent use of finding results at different frequencies

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