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Epoxy/Wood Apple Shell Particulate Composite With Improved Mechanical Properties

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ABSTRACT
Recently there has been a great interest in the industrial applications of composites developed from natural fibers, bio or industrial waste. Present work is an attempt to synthesize composites using a bio waste material i.e. wood apple shell. Composites with 10, 20 and 30 wt % wood apple shell particulate reinforced epoxy composites have been synthesized using Hand layup technique. Mechanical properties have been investigated in detail. Considerable increase in tensile strength and young's modulus was noticed with increase in filler content. Composites were found to be more resistant to abrasion. Flexural strength was found to be quite high in comparison to epoxy.
Keywords – Composites, Epoxy, Hand layup technique, Mechanical properties

I. Introduction

Due to an increasing concern about environment, lot of research is going on to develop a green technology in the field of material science. Recently there has been a great interest in the industrial applications of composites developed from natural fibers, bio or industrial waste [1-4]. So the development of high-performance composites using natural resources is increasing worldwide. The greatest challenge in developing these composites is large variation in their properties with the variation in filler content. Green composites or bio-composites are composite materials comprising one or more phase(s) belonging to natural or biological origin. As reinforcement, this include fibers from plant or vegetables such as cotton, flax, hemp, jute, cane, banana and the like, or bio waste like waste wood powder, waste paper, coconut shell, wood apple shell, or even by-products from food crops. Regenerated cellulose fibers (viscose/rayon) also belong to this category, as they also come from renewable resources, such as natural 'nano fibrils' of cellulose and chitin [3-7]. Green composites or bio composites properties are influenced by a number of variables, including the filler type, amount, processing methods and any modification in the filler used [4-6].

Today Scientists and engineers are searching for alternate materials, due to the scarcity of conventional materials. Natural waste materials have potential to replace the existing conventional materials because of few good properties they possess like low cost, easy fabrication, high strength to weight ratio, better thermal and insulating properties, renewable, completely or partially recyclable and biodegradable [7-9].

Today many researchers are focusing on the use of natural fibers derived from plants or vegetables and bio waste to use as reinforcement in the polymer matrix. Tropical fruits like Aegle marmelos (wood apple) and Cocos nucifera (coconut) can also be a promising material for a use as reinforcement in polymer matrix. Aegle marmelos commonly known as bael, golden apple, stone apple, wood apple is a species of tree native to India. It belongs to Rutaceae family and is cultivated throughout India, as well as in Sri Lanka, the northern Malay Peninsula, Java, the Philippines and Fiji. It is believed in India that wood apple tree is able to grow in places where other trees cannot. After the use of wood apple fruit its shell is bio waste. In the present work we used wood apple shell powder as filler in the epoxy matrix to develop composites. Mechanical properties have been investigated in detail for different compositions. Ball milling was used to make powder of its strong crushed shell.

Various investigations on glass jute, hemp and flax fiber/polymer composites have been done so far. These studies focus on many different variables such as comparison between NMT (natural fiber thermoplastic mat) and GMT (glass fiber thermoplastic mat) [10], the influence of fiber/matrix modification and hybridization with glass fibers [11], the effect of fiber treatment on adhesion and bonding [12], the effect of surface treatment on interface by glycerol triacetate, thermoplastic starch, methacryl oxypropyl, trimethoxy-silane and boiled flax yarn [13], effect of matrices such as PP and PLA on the composite properties [14], influence of processing parameters and materials used [15-16]. Buttler [17] presented the possibility of using flax fiber in composites for coachwork and bus industry. Mohanty et al. [18] studied the effects of surface modification on the mechanical and biodegradability of jute/Biopol and jute/PA (Poly Amide) composites. Epoxy / hemp fiber reinforced composites, have been studied regarding the effect of fiber architecture on the falling weight impact properties [19], Kunanopparat et al. [20,21] investigated the possibility of wheat gluten as a matrix for developing hemp fiber reinforced composites. They studied the effect of thermal treatment and plasticization on the mechanical properties. Hybrid composites of wood flour/kenaf fiber and PP were fabricated to study the hybrid effect on the composite properties [22]. Thermoforming has proven to enable the successful preparation of kenaf fiber reinforced PP sheets [23].

II. Materials and methods

2.1 Raw materials used in this experimental work are as follows:

I. Wood apple shell (Bael)

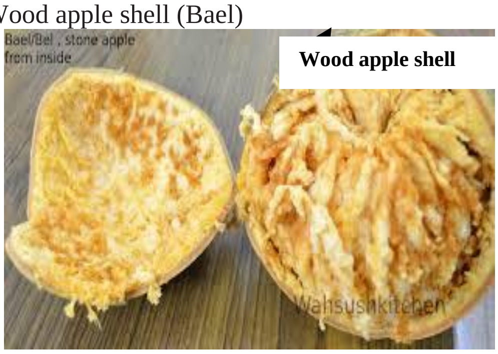

Figure1. Wood apple fruit and shell.

II. Epoxy resin, AY 103
III. Hardener, HY 951

2.2 Composite Preparation

In the present work 10, 20 and 30 wt % wood apple shell powder dispersed in Epoxy matrix (E-WA) composites have been prepared using Hand layup technique. For this purpose wooden mold of 200 X 50 X 10 mm^3 is used. Waxed Mylar sheet is used to cover the mould for good surface finish and easy withdrawal of prepared specimen. Firstly the wood apple shell was washed with the distilled water to remove the surface impurities. It was dried in the oven at 80^0C for 24 hours and crushed. Ball milling was used to make powder of the crushed wood apple shell. The epoxy and the hardener are mixed in a ratio of 10:1. Filler and the epoxy mixture with hardener are stirred with mechanical stirrer for homogenous mixing. Then the mixture of filler and epoxy along with hardener was poured into the mould. After 24 hours composites were removed from the mould, cut with a diamond cutter according to ASTM standard for different tests.

III. Result and discussion

Mechanical Properties

The mechanical properties of a composite are influenced by so many factors like type of filler, amount of filler, processing parameters, distribution of filler in the matrix and kind of bonding that takes place between matrix and reinforcement.
Sample prepared for tensile test had a cross sectional dimension of (2.25 X 3) mm^2, the length of the gauge section was kept 15 mm. Tensile tests were performed at room temperature. Stress–strain data were recorded up to a failure of samples. Three samples were tested to obtain a good error estimates.

3.1 Tensile Properties

Figure 2 shows the stress-strain curves of epoxy and its composites. Tensile strength increases from 16 MPa of epoxy to 32, 45 and 42 in case of E-10WA, E-20WA and EP-30WA composites respectively (Fig 3). Young's modulus, as calculated from the slope of the linear region of plots for composites. For Epoxy, E-10WAP, E-20WA and EP-30WA, the values are 370, 873, 1158, 882 MPa, respectively showing continuous increase in modulus upto 20 wt % of wood apple powder and then starts decreasing. Considerable increase in tensile strength and modulus in composites can be explained on the basis of better interaction between epoxy and WA powder. At higher content decrease in tensile strength and modulus may be because of agglomeration and inhomogeneous distribution of powder. Elongation at break decreases from 21% in case of epoxy to 15, 11 and 10% for E-10WA, E-20WA and E-30WA composites respectively. This decrease in the elongation at break in the composites may be because of the brittle nature of the wood apple powder. With the increase in the filler content in the polymer matrix mechanical properties are improved upto a certain limit, beyond that they start deteriorating because of poor adhesion between matrix and filler.

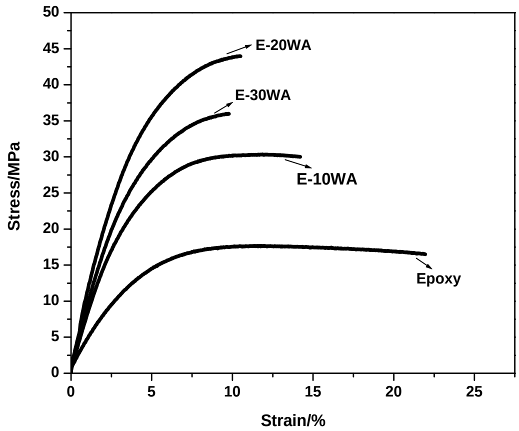

Figure 2. Stress-strain curve for Epoxy and composites

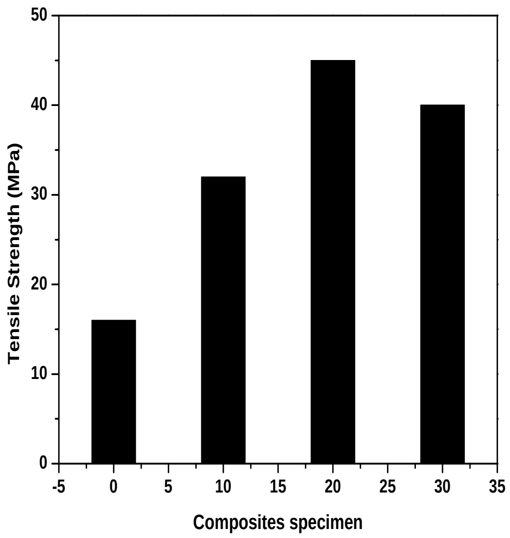

Figure 3. Tensile strength of Epoxy and composites

3.2. Flexural strength

As flexural strength also plays a very important role in structural application purposes. To determine the flexural strength of composites a three-point bending test was carried out. The rectangular samples for bend test are cut by using diamond cutter. It was found that flexural strength increases form 35 MPa in case of epoxy to 60, 72 and 65 in 10, 20 and 30 wt % composites respectively (Fig 4).

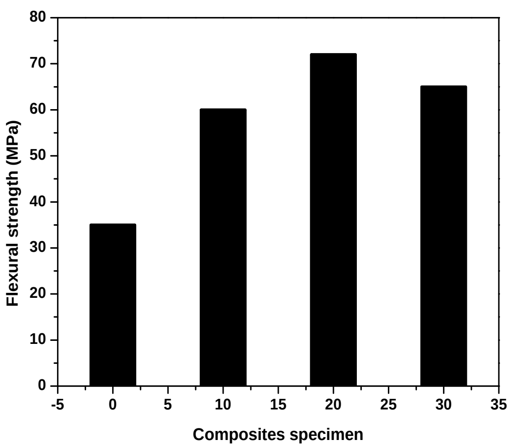

Figure 4. Flexural strength of Epoxy and composites

3.3. Hardness

Figure 5 shows the hardness values of epoxy and composites. It is evident from the figure that hardness increases with the increase in filler content in composites. It may be attributed to hard WA powder particles dispersed in the matrix, which imparts greater resistance to the surface against the externally applied load.

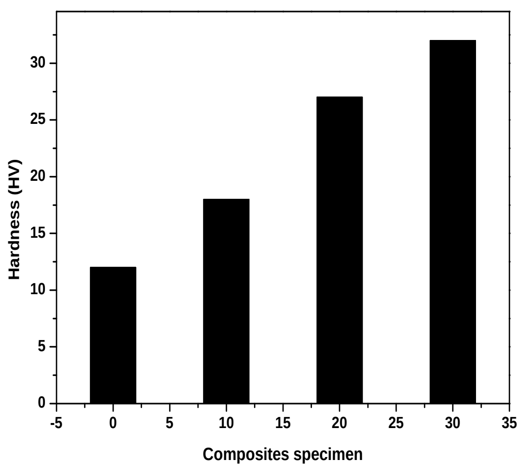

Figure 5. Hardness of Epoxy and composites

IV. Conclusion

Composites of epoxy dispersed with 10, 20 and 30 wt% wood apple (WA) powder have been successfully prepared using hand layup technique. Mechanical properties have been evaluated and it was found that composites exhibit superior mechanical properties than epoxy. Increase in the tensile strength has taken place with WA powder dispersion. Value of Young's modulus increases significantly which show greater resistance to the applied load. Hardness increased from 12 HV of epoxy to 32 HV in E-30WA composite which indicate better resistance to abrasion and wear. For further improvement in mechanical properties to the desired level, still much work is to be done, like optimization of processing parameters and filler treatment for better adhesion with the matrix.

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