

Dynamical analysis of Nano filled - Sisal fiber hybrid reinforced composites

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Abstract. In this present work, the nano filled (Multi walled carbon nano tube) glass and sisal fiber reinforced hybrid composites were fabricated with varying the wt. % of MWCNT's by 0%, 0.5% and 1% respectively. Compression molding technique is used to fabricate the composites and are subjected to dynamic analysis over a range of temperature (30-190 °C) at the frequency rate of 5Hz. The effect of temperature and nano filler on storage modulus (E') loss modulus (E'') and damping efficiency ($\tan \delta$) are determined by using dynamic mechanical analyser (DMA). The shear and loss modulus obtained maximum values for 0.5wt.% MWCNT composites. Damping value is higher for 1wt.% MWCNT incorporated composites. By using ultrasonic probe sonicator, nano fillers are mixed in to the epoxy resin to prepare a modified resin. The dynamic properties are evaluated as per as ASTM standards.

1. Introduction

In the recent years many researchers are focused in natural fiber reinforced hybrid composites due their beneficial properties like recycling, biodegradable and environmental friendly. Reubmann, T. Et.al [1] investigated on flax fiber reinforced polypropylene composites, and reported that higher fiber content leads to higher elastic shear modulus (E') and with a $\tan(\delta)$ peak is lower. When increasing the temperature from 23 to 80°C, the E' of 30% FFRP was decreased into 41.8%. Kaiser, J.et.al [2] concluded, when the volume fraction of a filler is increased from 0 to 50% in the epoxy matrix, the storage shear modulus (E') is increased upto 176% and significant improvement have been observed in the damping co efficient ($\tan \delta$). Yuan et al [3] studied on the effect of plasma treatment on enhancing the performance of wood fiber polypropylene composites. It states that dynamic mechanical analysis test of the composites have shown the improvement in the storage modulus after chemical treatment. Significant changes in the results have been observed by varying the frequency during DMA analysis. Jacob et.al [4], Mohamed et.al [5] investigated especially on natural fibers like flax, jute, sisal, banana, etc. They found that reinforced-foamed materials have especially important significance for reduction of density in automobile construction components due to its higher specific stiffness and specific tensile strength. Yuanming X et.al [6] studied on the dynamic mechanical properties of epoxy resin are dependent on the resin system with different monomial components and manufacturing technology.



Martins and Mattoso [7] reported on the dynamic mechanical behaviour of sisal fiber reinforced with tyre rubber. It states that in certain cases, when the fiber was chemically modified and subjected to DMA analysis its indicating the enhancements in the results. Amash et.al [8] have been revealed that outputs of the DMA will vary by changing the input frequencies. They have reported that effectiveness of cellulose fibre is increasing in stiffness and decreasing in damping coefficient. Thermal properties of sisal/glass hybrid composites investigated and concluded that, the addition of glass fibers will improve thermal properties of the glass/sisal comp of alkali treated jute fiber composite. The storage modulus and damping factor were manipulated by the alkali treatment of jute fiber. By swelling reaction it can change the native crystalline structure of the fiber. It can provide the improved interfacial bonding between fiber and matrix frequently. Andrej et al[12]'s investigated and states that the shear modulus increases when the fiber volume fraction upto 42 vol% and the damping coefficient values has been decreased. Further increasing the in the fiber content may leads to decrease the shear modulus.

Mou'ad. A et al [13] results stated that the storage modulus (E') and the loss modulus (E'') has been increased due to the addition of hybrid nano fillers. The OMMT and MWNTs incorporated hybrid composites were compared and concluded that the higher T_g values has been observed in MWCNT incorporated composites rather than OMMT composites.

2. Materials and methods

2.1. Materials

Sisal fibers obtained from Eco Craft, Hosur. Glass fibers, Epoxy resin Araldite LY556 and hardener HY951 obtained from M/s. Suntech fibers Chennai, From M/S US Research Nano materials Inc, USA, the MWCNTs has procured and used as constituents for fabricating the composite.

2.2. Preparation of modified Epoxy resin

MWCNT particles were initially taken by the Wt% of 0%, 0.5% & 1%. Using ultrasonic probe sonicator the MWCNT were dispersed into the epoxy resin without agglomeration. Then the blends are allowed to vibrate for the period of 2hrs using a rotary shaker for homogeneous mixing of MWCNT particles into resin. [14-16].

2.3. Preparation of MWCNT filled composites

In the present investigation, the composites specimens were prepared using compression molding technique. Sisal and glass fibers of 30 X 30 cm size used to fabricate the specimen. The specimens having five layers in which the glass fibers were used in extreme layers in-between sisal and glass fiber have arranged alternatively. The figure (1-3) shows the fabrication of composites using compression molding machine and dynamic mechanical analysis (DMA) of the composites. Figure 4 shows the prepared specimens for DMA testing.



Fig 1. Preparation of composites



Fig 2. Compression molding



Fig 3. Dynamic mechanical analyser

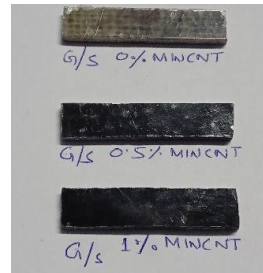


Fig 4. Composite Specimens

Natural fibers are taken from three bases. They are plant, animal and mineral. Fibers from plants are obtained from its stem, leaves, fruits, seeds and roots. In the same way the fibers from animals are extracted from hair, leather, internal organs etc. Mineral fibers are derived from the earth and are pre-treated before usage. Some important natural fibers with their properties and chemical compositions are listed in Table 1.

3. Result and Discussion

Dynamic mechanical analysis is one of the important technique to analyse the modulus of the material as well as structure of the material. The effect of temperature on shear modulus, loss modulus and damping co efficient at the frequency rate of 5Hz for various wt% of MWCNT hybrid composites are discussed below.

3.1. Shear Modulus

The fabricated composites predominantly cutted into a size as per ASTM standard and subjected to dynamic mechanic analysis. The fig (5) shows the effect of temperature on shear modulus for various wt% of MWCNT filled sisal glass fiber reinforced hybrid composites.

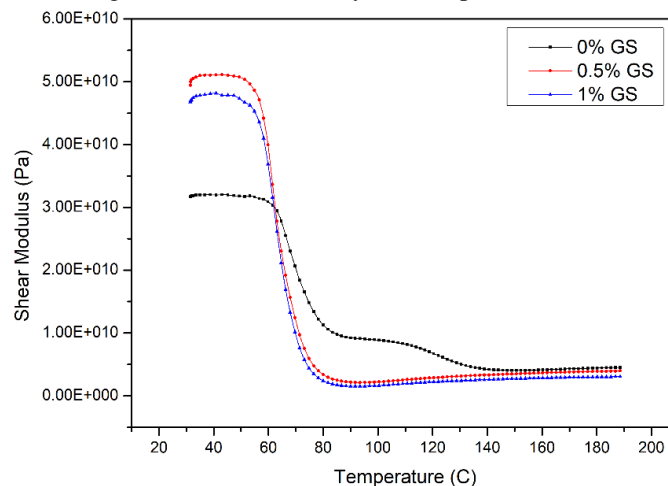


Fig 5. Effect of temperature on the shear modulus of different hybrid samples (frequency 5 Hz).

The shear modulus for 0.5% MWCNT incorporated composites shows the maximum value followed by 1wt% and 0wt% composites. The peak value of each respective specimens is maintained up to 55°C thereafter it's reduced dramatically when the temperature increased up to 90°C due to the molecule motions and interfacial strength bonding between the fibers and matrix. Then the shear modulus is increased slightly while increasing the temperature after 90°C. At minimum temperature the shear modulus for each specimen indicating maximum values due to their stress distribution between the two fibers.

3.2. Loss modulus

The loss modulus curve as shown in the figure (6) and it is the influence of the adhesive materials in the polymer composites. The loss modulus peaks are found to high for 0.5% incorporated MWCNT rather than the 1% and 0% respectively. The prompt rise in the loss modulus indicates an increasing the structural agility of the polymer composites. The maximum peak value of loss modulus indicates the maximum heat dissipation occurred at the temperature which shows the T_g of the system. Also observed incorporation of MWCNT into the matrix, the T_g is shifted to the higher temperature region. Higher wt % of nano fillers agglomerate in the composite may be the reason for reduction in loss modulus. Similar results have been reported by pothan et al.

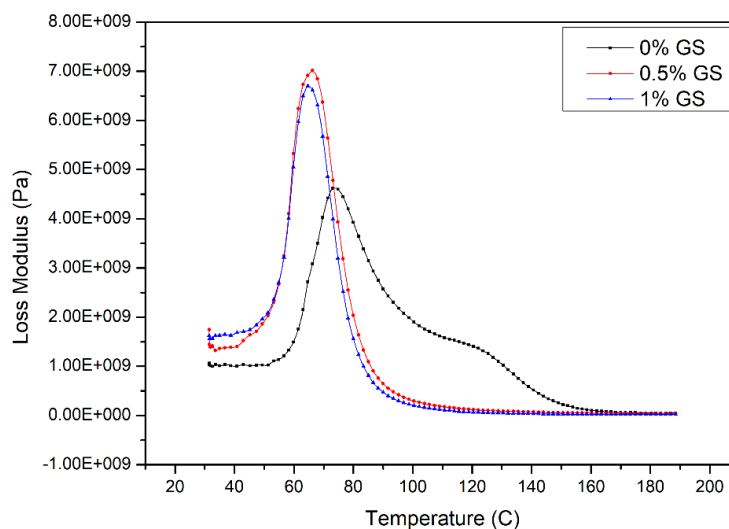


Fig 6. Effect of temperature on the loss modulus of different hybrid samples (frequency 5 Hz).

3.3. Damping coefficient

The ratio of the energy dissipation potential and absorption of the viscous elastic material is represented by $\tan D$. From the figure 7, comparing the various wt% of MWCNT's incorporated composites, 1wt% composites shows the maximum $\tan D$ peak value than the other two composites. The peak value of the 1wt% GS is obtained at 0.73 in 72°C which indicates the material has more energy dissipation potential compared with remaining composites. Also it's steadily decreases up to 120°C and it maintains constantly till 190°C. Due to the strong interactions between the fibre and matrix in which it tends to decrease the mobility of the molecular chains

results in diminishing of damping. The peak values might have been lowered because the amount of polymer due to fibre merging is not fair enough.

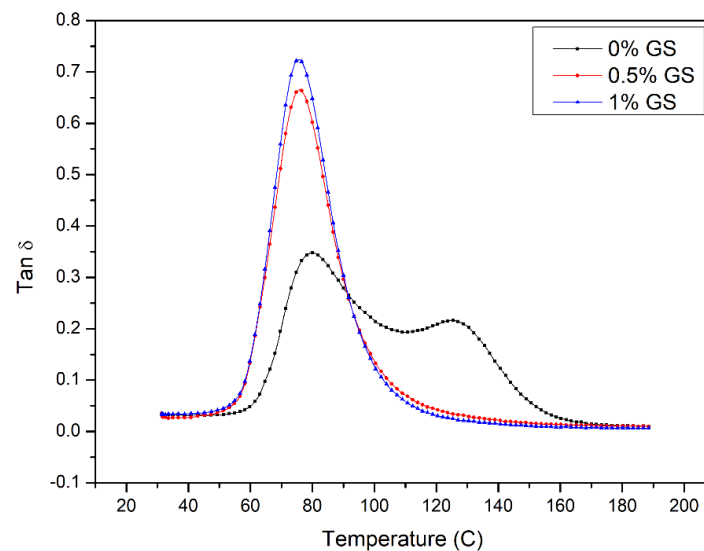


Fig 7. Effect of temperature on the tan D curve of different hybrid samples (frequency 5 Hz).

4. Microstructural analysis

Microstructure of the developed composites incorporated with 1wt.% and 0.5wt.% as shown in the figure 8 and 9. From the SEM images it is clearly observed that uniform dispersion of MWCNT into the epoxy resin. Hence the ultrasonic probe sonicator process is suitable for dispersing the nano fillers into the matrix. Also well interfacial bonding between the matrix and fibers are confirmed from the SEM images. Pulled out fibers and fiber breakages were identified during the deformation.

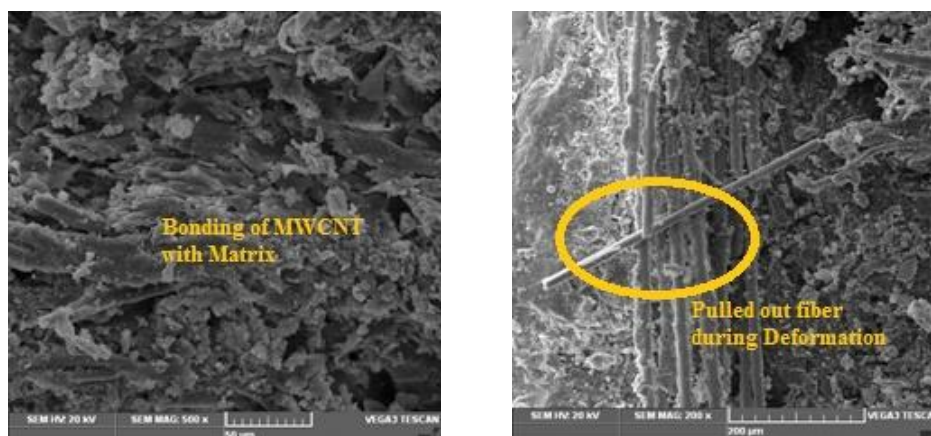


Fig 8. SEM micrographs for 1 Wt.% MWCNT incorporated composites

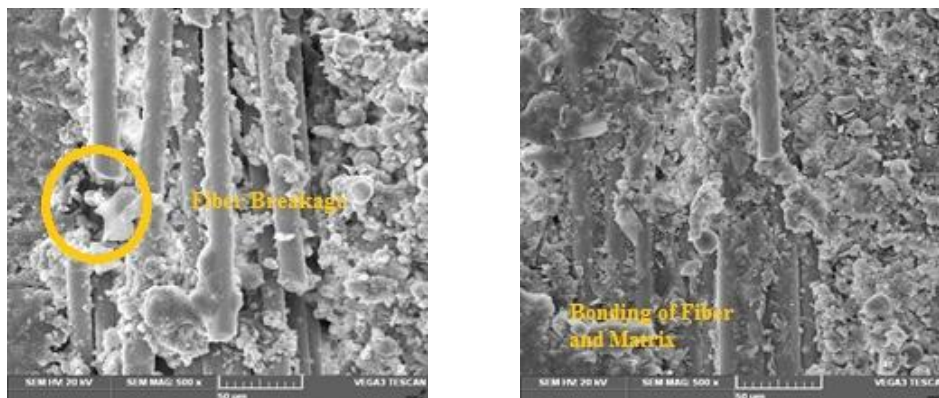


Fig 9. SEM micrographs for 0.5 Wt. % MWCNT incorporated composites

5. Conclusions

- The addition of nano fillers increase the storage modulus up to 0.5wt.% MWCNT. Further increasing with the nano fillers leads to reduce the storage modulus. It's may be due to agglomeration of nano fillers in the composites. In this work, storage modulus of 0.5wt% G/S composites shows vast improvement comparing other composites. Due to the agglomeration of MWCNT's leads to decrease in properties.
- The loss modulus for 0.5wt% MWCNT incorporated composites shows the highest value due to the maximum heat released at the peak value of Tg for further addition of the nano fillers leads the Tg values negative which indicates lower in the loss modulus.
- Higher damping value is obtained for 1%MWCNT incorporated composite rather than other Composites. Increasing the nano filler content improves the damping which indicates the damping characteristics of the nano filled polymer system.
- The micro structural analysis clearly shows that, presence of the MWCNT's in the composites which is dispersed in to the epoxy resin. Also the bonding between fibers and matrix and pulled out fibers during deformation were identified in the composites.

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