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MECHANICAL PROPERTIES OF NATURAL FIBER REINFORCED POLYMER COMPOSITES: AN OVERVIEW

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ABSTRACT

During the course of evolution, the traditional knowledge and practices developed by our ancestors on various uses of plants have been transmitted to future generations. Among the commonly used plant species by man, the fiber yielding plants hold the second position after the food plants with respect to their economic potential. In the last few years, the components obtained from bio fiber reinforced composite material are mostly used to produce the non-structural parts. The natural fibers such as Coir, Sisal, Zea, Banana and Korai were selected in the present investigation for the fabrication of polymer composites. The mechanical properties such as tensile strength, flexural strength, impact strength and compression strength of randomly oriented natural fiber Reinforced polymer composites were evaluated and compared in the present Investigation. The new variety of stem fiber such as Cyperus Pangorei was identified and it was effectively used in polymer composites.

Keywords*: Cyperus Pangorei, Thermoset resin, Static Mechanical Properties.*

1. Introduction

Natural fiber reinforced composites are used now a days for most of the engineering applications due to their better strength and stiffness to weight ratio [1-2]. The synthetic fiber reinforced composites are replaced by natural fiber a composite which is obtained from various parts of the plant and are used for composite applications. The growth period of Cyperus Pangorei is favoured by the atmospheric temperature of 23-30^{o}C and rainfall of 400 mm. The Cyperus Pangorei is often referred to as Korai fibers. The Photographic image of Cyperus Pangorei Seed and plant is shown Fig.1.

The Cyperus Pangorei fibers having high specific strength and low density and it is reinforced with polypropylene and polyester composites giving better results [3-4]. Some of the researchers worked on the bio-composites for comparing the various mechanical properties among themselves used in the applications of fall ceilings, automotive interiors [5-6]. Polymer-based composite material possess superior properties such as good corrosive resistance, high strength, so it is preferred for aerospace, automotive and sports equipment's [7-8]. In plasticized systems, we observed the changes in the fiber morphology suggestive of swelling by the PEG plasticizer. In the automotive industry, glass fibers are replaced by natural fiber reinforced polymer systems. The effects of different mercerization parameters such as concentration of alkali (NaOH), temperature, and duration time along with tensile stress applied to the fibers on the structure and properties of Cyperus Pangorei fibers..

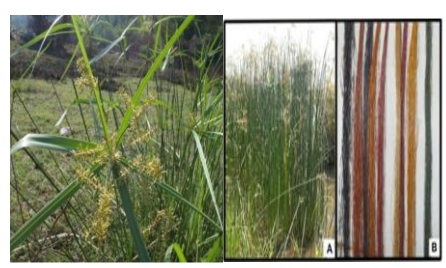

Fig. 1. Photographic image of Cyperus Pangorei seed and plant.

It was observed that the mechanical properties of the fibers can be controlled by using appropriate mercerization parameters [9-10]. By using the technique of mercerization, the fiber properties can be homogenized and controlled. This investigation is focused on improvement of the fiber modulus and strength for the higher elongation at break in order to achieve advanced composites impact properties [11-12]

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2. Materials And Manufacturing

2.1 Materials

The details of fabrication materials used in the present investigation is listed below.

Fiber materials : Coir, Sisal, Zea, Banana, Korai
Resin : Polyester
Accelerator : Cobalt Octoate
Catalyst : Methyl Ethyl Ketoneperxide

2.2 Extraction of fibers

The Cyperus Pangorei fibers were extracted from the stem of the plant which is soaked in water for 2 to 3 days. Then it is dried and the fibers were separated by hand stripping process. The photographic image of Cyperus Pangorei fiber is shown in Fig. 2.

Fig. 2. Photographic image of Cyperus Pangorei fibers

2.3 Properties of natural fibers

There has been a growing interest in the use of natural fibers as the reinforcement in polyesters composites. Most of the natural fibers are harvested yearly and the supply should be inexhaustible compared to the limited supply of oil reserve, from which many synthetic fibers are derived. Natural fibers are categorized based on their source of origin, which includes mineral fibers, animal fibers and vegetable or plant fibers. Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. Mineral fibers such as asbestos had been used historically for insulating houses. Animal fibers are mainly made of proteins such as collagen, elastin and keratin in combination with polysaccharides and complex phenolic compounds; examples include silk, wool, angora, mohair and alpaca.

Table.1. Properties of natural fibers

Fiber	Density (Kg/m^3)	Young's modulus (Gpa)	Tensile strength (Mpa)	Elongation at Break (%)
Flax	1.54	27.5-85	345-2000	1-4
Ramie	1.5-1.56	27-128	400-1000	1.2-3.8
Hemp	1.47	17-70	368-800	1.6
Sisal	1.45-1.5	9-22	350-700	2-7
Coconut	1.15	4-6	131-175	15-40
Jute	1.44	10-30	393-773	1.5-1.8
cotton	1.5-1.6	5.5-12.6	287-597	7-8
Kenaf	1.2	14-53	240-930	1.6
Bamboo	0.6-1.1	11-17	140-230	-
E-glass	2.5	70	2000-3500	2.5
carbon	1.4	230-240	4000	1.4-1.8

The development in plant based fibers has shown promise for certain end-use applications. Various parts of plants such as stems, leaves, seed-hairs, fruits, cereal straw or grass are found to be the viable source for plant fibers. The physical strength and chemical composition of these fibers depends upon the plants and parts of the plants, from which they are extracted shown in Table.1

2.4 Properties of thermoset resins

The main characteristic of thermosets is that they require curing, when they undergo a molecular cross-linking process which is irreversible and renders them infusible. They therefore offer high thermal stability, good rigidity and hardness, and resistance to creep. This also means that, once cured, the resin and its laminate cannot be reprocessed except by methods of chemical breakdown, which are currently under development. For practical purposes, therefore, cured thermosetting resins can be recycled most effectively if ground to fine particles, when they can be incorporated into new laminates or other products as fillers.

Table.2. Properties of thermoset resins

Sl.No	Properties	Polyester	Epoxy	Vinyl ester
1	Density (Kg/m^3)	1350	1540	1320
2	Poisson's Ratio	0.33	0.33	0.33
3	Young's Modulus (MPa)	1350	3500	3500
4	Thermal Expansion (W/ m°C)	0.21	0.57	0.21

For reinforced plastics, the compounds usually comprise a resin system (with curing agents, hardeners, inhibitors, plasticisers) and fillers and reinforcement. The resin system provides the 'binder,' to a large extent dictating the cost, dimensional stability, heat and chemical resistance, and basic flammability. The comparison of various properties of thermoset resins is shown in Table.2.

3. Testing Standard and Equipments

The compression moulding process was followed to fabricate the natural fiber-polyester composites.

3.1 Tensile Test

The static tensile test samples were cut according to ASTM D638 for the specimen dimension of 165 mm × 25 mm × 3 mm and the tensile behavior of Cyperus pangorei fiber composites was measured using a Tinius Olsen make 10 KN Dual Column Table Top Universal Testing Machine. The tensile specimen had straight sided, constant cross-section. The tensile test specimens were held in a testing machine by wedge action grips and pulled at a crosshead speed of 1.5mm/min.

3.2 Flexural test

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. The Flexural behavior of Cyperus pangorei fiber composites was measured using a Tinius Olsen make 10 KN Dual Column Table Top Universal Testing Machine.

3.3 Impact test

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. Impact strength testing was carried out using a Tinius Olsen Impact tester (Model 104) as per ASTM D256.The sample was incised into the dimension of 62.5 mm × 12.5 mm × 3 mm. The test specimen was supported as a vertical cantilever beam and broken by a single swing of a pendulum.

4. Results and Discussion

4.1 Comparison of tensile strength of composites

The tensile specimen had straight sided, constant cross-section. The tensile test specimens were held in a testing machine by wedge action grips and pulled at a crosshead speed of 1.5mm/min and the observed values are listed in Table 3.

Table.3. Comparison of tensile strength Values

Sl. No	Composites	Tensile Strength (MPa)
1	Coir-Polyester	15.2
2	Zea-Polyester	20
3	Sisal -Polyester	29.6
4	Banana-Polyester	28.2
5	Korai-Polyester	30.37

4.2 Comparison of flexural strength of Composites

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. The flexural strength values of various natural fiber reinforced polyester composites are given in Table 4.

Table 4. Comparison of flexural strength Values

Sl. No	Composites	Flexural Strength (MPa)
1	Coir-Polyester	25.7
2	Zea-Polyester	26
3	Sisal -Polyester	32.5
4	Banana-Polyester	35.3
5	Korai-Polyester	38.4

Table.5. Comparison of impact strength Values

Sl. No	Composites	Impact Strength (kJ/m^2)
1	Coir-Polyester	29.8
2	Zea-Polyester	27
3	Sisal -Polyester	32
4	Banana-Polyester	37.2
5	Korai-Polyester	43

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. The comparison of impact strength values of various natural fiber reinforced polyester composites are given in Table 5.

Table.6. Comparison of Compression Strength values

Sl. No	Composites	Compression Strength (MPa)
1	Sisal -Polyester	30
2	Banana-Polyester	63
3	Zea-Polyester	66
4	Korai-Polyester	69.75
5	Coir-Polyester	70

The Korai-Polyester composites exhibited better values of tensile strength, flexural strength, impact strength and compression strength values. The coir-polyester composites exhibited low values of tensile and flexural strength and intermediate values of impact strength and compression strength. The comparison of tensile, flexural, impact and compressive properties of various natural fibers reinforced polyester composites are shown in Fig. 3, 4, 5 and 6 respectively.

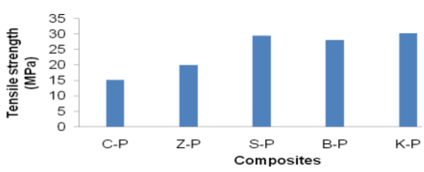

Fig. 3. Comparison of tensile strength values

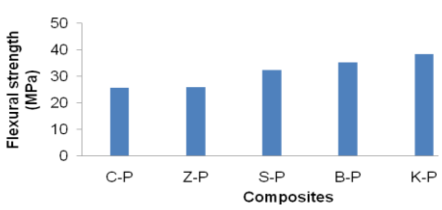

Fig. 4. Comparison of flexural strength values

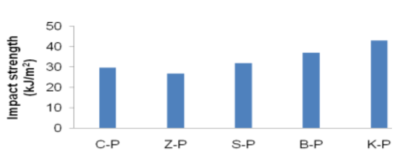

Fig. 5. Comparison of impact strength values

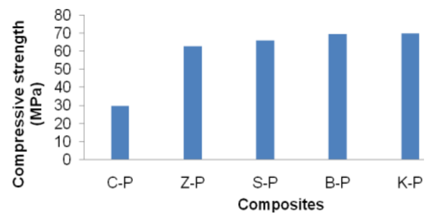

Fig. 6. Comparison of compressive strength values

5. Conclusions

The mechanical behaviours of various natural fibers such as Coir, Sisal, Banana, Zea and Korai reinforced Polyester composites were compared in the present investigation. Among the different natural fibers, the Korai fiber-Polyester composites exhibited better value of tensile, flexural, impact and compressive behaviours. The alkali treatment of fibers, particles inclusion in matrix and the continuous fiber orientation may be carried out in order to improve the mechanical properties further in Korai fiber-Polyester composites.

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