Tensile And Hardness Properties Of Banana/Pineapple Natural Fibre Reinforced Hybrid Composites.

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ABSTRACT

A study has been carried out to investigate the tensile and hardness properties of composites made by reinforcing Banana and Pineapple as the new natural fibres into epoxy resin matrix. The natural fibres were extracted by retting and manual processes. The composites are fabricated using banana pineapple reinforcements. Hybrid composites were prepared using banana/pineapple fibres of 0/40, 15/25, 20/20, 25/15, and 40/0 Weight fraction ratios, while overall fibre weight fraction was fixed as 0.4Wf. It has been observed that the tensile properties increase with the increase in the weight fraction of fibres to certain extent. The hybridization of the reinforcement in the composite shows greater tensile strength when compared to individual type of natural fibres reinforced. All the composites shows increase in tensile strength in longitudinal direction. Similar trends have been observed for elongation, hardness, break load and tensile modulus values.

Keywords: **Natural fibres, Banana & Pineapple fibres, Hybrid composites, Hardness and Tensile strength.**

1. INTRODUCTION

Two or more distinct materials are combined to get composite materials. The combination results in superior properties not exhibited by the individual materials. Many composite materials are composed of just two phases one is termed as matrix phase, which is continuous and surrounds the other phase often called the dispersed phase or reinforcement phase [1-2]. The reinforcement is usually much stronger and stiffer than the matrix, and gives the composite good properties. The matrix holds the reinforcements in an orderly pattern. Because the reinforcements are usually discontinuous, the matrix also helps to transfer load among the reinforcements.

The matrix phase binds the fibres together and acts as medium by which an externally applied stress is transmitted and distributed to the fibres. Only a very small portion of an applied load is sustained by the matrix phase and major portion is sustained by the fibres. The fibres are basically two types. They are Natural and Synthetic Fibres. Cotton, Jute and Sisal are some examples for Natural Fibres and Glass, Nylon and Carbon are some examples for Synthetic Fibres.

Natural fibres, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally friendly, fully biodegradable, abundantly available, and renewable. Plant fibres are light compared to glass, carbon and aramid fibres. The biodegradability of plant fibres can contribute to a healthy ecosystem while their low cost and high performance fulfils the economic interest of industry. When natural fibre-reinforced plastics are subjected, at the end of their life cycle, to combustion process or landfill, the released amount of CO_2 of the fibres is neutral with respect to the assimilated amount during their growth. Natural fibres such as banana, cotton, coir, sisal and jute have attracted the attention of scientists and technologists for application in consumer goods, low cost housing and other civil structures. It has been found that these natural fibre composites possess better electrical resistance, good thermal and acoustic insulating properties and higher resistance to fracture. They are also renewable and have relatively high strength and stiffness and cause no skin irritations. On the other hand, there are also some disadvantages, for example moisture absorption, quality variations and low thermal stability. Many investigations have been made on the potential of the natural fibres as reinforcements for composites and in several cases the result have shown that the natural fibre composites own good stiffness but the composites do not reach the same level of strength as the glass fibre composite [3]. Hybrid composite materials are made by combining two or more different types of fibres in a common matrix. Hybridization of two types of short fibres having different lengths and diameters offers some advantages over the use of either of the fibres alone in a single polymer matrix. Most of the studies are on the hybridization of natural fibres with glass fibres to improve the properties [4–10]. With this background, in the present work an attempt has been made to fabricate and to evaluate the properties of natural fibre reinforced hybrid composites.

2. EXPERIMENTAL DETAILS

2.1 Materials

Banana fibre (Musaceae family) a type of bast fibre, is extracted from the bark of banana tree. Pineapple is multi-cellular and lignocelluloses materials extracted from the leave of plant Ananas cosomus belonging to the (Bromeliaceae family) that yields a stiff fibre, traditionally used in making twine and rope. Both fibres are purchased from Perfect Banana fibre & Articles Manufacturer, Coimbatore, Tamilnadu. Hardener and Resin was purchased from Shakti glass fibres and Traders, Chennai, India. The properties of banana and pineapple fibres are given in Table 1 [11].

2.2 Fibre Preparation

The obtained fibres are cleaned with water and dried. Then the segregations are gently dispersed with hand sitting patiently. Pineapple and banana fibres after retting the husks are beaten with a hammer. These fibres are ripped from the husks and separated from the comb. After drying at the room temperature, both the fibres were combed with a cotton carding frame for several times further separate the fibres in to individual state. After that, both the fibres are measured for proper weight and length.

2.3 Weight fraction of the fibre

The weight of the matrix was calculated by multiplying density of the matrix and the volume (volume in the mould). Corresponding to the weight of the matrix the specified weight percentage of fibres is taken. For hybrid combination the corresponding weight of fibre obtained is shared by two fibres.

Fig. 1 - Banana fibres and Pineapple fibres

2.4 Preparation of epoxy and hardener

Epoxy LY556 of density 1.15–1.20 g/cm^3, mixed with hardener HY951 of density 0.97–0.99 g/cm^3 is used to prepare the composite plate. The weight ratio of mixing epoxy and hardener is 10:1. This has a viscosity of 10-20 poise at 25^{0}C. Hardeners include anhydrides (acids), amines, polyamides, dicyandiamide etc.

Fig. 2 - Resin and Hardener

2.5 Mould Preparation

Mould used in this work is made of well-seasoned teak wood of 200 mm X 200 mm X 3 mm dimension with five beadings. The fabrication of the composite material was carried out through the hand lay-up technique. The top, bottom surfaces of the mould and the walls are coated with remover and allowed to dry. The functions of top and bottom plates are to cover, compress the fibre after the epoxy is applied, and also to avoid the debris from entering into the composite parts during the curing time.

2.6 Fabrication of Composites

The moulds are cleaned and dried before applying epoxy. The fibres were laid uniformly over the mould before applying any releasing agent or epoxy. After arranging the fibres uniformly, they were compressed for a few minutes in the mould. Then the compressed form of fibres (banana/pineapple) is removed from the mould. This was followed by applying the releasing agent on the mould, after which a coat of epoxy was applied. The compressed fibre was laid over the coat of epoxy, ensuring uniform distribution of fibres. The epoxy mixture is then poured over the fibre uniformly and compressed for a curing time of 24 h, with load of 5kg. Composites are prepared by changing the weight fractions of both pineapple and banana fibres. Individual composites with banana and pineapple as reinforcement are also prepared under similar processing conditions for comparison purpose.

Table 1 Properties of Banana and Pineapple fiber[11].

Properties	Banana	Pineapple
Cellulose (%)	63–64	81-12
Micro fibrillar angle	11	14-8
Hemi cellulose (%)	6 - 19	16-19
Lignin (%)	5-10	4.6-12
Moisture content (%)	10-11	11-12
Density (kg/m^3)	1350	1440
Lumen size (mm)	5	2-3
Tensile strength (MPa)	529-914	413-1627
Young’s modulus (GPa)	27-32	60-82

3. TESTING STANDARDS

3.1 Tensile Test

Tensile test was carried out as described in American Standard Testing and Measurement (ASTM) method D638, using the associated universal testing machine (FIE) make at crosshead speed of 2.5mm/min using dumbbell test piece. In each case, five specimens were tested to obtain the average value. Each tensile specimen was positioned in the associated universal tester, as the specimen stretched the desired parameters and computer generated graph were recorded until the specimens fractures. A graph of tensile stress versus tensile strain was plotted automatically by the computer.

3.2 Micro Hardness Test

The Micro-hardness test was carried out as described in American Standard Testing and Measurement (ASTM) method D2240 using forcing a diamond cone indenter into the surface of the available in tropical regions. Five hardness values were obtained for each specimen and the values were summed up to get an average for each specimen.

4. RESULTS AND DISCUSSION

Table 2 gives the summary of results obtained for various weight fraction composites.

Table 2 Tensile properties of different composite samples.

% Weight fraction	Elongation (%)	UTS (Mpa)	Tensile Modulus (Gpa)	Maximum Displacement (mm)
0/40	4.16	60	0.0207	1.66
15/25	3.33	38	0.015	2.11
20/20	3.74	42	0.0145	2.11
25/15	5.15	62.5	0.0196	2.86
40/0	4.65	55.3	0.0074	1.85

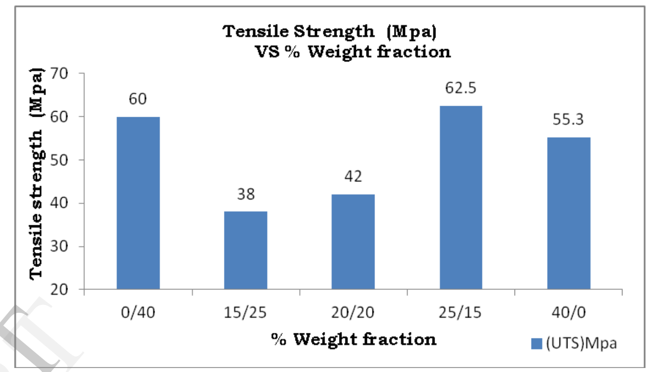

Fig. 3 - Tensile strength Vs % Weight fraction of composites

The tensile strength behaviour of various weight fractions composites are shown in figure 3, it can be observed that pure pineapple and pure banana shows the tensile strength of 60 Mpa and 55.3 Mpa. The strength of the hybrid composites is initially low at small % weight fractions i.e. 38 Mpa, upon further addition of pineapple to banana fibre for strength has increased up to 42 Mpa. The effect of hybridization found to be negligible at the initial % weight fraction of fibres. However higher tensile strength is obtained for 25/15 weight fraction of composite. This behaviour can be correlated to hybridization effect as both fibres contributed to higher strength of composite.

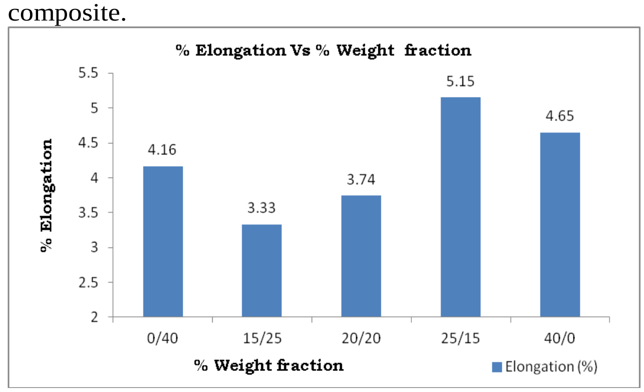

Fig. 4 - Elongation Vs % Weight fraction of composites

From figure 4, represents elongation behaviour of various weight fraction composites. For pure banana and pure pineapple composites the elongation was found to be 4.16 % and 4.65 %, up on the addition of pineapple fibre the elongation value is decreased at 15/25. The further addition of pineapple fibre the elongation value is found to be increasing, i.e. up to 20/20 weight fraction. A drastic increment in elongation has been observed at 25/15 weight fraction composite and the maximum value is obtained as 5.15%. This can be attributed to be a good ductile behaviour and hybridization yielded good result.

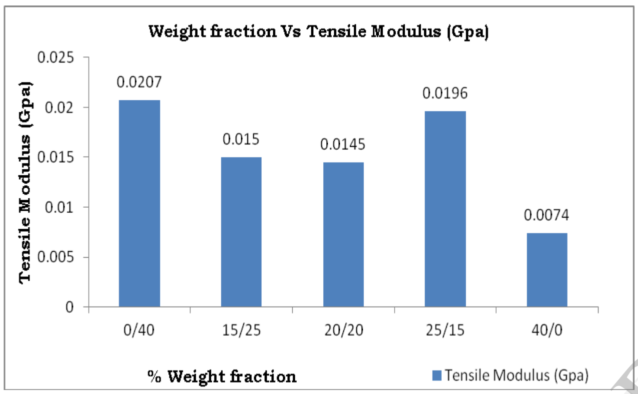

Fig. 5 - Tensile modulus Vs % Weight fraction of composites

From figure 5, the tensile modulus of the pure banana composite along longitudinal direction is 0.020 Gpa for 0/40 ratio. The tensile modulus of hybrid composite is 0.019 Gpa. This is close to pure banana composite. The tensile modulus of three composites with weight fraction 15/25, 20/20, 40/0 is poor when compared to pure banana and 25/15 hybrid composite.

Summary of hardness and break load values for various weight fraction composites as shown in table:3

Table 3 Hardness & Break load values of different composite samples.

% Weight fraction	Hardness (HRB)	Break load (kn)
0/40	683.16	2.7
15/25	650	2.3
20/20	670	2.33
25/15	711	2.88
40/0	708.5	2.48

From figure 6, shows the trend of breaking strength with respective various weight fractions. Pure banana and pure pineapple composites have shown 2.7 Kn and 2.48 Kn at break point at 15/25 and 20/20 the values were observed to be low as compared to pure

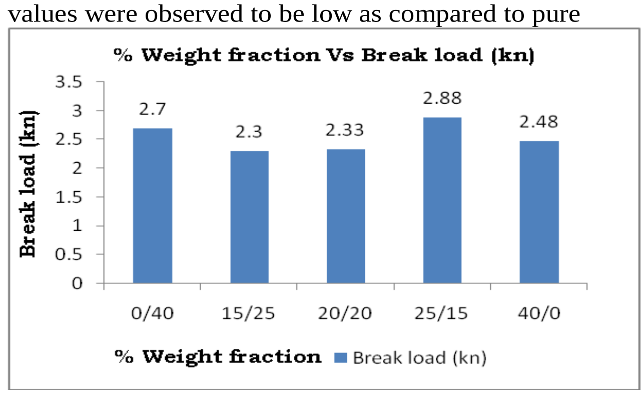

Fig. 6 - Break load Vs % Weight fraction of composites

composite. This can be attributed to improper mixing, Mismatch of individual fibres as a whole to the hybrid composite at 25/15, the hybrid composite has shown maximum breaking load (2.88 Kn) as compared to pure composite and other hybrid composites. This mixing ratio of both the fibres might have contributed proportionately thus resulted in superior breaking load capacity.

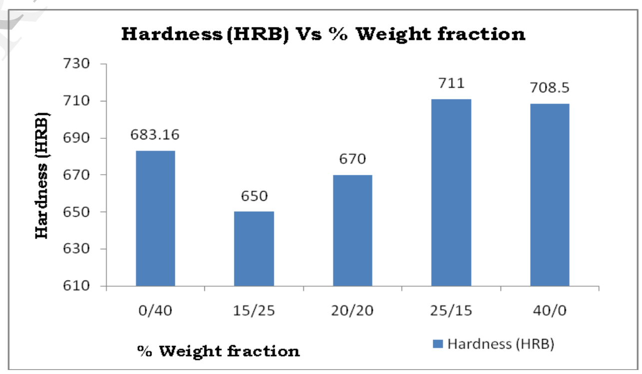

Fig. 7 - Hardness Vs % Weight fraction of composites

From figure 7, shows the hardness trend for pure as well as hybrid composites. Pure banana composite resulted 683.16 HRB and pure pineapple resulted 708.5 HRB at 15/25 partially weight fraction banana fibres have been replaced with pineapple fibres. Though individual pineapple fibre composite has shown superior hardness values compared to banana the effect of hybridization is negligible. Up on further addition the hardness values are increased to some extent. At 25/15, since more weight fraction pineapple fibres have been added to banana fibers which have resulted. Superior hardness values among all composites.

From figure 8, the comparison of tensile strength, hardness with respective weight fraction of the composite. Both tensile strength and hardness have shown similar trend with respective weight fraction composites. It is interesting to note that 25/15 hybrid

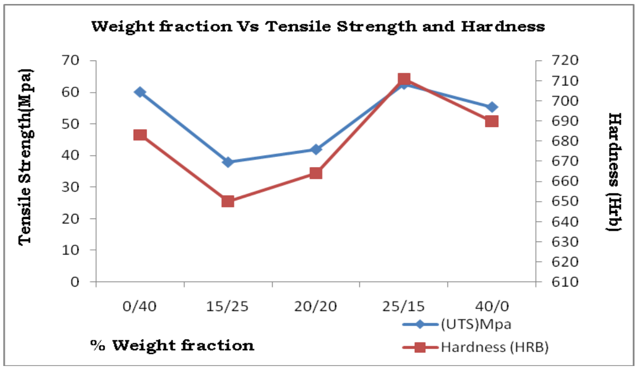

Fig. 8 - Hardness and Tensile Strength Vs Weight fraction of composites

composite both the tensile strength and hardness results were shown close agreement which can be justified for hybridization effect.

5. CONCLUSIONS

After determining the material properties of natural fibre reinforced epoxy hybrid composites using five different weight fractions of the materials, the following conclusions can be made.

i. The natural fiber reinforced epoxy hybrid composites are successfully fabricated using hand lay-up technique.

ii. The banana/pineapple hybrid composite with weight fraction of 25/15 shows maximum tensile strength and maximum tensile modulus.

iii. The banana/pineapple hybrid composite with weight fraction of 25/15 shows maximum hardness.

iv. The hybridization of these natural fibres has provided considerable improvement of tensile strength when compared to individual reinforcement.

v. Due to the low density of proposed natural fibers compared to the synthetic fibres (Glass fibres, carbon fibres, etc...), the composites can be regarded as a useful materials in light weight applications.

vi. The banana/pineapple hybrid composite with weight fraction of 25/15 shows maximum break load.

vii. The banana/pineapple hybrid composite with weight fraction of 25/15 shows maximum elongation.

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