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Jute/Kevlar Epoxy Nanocomposites: Effect of Clay Treatment on Dynamic Mechanical Properties

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Abstract: *The morphology and dynamic mechanical properties of jute/Kevlar epoxy nanocomposites are depicted. 3mm thickened laminates made of jute and Kevlar layers were manufactured by utilizing montmorillonite (nanoclay) which is at 3wt% blended with the epoxy (matrix material) in the mechanical stirrer at the rate of 500 RPM amid creation. The laminates so acquired were exposed to the dynamic mechanical thermal analysis at a fixed recurrence of 1 Hz over a temperature scope of 30 – 180°C. The volume portion of fibers ran somewhere in the range of 0.21 and 0.25. The fortifying impact for the two fibers were in the substitute request for the laminates L2, L3 and L4 when contrasted with the laminate L1 comprising of jute layers. The laminates comprising of shifting layers of Kevlar demonstrated higher storage modulus, loss modulus and glass transition temperature than that of jute-strengthened composites which showed more flexible conduct. The tan delta demonstrated the solid impact of the fiber content. Odd patterns in temperature fluctuation of the loss modulus, damping parameter (tan δ) and in the glass transition temperature (Tg) and four distinctive hybrid composites are deciphered and comprehended.*

Keywords: *Jute, Kevlar, montmorillonite, epoxy, storage modulus, loss modulus, tan delta, glass transition temperature*

I. Introduction

Polyester resin is being used for some analysts for applications in numerous fields. Its properties have expanded in the wake of strengthening strands and fillers into it. Common strands increases have enhanced its properties from numerous points of view. Bagasse[1], pineapple leaf fibre[2], cotton/kapok fibre[3], jute[4], coconut[5], glass fibre[6] have been strengthened in polyester and numerous properties have been considered. New strategies and advancements are additionally talked about as far as common strands examining their mechanical and interfacing properties. [1-6]. Composite materials of diff erent varieties were acquainted for diff erent applications with decrease the weight and cost. The fiber-fortified polymer materials have been more noticeable than different types of composites because of high quality and stiff ness in the fibrous frame. Strands are believed to be the most eff ective support stages for polymer materials and the fiber-fortified composite materials dependably demonstrate high mechanical execution. Kevlar fibers, particularly, indicate unrivaled properties, for example, higher Young's modulus, better quality, better thermal conductivity and more amazing electrical properties than different fibers. Along these lines, Kevlar fibers are at present the most widely utilized reinforcement for composites in light of their accessibility and unwavering quality [7]. As of late, more prominent accentuation has been rendered in the improvement of fiber-filled composites dependent on normal fibers with a view to supplant glass fibers either exclusively or to some degree for different applications. The degree for utilizing jute fiber instead of the customary glass fibers comes from the lower specific gravity and functional specific modulus of the jute fiber contrasted with those of glass fiber. Additionally, the much lower cost and the sustainable nature make it an appealing fiber for use as a strengthening material in the fiber-filled composite. Disregarding the different attractive properties of the jute fiber to go about as a fortifying material, its business usage in the fiber-filled composite has not increased much achievement. With DMA, the glass transition temperature can be found. The Dynamic Mechanical Analysis (DMA) performed on a material furnishes critical data of material conduct concerning the Modulus variety with the temperature. DMA test gives more knowledge on mechanical modulus and temperature dependant conduct. The distortion connected on the sample in a cyclic way and the DMA results are recorded in type of chart. At the point when an oscillatory power is connected on the sample, the adjustments in firmness and Damping is recorded. The storage modulus, loss modulus and tan delta esteems give subtle elements of modulus data, mechanical properties in recurrence extend, touchy glass progress temperature, Curing responses, effect of fillers and association of the fillers and network in different conditions [8-15]. Dynamic mechanical tests, when all is said in done, give more data about a composite material than different tests. Dynamic tests, over an extensive variety of temperature and recurrence, are particularly delicate to a wide range of advances and unwinding procedure of matrix resin and furthermore to the morphology of the composites. Dynamic mechanical investigation (DMA) is a touchy and adaptable thermal analysis system, which estimates the modulus (solidness) and damping properties (vitality dispersal) of materials as the materials are distorted under intermittent pressure. DMA additionally gives solid data about the T_g of a fiber filled composite. The goal of the present article is to think about the impact of nanoclay on the jute/Kevlar blend for enhancing its reasonableness as strengthening material in the epoxy based composite by utilizing the dynamic mechanical thermal examination.

II. Experimental Details

In present invstigation the jute and Kevlar filaments are utilized for manufacturing the composite sample with epoxy as the matrix and nanoclay as filler. The jute is acquired from jute cottage, indiranagara, Bengaluru. Kevlar is acquired from hindoostan Mumbai. The epoxy resin i.e. diglycidyl ether of bisphenol is acquired from near by source and the hardener utilized is araldite L556, nanoclay (montmorillonite) is gotten from sigma Aldrich organisation, Bengaluru.

The base resin was warmed in the oil shower, kept up at the consistent temperature of 60℃. Nanoclay at 3 %wt was added gradually to the resin and afterward blending was done mechanically for two hours. In the wake of mixing, modified epoxy arrangement was blended with the hardener and mixing up to 20 mins was finished. At last, the blend was connected to the fibre sheet on the two sides utilizing hand lay up and left over night for drying. The laminas were restored under surrounding temperature to get the shape as that of a pit. Finally the samples were cut according to ASTM principles. The laminates along with the designations are shown in the **Table 1**.

In this study, jute/Kevlar reinforced polymer hybrid nanocomposite will be investigated by machining the specimens by means of water jet cutter to the required dimension as per ASTM:D 7028 standard (sample dimension is 45x5x3 mm^3) to regulate the storage modulus, loss modulus, damping factor and glass transition temperature (T_g).

Table 1: Laminate designations with nanoclay

Laminates	***Nanoclay***	***Compositions***
L5	*3wt%*	*J+J+J+J*
L6	*3wt%*	*J+J+K+J+J*
L7	*3wt%*	*J+K+J+K+J+K+J*
L8	*3wt%*	*J+K+K+J+K+J+K+K+J*

A. Testing and Evaluation

The model is Eplexor 500 N with software Eplexor Ver 8. The load capacity force range is 500 N. The frequency range is 1 Hz at the temperature ramp of 3°C for the temperature range of 30°C to 150°C. The clamping device used to be 3-point bending. A typical D.M.A. apparatus consisting of grips to clamp the sample well and then inserted in the chamber is shown in **Fig 1.** The mounted sample is put in a thermal chamber. The analyzer applies torsional wavering to the test while gradually traveling through the settled temperature go. The test was conducted in the Department of Materials Science Engg, I.I.Sc, Bengaluru.

Fig 1: D.M.A. Apparatus

III. Results And Discussion

DMA is a system, which is utilized to think about the stress, temperature and recurrence of the material when it is exposed to little twisting by sinusoidal load. In polymers, the DMA is delicate method to gauge the fine changes. DMA measures the stiffness and damping regarding modulus and tan delta. The dynamic mechanical properties, for sample, the storage modulus, loss modulus and tan delta with the reaction of temperature of the samples L5, L6, L7 and L8 were appeared in **Figures 2** to **4** respectively. At the point when the temperature was expanded slowly, the sample was less hard in glass transition region, which prompted less storage modulus and tan pinnacles. The aftereffects of DMA are appeared in **Table 2**. The correlations of properties of glass transition temperature (T_g), storage modulus and tan delta are appeared in **Figures 5** to **7**. The DMA is just the way to deal with measure the glass transition temperature of the composite with a thermoset resin and high fiber volume divisions. The glass transition temperature which is accounted for in this investigation is from the pinnacle of loss modulus bend. The glass transition temperature (T_g, i.e. pinnacle of loss modulus bend) of the L6 is 82.1°C and it demonstrates the expansion of temperature up to 14% than the plain jute in the laminate L5. In like manner the laminate L7 having T_g of 97.5°C demonstrated the temperature incline of 18.75% and the laminate L8 had the T_g of 107.2°C demonstrated the temperature increment of 10% when contrasted with the laminate L7. The much enhanced moduli of the three laminates which comprised of changing layers of Kevlar may be because of the more prominent interfacial bond quality between the matrix resin and the fiber. The hydrophilic idea of the jute initiates poor wettability and adesion charecteristics with the epoxy resin and the nearness of the dampness at the jute matrix interface advances the development of voids at the interface. In this way the nearness of dampness and the voids at the interface debilitate the bonds and create composite of lower firmness and quality. The nearness of dampness in the framework may result in the dispersion of barometrical dampness through the matrix on consequent maturing. These were watched and gotten by the move of the pinnacle of loss modulus bends to the right in **Figures 2** to **4** of the jute/Kevlar epoxy nanocomposites and correlation of T_g was featured in **Fig 6.** The pinnacle of tan bends to right side and the move in abatement patterns and advances are in wide range. This wide progress proposes thermal corruption of the material, which features the T_g. The storage modulus of the laminates L6, L7 and L8, which demonstrated expanded patterns than that of unadulterated jute in the laminate L5, was seen from the outcome appeared in **Fig 5**, in this way the relating loss modulus was expanded with expanding of nanoclay filler stacking. The proportion of loss modulus to storage modulus, which is known as tan delta or regularly called as damping factor, is appeared in **Fig 7**. The damping was decreased with the presence of nanoclay particles with jute/Kevlar hybrid composites. The expanding patterns of storage modulus and loss modulus of the laminates from L5 to L8 nanoclay filled jute/Kevlar hybrid composites demonstrated the better interfacial security between the nanoclay particles with jute/Kevlar reinforcement and epoxy matrix. The expansion of Tg with the expansion of nanoclay to the jute/Kevlar laminate composites signified the better thermal opposition and dimensional soundness of the composite.

Table 2: DMA Results of the jute/ Kevlar Hybrid Nanocomposites

Laminate	Storage Modulus (GPa)	T_g (°C)	Tan □
L5	*7.53E+08*	*71.9*	*0.08*
L6	*2.32E+09*	*82.1*	*0.14*
L7	*2.59E+09*	*97.5*	*0.25*
L8	*2.64E+09*	*107.2*	*0.27*

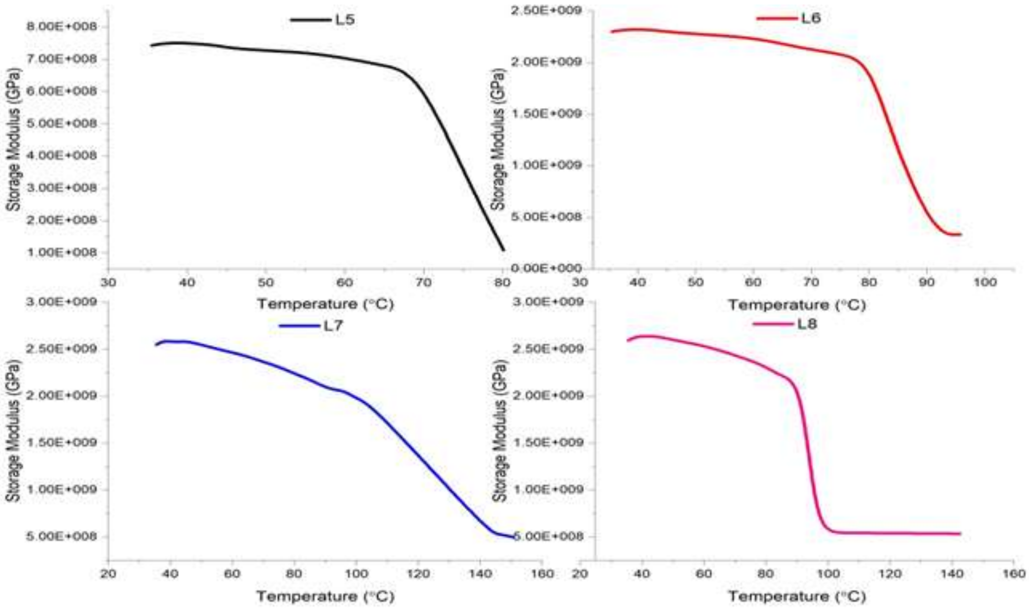

Fig 2: Storage Modulus vs. Temperature

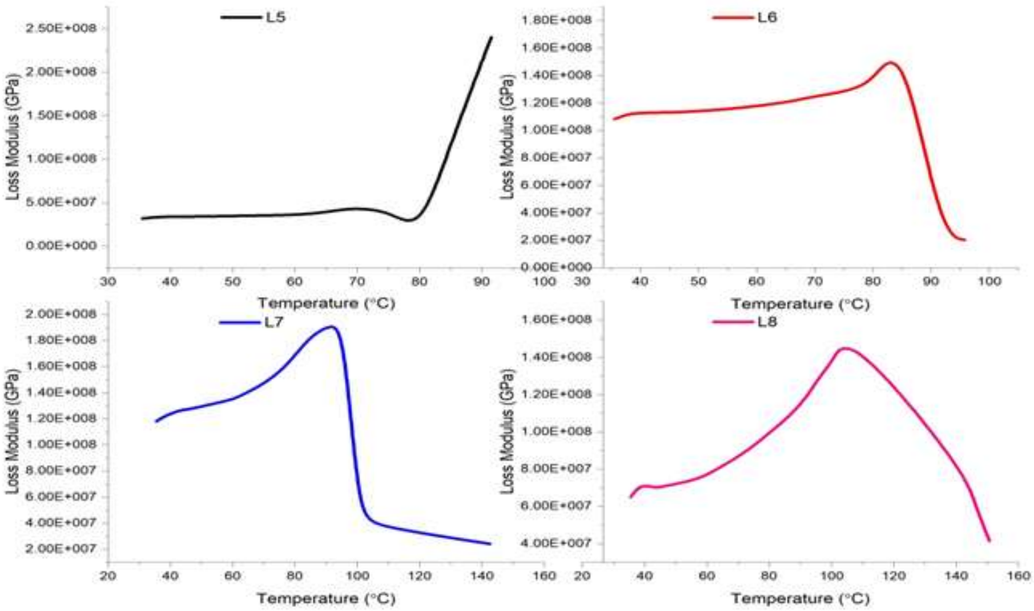

Fig 3: Loss Modulus vs. Temperature

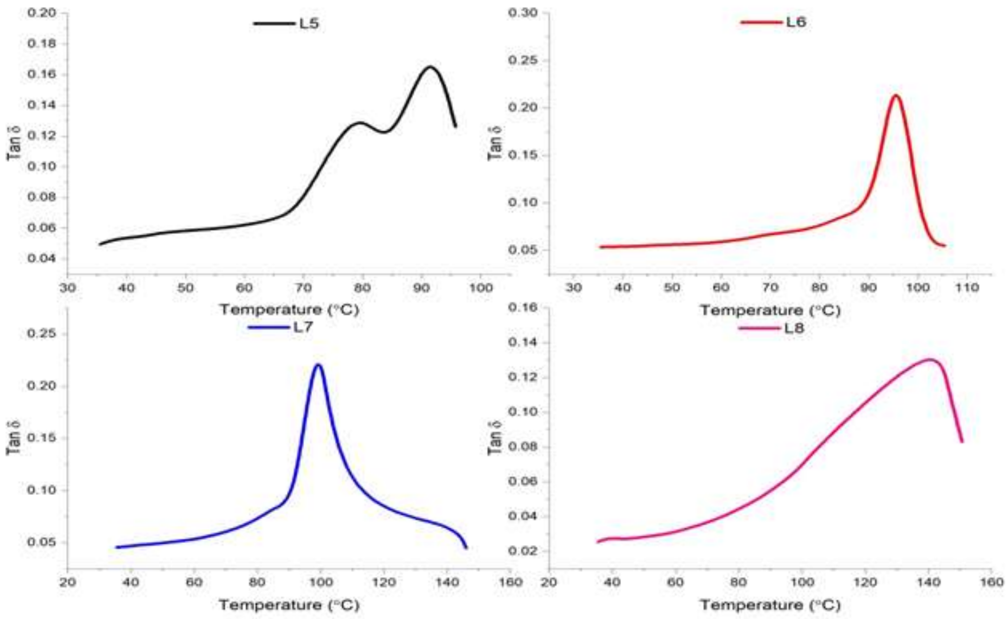

Fig 4: Tan Delta vs. Temperature

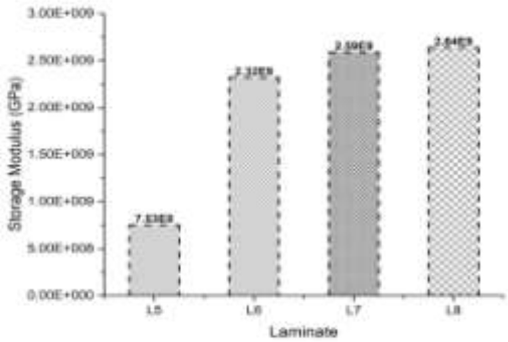

Fig 5: Storage Modulus vs. Laminates

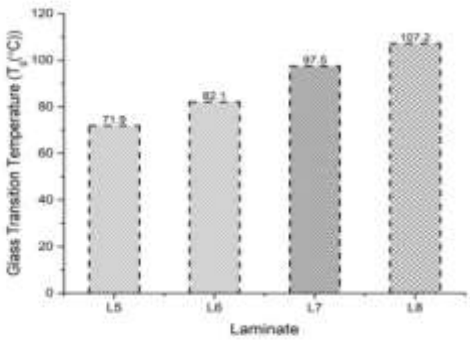

Fig 6: Glass Transition Temperature vs. Laminate

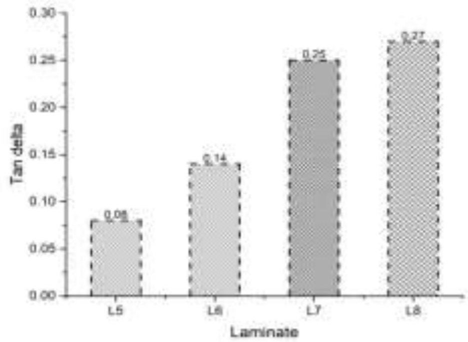

Fig 7: Tan Delta vs. Laminate

Scanning Electron Microscopy (S.E.M.) Analysis:

SEM analysis was performed in the BMS college of Engg for the laminates and the clear images were selected and are shown in the **Fig 8.** The layers of Kevlar included laminate has demonstrated the great maintenance of resin on broken fiber closes, while an unadulterated jute nanocomposites in the laminate L5 demonstrates the openings in the matrix. In this way the sign of the better fiber-matrix holding on account of jute/Kevlar hybrid nanocomposites is additionally bolstered by scanning electron microscopy study.

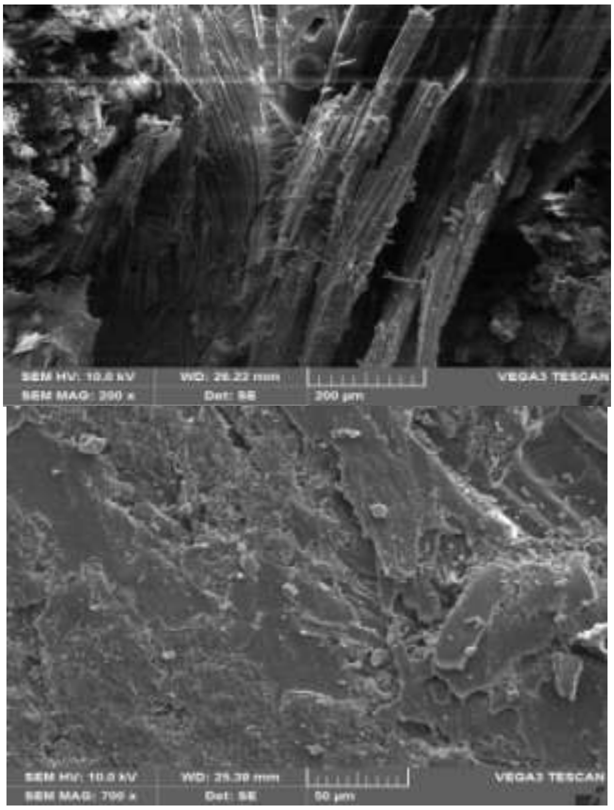

Fig 8: Scanning electron micrographs of the fractured surfaces of the (a) pure jute nanocomposite laminate (b) Jute/ Kevlar nanocomposite laminate.

IV. Conclusions

The unadulterated jute hybrid nanocomposite laminate and jute/Kevlar nanocomposite lamiantes were set up with the expansion of shifting layers of Kevlar and their dynamic mechanical properties were contemplated and contrasted with the unadulterated jute nanocomposite laminates. The accompanying ends could be drawn from the consequences of the present examination

1. The thermal security and the visco-elastic properties of the jute/Kevlar hybrid nanocomposites were planned and contrasted with the unadulterated jute nanocomposite laminates.
2. All composites had the storage modulus, loss modulus and mechanical loss factor i.e. damping values higher than those of the unadulterated jute nanocomposite laminates. The characteristic fiber filled epoxy laminate act more flexibly than their other partner. Composites laminates containing layers of changing Kevlar i.e. L6, L7 and L8 displayed most elevated storage modulus esteems individually demonstrating better proficiency. Among various composite definitions, the damping was most reduced for the laminate L1 everywhere throughout the considered temperature extend as it was more flexible in nature. The impact of the fiber content was wonderful both on expanding the firmness and on diminishing the damping in the composite frameworks.
3. It is conceivable to deliver considerably stiffer and more grounded jute hybrid nanocomposite laminate by the expansion of more number of Kevlar to change over them to the hybrid composite.
4. The change that is the tan δ peak, is moved to the higher temperature as the measure of fiber stacking increments.
5. The glass transition temperatures (Tg) of the laminates were expanded with the expansion of the layer of Kevlar.
6. The scanning electron micrographs of the crack surface of the laminate uncover the enhanced holding at the interface between the jute/Kevlar fiber and the epoxy resin.

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