



MECHANICAL CHARACTERISATION OF TYPHA DOMINGENSIS NATURAL FIBER REINFORCED POLYESTER COMPOSITES

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Abstract: Partially biodegradable *Typha domingensis* natural fiber-reinforced polyester composites were prepared. Samples were fabricated by the hand lay-up process (30:70 fibre and matrix ratio by volume) and the properties were evaluated by using the INSTRON material testing system. The mechanical properties were tested and showed that has the maximum tensile strength of 49.72 MPa, and the impact strength of 121 J/m.

Keywords: Impact strength; Natural fiber composites; Tensile properties, Hand layup process.

I. INTRODUCTION

The importance of natural fibers has been recognized since their use by the Egyptians 3,000 years ago, but since the 1970s a number of high-tech synthetic fibers such as glass, aramid, and carbon have entered and dominated the composite market because of their superior mechanical and thermal properties. With increasing environmental concerns, natural fibers are once again being considered as reinforcements for polymer composites.

The use of natural fibers to make low-cost and eco-friendly composite materials is a subject of green importance. The development and applications of several natural fiber polymer composites have been comprehensively reviewed.[1–5] Unsaturated polyester has extremely multipurpose properties and applications and is a popular matrix for making composites. This matrix has been used for many years in broad technology fields such as shipping construction, offshore applications, waterlines, and building construction.[6] The mechanical properties of natural fiber-reinforced composites can be further improved by chemically promoting good adhesion between the matrix and the fiber. The tensile properties of elephant grass fiber-reinforced polyester composites with and without chemical treatments were reported.[12] The extraction of rice straw fibers and their incorporation in a polyester resin matrix to prepare composites was also explained.[13]

Natural fibre-reinforced composites have been increasingly utilized in quite widespread applications. Natural fibres are obtained from different parts of the plants, to name a few, for example jute, flax, kenaf, coconut, hemp, ukam, sisal, banana, pineapple fibres from the leaf; cotton and kapok from seed; coir and coconut from the fruit. For example hemp, jute, flax and sisal fibres are already used in automotive industry

II. EXPERIMENTAL METHOD

A. FIBER

Typha Domingensis

It is mostly found in regions where there is a stock of water, sewage water in open places, and also in waste lands. These plants are helpful in some cases, such as chemical wastewater from industry where they absorb harmful water. It is a perennial growing 1 m to 3 meters long with spongy strap-like leaves. *Typha domingensis* is available abundantly in nature and is renewable. It is flower from May to August, and the seeds ripen from Jun to September. The flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are pollinated by wind. It is suitable for light (sandy), medium (loamy) and heavy (clay) soils. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in saline soils. It cannot grow in the shade.



B. Resins

Unsaturated polyester with density (0.909) g/cm³ was obtained from BORNEO INDAH SDN BHD with the properties such as appearance (pink), density (1.12) g/cm³, and stability in the dark below 25°C.

C. Curing Agents

Methyl ethyl ketone Peroxide (MEKP) and Dimethyl Aniline (DMA) were obtained from the same supplier for unsaturated polyester resin and used as a catalyst and accelerator, respectively. The properties of DMA were as follows: the density at (20-24) °C temperature - (0.955-0.960) g/cm³, molecular weight - 121.18 g/mol,

D. Extraction of Fibers

The extraction of fibers involves the retting process followed by decortication. The stems of *Typha domingensis* were cut at their base and immersed in a water tank for three weeks. Then they were removed; the fibers were stripped from their stalks by hand, washed, and dried in the sun. After drying, any unwanted matter that might still be adhering to them was removed by washing it with NaOH. The extracted fibers were used for composite making.

E. Fabrication of composites

For the fabrication of the randomly oriented *Typha domingensis* fiber-reinforced composite. A releasing plastic sheet is spread over the wooden mold. Heavy duty silicon spray is applied to the plastic sheet for easy removal of the composite plate. The fibers are cut into 30 mm length and distributed uniformly at the bottom of the mold which is prepared before. Thirty volume percentage of the fiber is used for the fabrication of the composite. A load of 10 metric tons was applied on the plates by hydraulic compression to form a single sheet. Then resin and curing agent are mixed together on a volume percentage of 10:1 to form a matrix. The matrix is poured over the fibers in an evenly manner and left for curing for 24 h. Composite samples were prepared with five different percentage volumes of *Typha domingensis* fibers. The picnometric procedure was adopted for measuring the density of the composite.

III. TESTING

A. Tensile Testing

The tensile properties of the composites were calculated as per the standard test method, ASTM D 3039 M. Test specimens 150mm long, 12.5mm width, and 3mm thickness were prepared. The sample of 10 cm length was clamped into the two jaws of the machine. Each end of the jaws covered 2 cm length of the sample. Reading of the tensile strength test instrument for Newton force and extension were initially set at zero. The test was conducted at the constant strain rate of the order of 10 mm/min. Five specimens of each sample have been used for the measurement of the above mechanical properties at ambient laboratory environment and average results are reported.

B. Impact Testing

The impact strength of notched specimen was determined by using an impact tester according to ASTM D 256-05 standards. The specimens were 62.5mm long, 12.5mm width, and 3mm thickness. The samples were fractured in a plastic impact testing machine and the impact toughness was calculated from the energy absorbed and the sample width. In each case three specimens were tested to obtain average value.

IV. RESULTS AND DISCUSSION

A. Tensile Test

The variation of mean tensile strength with varying fiber content is shown in Figure 1. It is clearly seen that increasing the fiber content in the polyester matrix, increases the tensile strength. This is due to the fact that the polyester resin transmits and distributes the applied stress to the *Typha domingensis* fibers, resulting in higher strength. The tensile modulus also increases as shown in the Table I. Mean tensile properties of *Typha domingensis* polyester composites increases as the volume fraction of fiber increases in the composites and is 1.041GPa at 0.387 volume fraction of fiber loading (Figure 2).

Table I. Mean tensile properties of Typha domingensis polyester composites

Volume fraction of fiber	Density of composite (kg/m ³)	Mean Tensile strength (M Pa)	Mean Tensile Modulus (G Pa)
0.000	1343	32.34	0.712
0.192	1289	34.20	0.896
0.227	1146	37.45	0.914
0.278	1097	40.43	0.947
0.312	1078	43.71	0.988
0.387	1041	49.72	1.041

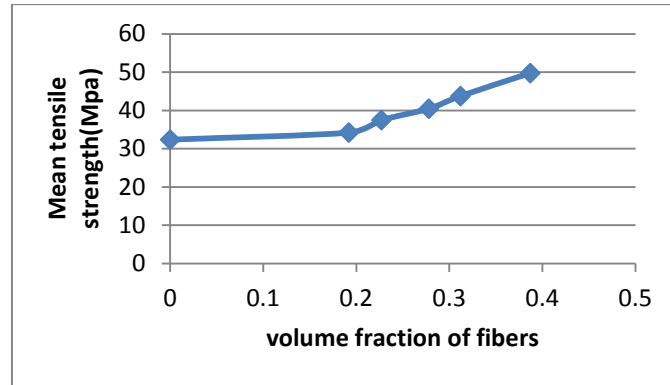


Figure 1. Effect of volume fraction of fiber on mean tensile strength of the composite.

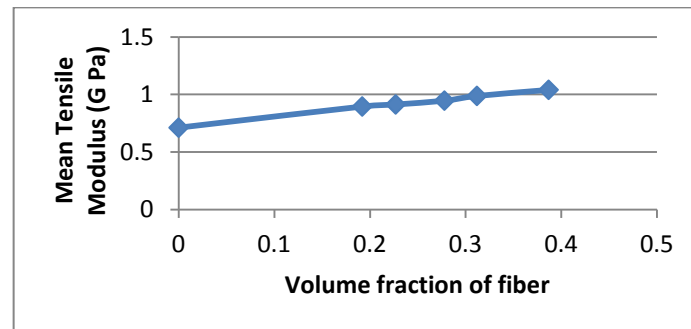


Figure 2. Effect of volume fraction of fiber on mean tensile modulus of the composite.

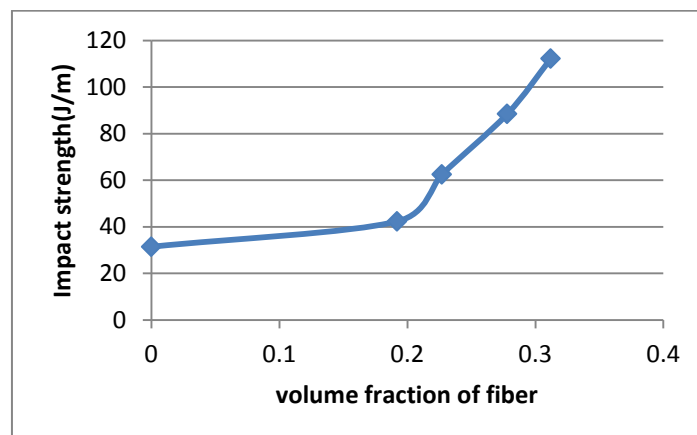


Figure 3. Variation of impact strength of fiber-reinforced composite with volume fraction of fiber.

B. Impact Test

The results of the impact test are shown in Figure 3. As the volume fraction of Typha domingensis fiber increases, the impact strength increases. The composite has impact strength of 121 J/m, at maximum volume fraction (0.387). This is understandable as most natural fibers impart better load-bearing capacity

V. CONCLUSION

In this work, Typha domingensis fiber-reinforced polyester composites were prepared. Typha domingensis is available abundantly in nature and has low density. The tensile and impact properties of the composites with these fibers were found to be higher than those of the matrix and increased with fiber content. Thus, the composites of Typha domingensis fiber-polyester composites were found to be light in weight and possessed better mechanical and insulating properties. Hence, the newly developed composite material can be used for applications such as electronic packages, insulation boards, automobile parts, building construction, and other uses.

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