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Fabrication and Characterization of Kenaf/Cocos Nucifera Sheath Reinforced CNT Modified Epoxy Composites

Mega Ramesh, Melvin Akash A, Nithin Jacob F
Guided by: Mr. E. Sathish, M.E.,
Department of Mechanical Engineering,
Loyola Icam College of Engineering and Technology

***Abstract*— As the world population continues to grow, so does the amount of garbage that people produce. On the go lifestyle requires easily disposable products , such as soda cans or bottles of water, but the accumulation of these products has led to increase amounts of plastics pollution around the world .As plastics is composed of major toxic pollutants, it has the potential to cause significant harm to the environment in the form of air , water, and land pollution.**

Hence we are going to reduce the usage of plastics by replacing it with the natural fiber. The fibers used are kenaf fiber , cocosnucifera sheath and carbon nano particles using various chemical treatment for the fiber and by having different composition. The kenaf fiber is chosen since it is available in large amount and the fiber obtained is twice the amount of jute , cotton etc. and the tensile strength is more in this fiber . And the cocosnucifera sheath also has higher mechanical strengths . the kenaf fiber is treated with NaOH chemical to further increase its strength. and both the fibers are reinforced with epoxy resin which is mixed with carbon nano tube particles which will again increase the strength of the composite . thus the composite is strong enough and can be used to replace the plastics.

Keywords:- Pollution, Replace plastic, Natural fiber, Chemical treatment

I. INTRODUCTION

Synthetic fiber reinforced polymeric composites offer many advantages such as higher specific strength, stiffness, corrosion resistance and enhanced fatigue properties compared to conventional metallic materials. Kenaf fiber based polymeric composites are widely used in ballistic applications due to its ability to resist high kinetic energy projectiles. Even though these aramid fibre composites having higher specific strength, impact strength and corrosion resistance most of the fibres are manufactured from petroleum based resources (Liu and Strano, 2016) . Depletion of petroleum based resources urges the researchers to find a sustainable replacement. Moreover, disposal of Kenaf releases enormous amount of carbon dioxide which pollutes the environment (Wambua et al., 2003). Hence, it is imperative to find an alternate material to man-made Kenaf fabric for armour applications. In addition, usage of Kenaf fabric increases the overall fabrication and product cost (Joshi et al., 2004).

Currently, natural fiber reinforced polymer composites are efficiently employed in automotive (Holbery and Houston, 2006), packaging (Chaudhary et al., 2010), insulation (Zhou et al., 2010), sound absorbing panels (Fouladi et al., 2010) and in construction sectors (Ali et al., 2012) . The possibility of utilizing natural fibers for ballistic applications were explored (Benzait and Trabzon, 2018b). It has been found that plant fibers or natural fibers can act as an alternative and sustainable replacement to synthetic fibers. The merits of using plant fibers encouraged many researchers to utilize natural fiber for ballistic applications (Wambua et al., 2007). Fibers extracted from natural resources are eco friendly and biodegradable. Also, natural fibers are abundantly available, inexpensive,light weight,non abrasive and holds higher specific strength and stiffness (Joshi et al., 2004).

II. NATURAL FIBERS AND ITS COMPOSITES

Generally, the natural fiber comprises of different natural chemicals such as cellulose, hemicellulose, lignin, pectin and wax. The percentage of individual natural chemical varies with different natural fiber. However, same natural fibers harvested in different regions and environmental conditions may have different chemical compositions (Mohammed et al., 2015). Each natural chemical is responsible for different properties. Cellulose is a crystalline or semi crystalline polysaccharide. Hydrophilic nature of the plant fiber mainly depends upon the cellulose content. Hemicellulose is amorphous in nature and the molecular weight is lower than cellulose. Amorphous hemicellulose has led to partial solubility in alkaline solution and water (Bledzki and Gassan, 1999). The lignin also amorphous in nature and comprised of aromatics. Moreover, it act a natural binder. The main function of pectin is to hold the micro fibrils together in the natural fiber (Saheb and Jog, 1999).

Based on the origin, natural fibers were categorised into plant fiber, animal fiber and mineral fiber . The plant fiber or cellulosic or lignocellulosic fibers were further classified into bast, leaf, sead, wood and grass fibers. The detailed classifications and example for each type of natural fiber has been shown in figure.

III. CARBON NANO TUBE (CNT) BASED POLYMERIC COMPOSITE

The performance of FRP composites could be improved with different nano fillers. The most commonly used nano fillers are nano clay, carbon nanotube (CNT), silicon carbide and carbon nano fibers (Hossain et al., 2016). Among these fillers CNT exhibited higher strength, stiffness, aspect ratio and specific surface area (Geng et al., 2008, Spitalsky et al., 2010, Hong et al., 2007) . Besides its advantages, the major impediment of using CNT is higher production cost which affects the mass production of CNT filled nanocomposites (Spitalsky et al., 2010). Researchers found that CNT act as potential reinforcement in the polymeric composites (Hossain et al., 2016). This is mainly due to its higher mechanical properties, thermal stability, chemical resistance and (Wang et al., 2016b)

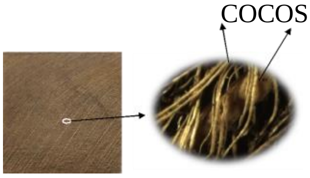
The CNT could efficiently transfer the stress and improves the load carrying capability due to large specific surface area. At an optimal CNT loading in the polymeric composites enhanced the mechanical, dynamic mechanical thermal and electrical properties of polymer (Wang et al., 2015). CNT is widely used as a nano filler in polymeric nano composites for advanced applications such as super capacitors, batteries, lubricants, defense, and sensors (Stankovich et al., 2006, Ramanathan et al., 2008, Park and Ruoff, 2009). Researchers reported that graphene based nano composites showed higher strength and stiffness compared to clay or carbon filler based nano composites (Eda and Chhowalla, 2009, Liang et al., 2009).

IV. COCOS NUCIFERA SHEATH :

The Cocos nucifera sheath is a naturally woven material which contains core and outer fibers .Generally, the diameter of core fiber is higher than the outer fiber . Figure 3.2 shows the naturally woven Cocos nucifera sheath .The weaving nature of the Cocos nucifera sheath is that the outer fibers are randomly interlaced around the core fiber. Chemical composition, mechanical and physical properties of the Cocos nucifera sheath are listed in the in Table 3.1. The average density of Cocos nucifera sheath is 1.37-1.50 g/cm3.The Cocos nucifera sheath is aa agrowaste which is available everywhere. The Cocos nucifera sheaths were collected manually from Serikembangan ,Malaysia. The Cocos nucifera sheath wastes were collected manually from the coconut tree. The sheaths were immersed in the water for 1 week and then they were thoroughly washed with both tap water and distilled water. After complete removal of debrises the sheaths were dried in the hot sun for 1 week. Finally, the sheaths were cut into the required size for fabrication.

The aramid fibre utilized in this study is Kenaf 29 . The properties of Kenaf 29 fabric were taken from the suppliers data which are listed in the Table 3.2. Figure 3.3 shows the 2D plain Kenaf 29 fabric with warp and fill. The matrix used in this study was D.E.R.331 liquid epoxy resin with joint amine type (905-3S) curing agent supplied by TAZDIQ Engineering Sdn. Bhd. (Selangor, Malaysia). The density of the epoxy matrix is 1.08 g/cm^3

COCOS NUCIFERA



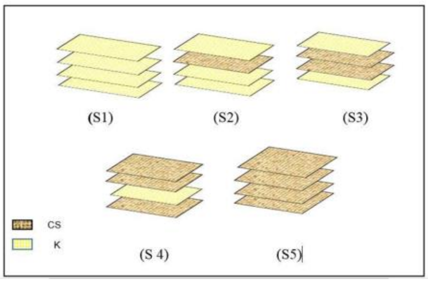
a. *Extraction of naturally woven Cocos nucifera sheath*

The Cocos nucifera sheath wastes were collected manually from the coconut tree. The sheaths were immersed in the water for 1 week and then they were thoroughly washed with both tap water and distilled water. After complete removal of debrises the sheaths were dried in the hot sun for 1 week. Finally, the sheaths were cut into the required size for fabrication.

Figure shows the Cocos nucifera sheath extraction process.

V. KENAF FIBER

Natural fibers were presented with the intention of yielding lighter composites, together with lower costs lower density as compared to the glass fiber, which confirms the production of lighter composites (Abdul Khalil et al., 2008). Various conventional petroleum based polymers are used widely with natural fibers such as jute, bamboo, banana, hemp, sisal, coir, wood, kenaf etc., (Akil et al., 2011). Recently, the rapidly expanding use of composite components in automotive, construction, sports and leisure, and other mass production industries, has been focused on sus-tainable and renewable reinforced composites (Azwa and Yousif, 2013). Among all natural fibers, kenaf fibers have received much attention in the composite industry due to its potential as polymer reinforcements. Kenaf fibers are becoming increasingly popular in Malaysia as one of the natural materials may contribute to the development of environmental friendly resources for the automotive, food packaging, furniture and sports industries. In recent times, it has been used as an alternative to wood in pulp and paper industries in order to help preserve forests, and as non-woven mats, it has been applied in industries such as automotive, textiles, and fiberboards. In the composite industry, mature kenaf fiber have been employed as fiber reinforcements to various matrices. Studies have shown that the addition of kenaf fibers have improved the mechanical properties of neat polymers (Azwa and Yousif, 2013). Kenaf fiber is extracted from the bast of the annual fast growing plant named Hibiscus cannabinus. The main constituents of kenaf are cellulose (45–57 wt%), hemicelluloses (21.5 wt%), lignin (8–13 wt%), and pectin (3–5 wt%).



Stacking sequence of laminates

a. Silane Treatment :

Silane is used as coupling agents to allow natural fiber to adhere to a polymer matrix, thus stabilizing the composite material. Silane coupling agents may reduce the number of cellulose hydroxyl groups in the fiber–matrix interface. In the presence of moisture, the hydrolysable alkoxy group leads to the formation of silanols. The silanol then reacts with the hydroxyl group of the fiber, forming stable covalent bonds to the cell wall that are chemisorbed onto the fiber surface. The reaction schemes are given as:

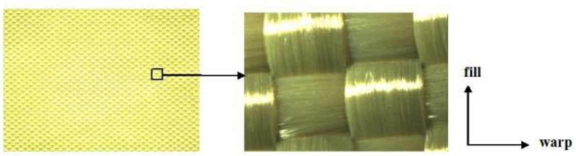
Kenaf Fiber—OH þ R—Si ðOHÞ$_3$-Fiber—O—Si ðOHÞ$_2$—R

Silane treatment has been introduced to kenaf fiber by previous researchers over the past few years (Huda et al., 2008). Magnificent results were recorded for treated composites, in terms of interfacial adhesion between kenaf filler and the polymer matrix.

VI. FABRICATION OF COMPOSITES

Laminated hybrid composites were fabricated by using simple hand lay-up method followed by hot pressing. A wooden mould of dimensions 200× 200 × 3 mm^3 was used. The mould was first cleaned and applied with a releasing agent (Silicone spray) to prevent the adhesion of laminated composites with the wooden mould. After curing it improved the surface finish of the composites. Epoxy resin and the curing agent were mixed for 15 minutes with 2:1 ratio respectively. The overall fiber/matrix weight ratio was kept as 45/55.

The laminated composites were fabricated with different Kenaf/ Cocos nucifera sheath fiber weight ratios such as S1 (100/0), S2 (75/25), S3 (50/50), S4 (25/75) and S5 (0/100).



Symbol	Stacking Sequence	Weight (Wt. %)	Percentage
		K	CS
S1	K/K/K/K	100	0
S2	K/CS/K/K	75	25
S3	K/CS/CS/K	50	50
S4	CS/CS/K/CS	25	75
S5	CS/CS/CS/CS	0	100

K-Kenaf; CS-Cocos nucifera sheath

VII. TENSILE TESTING

Tensile test was conducted as per ASTM D 3039 standards. The specimens for tensile testing were cut from the laminated composites using band saw with a sample size of 120mm×20mm ×3mm. Accurate surface finishing could be obtained using emery paper. Tensile strength and modulus were measured by using an INSTRON 5566 Universal Testing machine. The magnitude of load and the rate of loading were 10 kN and 5 mm/min. In each group five identical test samples were tested and the mean value has been tabulated.

Fig 6.1: Tensile test set-up

Flexural Testing

The flexural test was carried out according to ASTM D 790 with a specimen size of 120mm×20mm ×3mm through three point bending test using an INSTRON 5566 Universal Testing machine (UTM). The standard span to depth ratio of 16:1 was considered. The magnitude of load and the rate of loading were 10 kN and 2 mm/min. Five identical samples were tested for each layering sequence and the average results were reported.

Fig. 6.2: Flexural test setup machine

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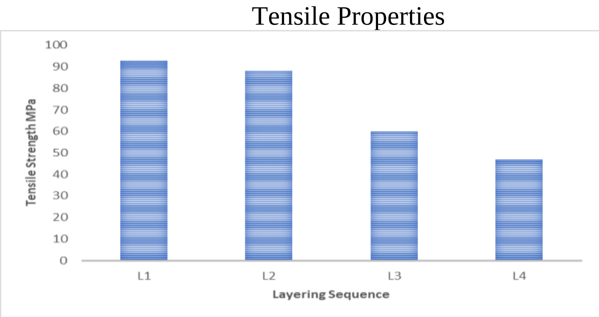
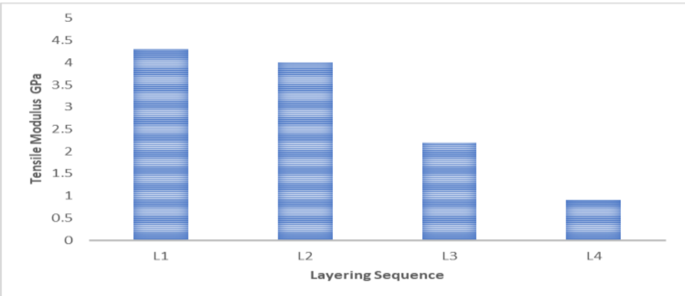
VIII. RESULTS AND DISCUSSION



Tensile Strength of Kenaf/Coconut sheath/CNT epoxy composites

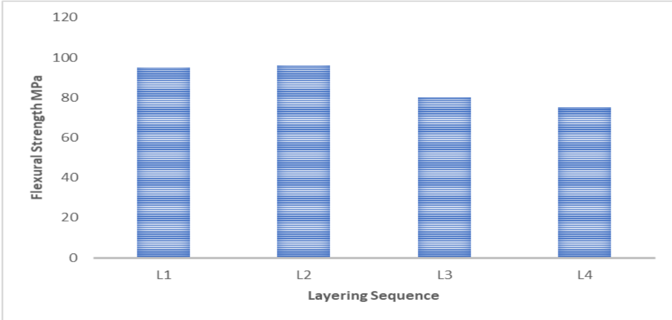
Tensile properties of the laminated composite are mainly depending on the fibre strength, modulus, adhesion between the fibre and matrix, fibre geometry and the type of weave. Fig. 7.1 shows the tensile strength and modulus of different laminated composites. Pure Kenaf fabric/CNT/epoxy polymer composites (L1) exhibited maximum tensile strength and modulus among the five different laminates. This is because of the tensile properties of kenaf single fibre is much higher than the Cocos nucifera sheath single fibre. Replacement of Kenaf with 25 wt.% of Cocos nucifera sheath (L2) reduces the tensile strength by only 5%. Similar results were observed in case of tensile modulus. Hence, the High performance non available Kenaf fibre can be replaced with naturally woven agro waste (coconut sheath) for non-load bearing applications such as automotive and aircraft interior components.



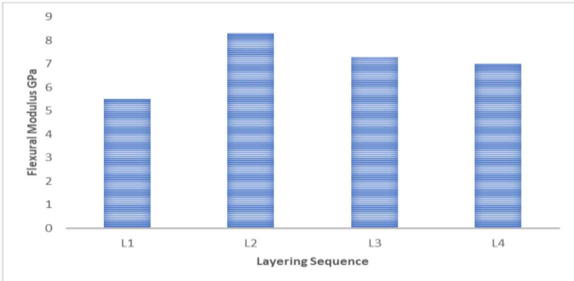
Tensile modulus of Kenaf/Coconut sheath/CNT epoxy composites

Flexural properties

The flexural property is specifically important among the mechanical properties because bending induces combination of different stresses consisting of compressive and tensile, i.e. top layer of the hybrid composite is subjected to compression while the bottom layer is in tension. The position of the woven layers and fibre properties plays a vital role to improve the flexural properties of the laminated composites . The flexural strength and modulus of different layering sequence are shown and compared in Fig. 7.3 and 7.4. Interestingly, it was found that the hybrid laminate L2 possess the highest flexural strength (96 MPa) and flexural modulus (8.3 GPa) than pure kenaf fabric (L1) reinforced epoxy composites. This is mainly be due to the dense, tight fibre architecture and higher lignin content of Cocos nucifera sheath compared to other natural fibres. Lignin act as a chemical bond in the natural fibres. Higher lignin content of the Cocos nucifera sheath improved the bending resistance of the L2 composites. The increase in flexural properties of hybrid woven composites (L2) is also because of the combined advantage of its 2D plain architecture of kenaf fabric, dense architecture of Cocos nucifera sheath.



Flexural Strength of Kenaf/Coconut sheath/CNT epoxy composites



Flexural modulus of Kenaf/Coconut sheath/CNT epoxy composites

Impact Properties

Izod's impact test was conducted to investigate the effect of cocos-nucifera sheath hybridization on the impact energy absorption capability of kenaf fabric reinforced CNT mofdified epoxy composites. The absorbed energy is the amount of energy required to fracture the specimen completely. Impact strength of the material is the most important factor in case of armour applications. The material which is having highest impact toughness can efficiently dissipate the kinetic energy of the projectile rapidly away from the impact zone. Moreover, in the fibre reinforced polymer composites the moderate fibre/matrix bonding is essential to achieve higher energy absorption.

The results from the Izod's impact test of hybrid Kenaf/Cocos nucifera sheath reinforced CNTepoxy polymer composites are shown in Fig. 9. The impact toughness of the L1 laminates possess the highest impact toughness among the laminates. Addition of Cocos nucifera sheath with the kenaf fabric reinforced epoxy composites declined the impact toughness only by 4.4%. Both L3 and L4 laminates showed almost similar impact toughness.

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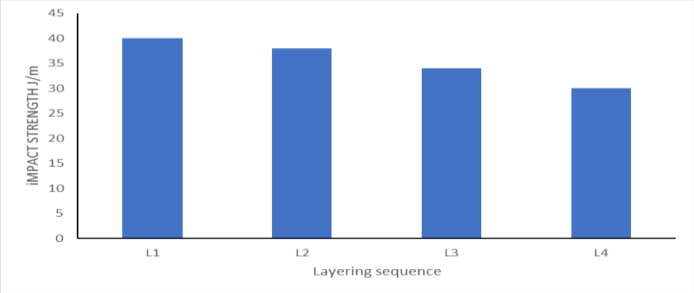

Impact Strength of Kenaf/Coconut sheath/CNT epoxy composites

CONCLUSION

Research on kenaf fibre reinforced composite is generating increased attention due to its excellent properties and ecological considerations. The aforementioned topics are aimed at bringing scientists to look at the potential of kenaf fibre as an alternative medium to replace conventional materials or synthetic fibres as reinforcement in composites. Processing techniques for kenaf fibre reinforced composite are well documented and many of their main properties have been studied. In general, the use of kenaf fibre reinforced composite can help to generate jobs in both rural and urban areas; in addition to helping to reduce waste, and thus, contributing to a healthier environment. However, looking at future demands, more crucial studies are required on product commercialization and manufacturing processes, especially for large scale end products. So hence we developed a new layer test specimen composite by using fibre reinforced sandwich layer formation method. We use new combination (kenaf fibre and cocos nucifera sheath in order to improve the replaced properties of already existing fibre systems in mean of providing different layouts. Hence here we find out tensile, compressive strength test and flexural test to evaluate with their properties and characteristics.

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