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Preparation and Characterization of Roselle Fibre Polymer Reinforced Composites

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ABSTRACT: ***In recent years, for high performance natural fibre composites, the bast fibers, extracted from the stems of plants such as jute, kenaf, flax, ramie, mesta and hemp are widely accepted as the best candidates due to their very good mechanical properties. In this present work, untreated bast–roselle fibre with different proportion was used as reinforcements to polymer based matrices. The aspect ratios of the fibres are maintained as 15cm constantly for all fibre contents. The effects of fibers content on mechanical properties and machinability of roselle fibres composite material without and with moisture were studied. An improvement in strength and stiffness combined with high toughness were achieved in without moisture composite specimen by varying the fibre content. On the other hand, the addition of roselle to the matrix was found to decrease the impact strength with the exception of 10 % fibre content for the composite without moisture and also 10% fibre content of the composite with moisture. A decrease in strain at break was observed with an increase in fibre content in both cases. In wear testing, 30% fibre content composites showed good wear resistance in both cases.***

Key words: Natural fibres composites; Bast-Roselle fibre; Polyester; Mechanical properties.

I. Introduction

Nowadays, the natural fibers such as sisal, coir, jute, ramie, pineapple leaf, and kenaf have the potential to be used as a replacement for glass or other traditional reinforcement materials in composites. Other advantages include low density, high toughness, comparable specific strength properties, reduction in tool wear, ease of separation, decreased energy of fabrication. The bast fiber composites include kenaf, hemp, flax and roselle, while sisal may be considered a leaf fiber. Compared to glass fibers, the bast fibers tend to show approximately the same flexural strength and a higher MOE. These fibers have many properties which make them an attractive alternative to traditional materials. They have high specific properties such as stiffness, impact resistance, flexibility, and modulus. In addition, they are available in large amounts, and are renewable and biodegradable. Other desirable properties include low cost, low density. Uses of these fibers satisfy both economic and ecological interests. Apart from above mentioned fibers, roselle, a close relative of jute and hemp, has not yet been explored as a reinforcing material for a commodity thermoplastic and thermosetting. The roselle fibers were chosen and used as reinforcing fillers for isotactic polypropylene. The results showed that the highest mechanical properties were observed when roselle bast fibers we

now that both the strength and stiffness of fiber composites depend on fiber concentration, fiber aspect ratios, fiber-matrix adhesion, as well as fiber orientation and dispersion. The present contribution reports utilization of untreated roselle fibers as reinforcing fillers for commercial available unsaturated polyester resin as matrix for the first time. The roselle fiber-reinforced polyester composites were prepared using hand molding method. The effects of fibers content on mechanical properties such as tensile, flexural and impact of the composites without and with moisture condition were investigated and reported.

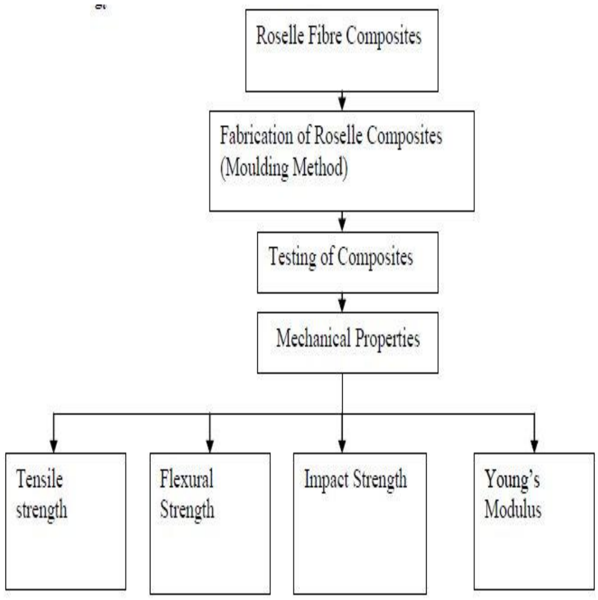
II. Experimental Materials

The matrix material used in this investigation was based on commercially available polyester, Trade name satyan polymer supplied by GV Traders. The matrix was mixed with curing catalyst at a concentration of 0.01 w/w of the matrix for curing. Commercially available untreated roselle fibres with dry condition were taken as reinforcement. Methyl ethyl ketone and Cobalt were used as catalyst and accelerator respectively.

A. Preparation of roselle/polyester composites

In this work, the composite consisted of natural fibre (resole) /matrix (polyester) where the fibres content was varied with constant aspect ratio of 15cm. The untreated

content of moisture from atmosphere which cause swelling during compounding and hence, a decrease in mechanical



properties. Also, dry fibre gives better wetting with the matrix during compounding. This fibre content was chosen to observe the effects of fibres content on the mechanical properties as the fibre content are increased.
flexural strength properties (54 MPa) of hemp composites compare quite well with glass mat composite (60 MPa). The tensile strength of the ductile hemp composites was almost doubled by the reinforcement with 27% of hemp fibres to 30 MPa.

B. Tensile strength

The tensile strength was determined on 6 specimens (the average was recorded) after conditioning for 3 days at 23°C and 50% relative humidity. The tensile properties of the composites were measured with Universal Testing Machine. Specimens were prepared according to the ASTM standards. The width and the thickness of each sample were approximately 15 cm X 2cm X 3mm, respectively. The elastic modulus, stress at break and strain at break were calculated from the stress strain curve.

C. Flexural strength

Rectangular test pieces for flexural test were cut from the hand molded tensile test specimens. The flexural tests were performed on the same machine as tensile tests using the 3-point bending method according to ASTM standard. The specimen was freely supported by a beam and the maximum load was applied in the middle of the specimen. The tests were carried out at a temperature of 23°C and the relative humidity of 50%. For statistical purposes, a total of 6 samples were tested.

D. Impact strength

The impact strength of the samples was measured on the hand molded tensile test specimens using an Izod impact test machine. All test samples were notched. The method used for impact strength testing was according to ASTM standard. The test specimen was supported as a vertical cantilever beam and broken by a single swing of a pendulum. The pendulum strikes the face of the notch. A total of 6 samples were tested and the mean value of the absorbed energy was taken.

5.5. Wear test

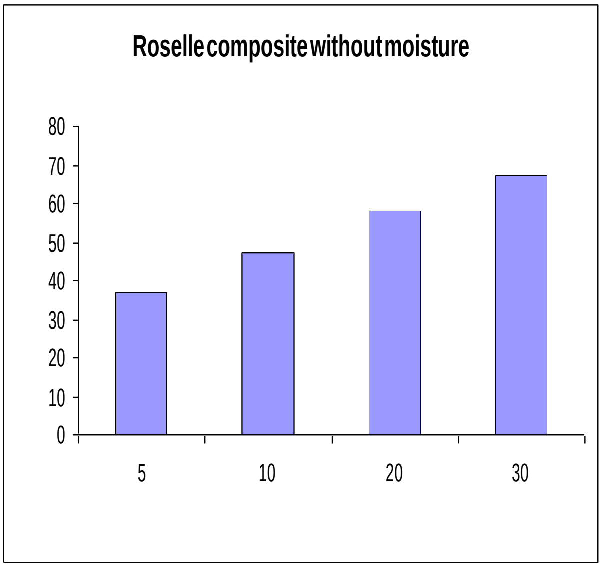
The rectangular specimen of 55 mm x 45 mm was slid against a rotating abrasive wheel. A constant load of 500 g was applied during the wear test for all the samples. The weight loss was measured for the specified time intervals such as 4, 8 and 12 minutes.

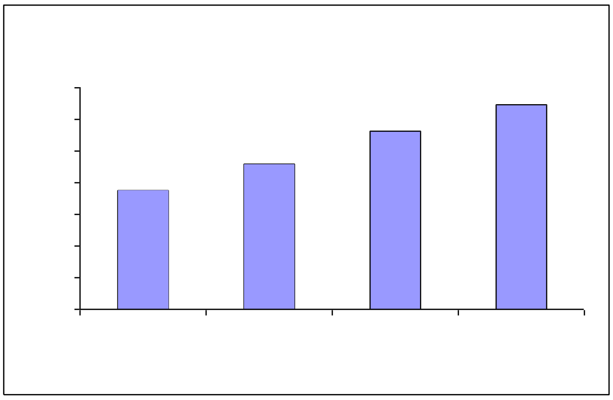
VI. Results and Discussions

A. Effect of fibre content on flexural Strength

As expected, it is clear from Figures 1 and 2 that the flexural strength of roselle composites increased with increasing in fibre content. The composites of without moisture showed a flexural strength value (67.1 MPa) at 30% fibre content while the composites with moisture showed the highest (64.5MPa, respectively) flexural strength at 30% fibre content. For 5-10% fibre contents, the composites without moisture show almost same amount (37.3MPa) flexural strength when compared with the composites with moisture (36.9MPa). A significant increase in flexural strength was observed in the composites of without and with moisture at 20 to 30% fibre content.

The specimens under without moisture give an increasing trend on increasing the fibre content. In contrary, under moisture condition, there is a small change in the flexural strength on increasing fibre content. The flexural strength of composites is highly influenced by the properties of the materials closest to the top and bottom surface of the samples. Quite interestingly, the performance of surface condition of composite is compression. This could be due to the expansion of the fiber is restricted by the surrounding matrix which in turn produce a un-equilibrium condition between fibers. This resulted the week bonding strength between the fibers and showed negative performance on applied load. The fractured surface of the composite is looking like brittle fracture.





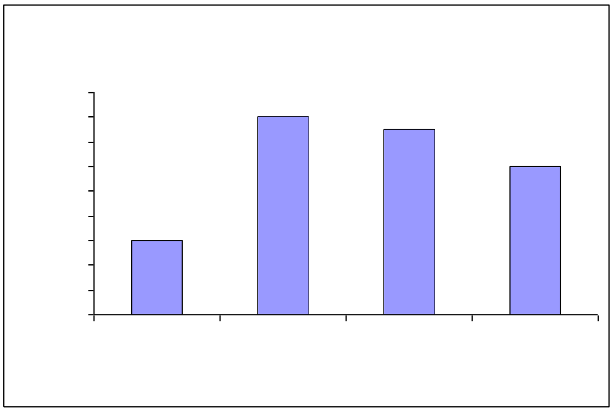


Fig. 3 Effect of fibre content on impact strength

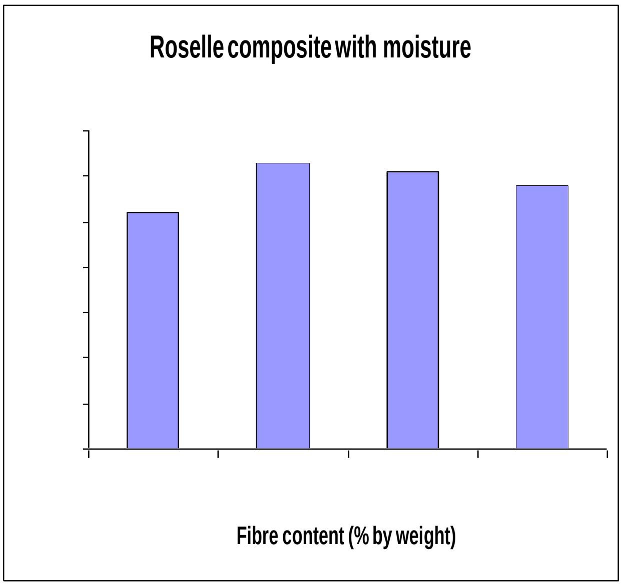


Fig. 4 Effect of fibre content on impact strength

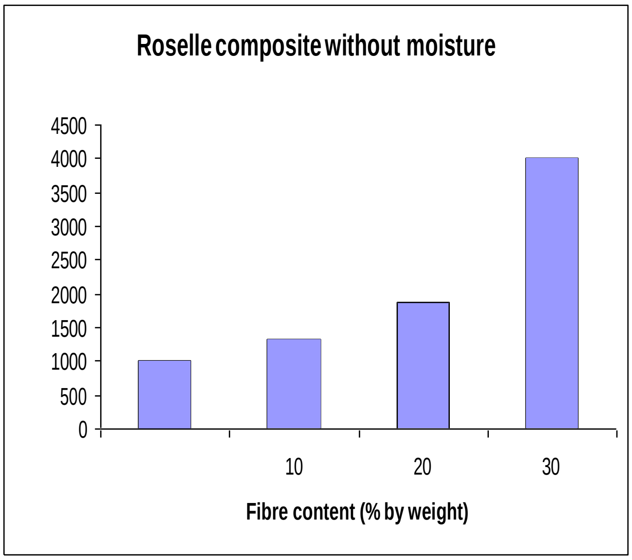
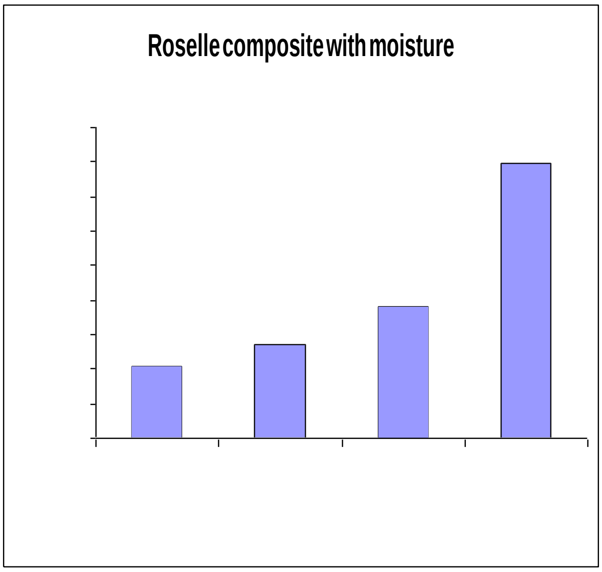


Fig. 5 Effect of fibre content on young's modulus

Effect on fibre modulus on tensile strength

As expected, fibre reinforcement resulted in a significant increase in modulus. This behavior was observed in both without moisture and with moisture roselle composites (see Figures 5 and 6). In the case of without moisture composites, 30% fibres content showed better reinforcements than 5%, 10% and 20% fibres content. Also in the with moisture composites, 30% fibres content showed better reinforcements than 5%, 10% and 20% fibres content. It is also clear that an increase in fibre content led to an increase in stress at break for without moisture composite materials. A large variation between stress at break for both without and with moisture composites can be observed (see Figures 7 and 8). In the case of without moisture composites, 5% and 30% fibres content showed the highest value of stress at break, but levels off at 10% and 20% fibres content. A sudden increase in stress at break was observed at 5% and 30% fibres content in with moisture composites and then remained constant with an increase in fibres content. It is observed that the modulus, stress at break and the strain at break of without moisture composites compare favorably well with moisture composites. The results obtained prove that the fibre contents and the type of matrix influence the modulus and the tensile strength of composites.



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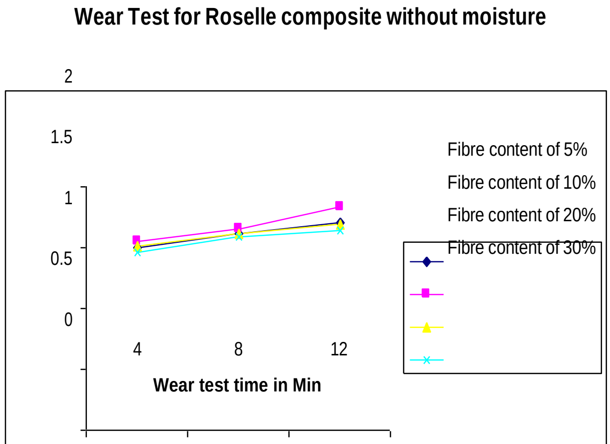

Fig. 7 Effect of wear test time on weight loss

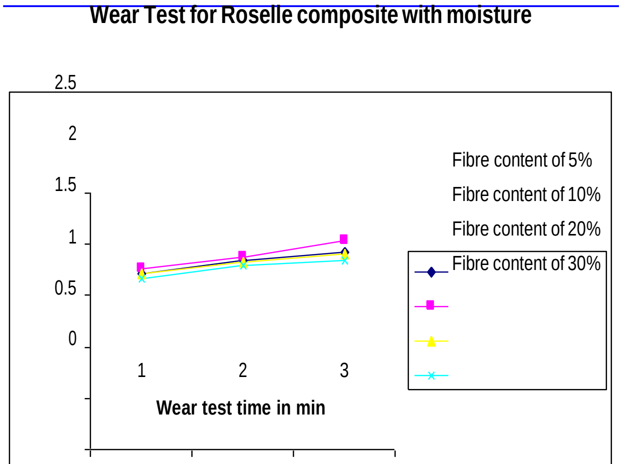

Fig. 8 Effect of wear test time on weight loss

The above figures depict the effect of wear test time on the weight loss of the roselle composite materials. Gradual weight loss is observed in all the cases. The composites with 30% fibres content are found to be of better wear resistant in both cases. The wear tests conducted for the with moisture samples showed inferior wear performance compared to the without moisture samples. The wear resistances of with moisture composites are found to be decreasing in gradual range. The reduction in the wear resistance could be expected due to the damaging of the fiber structure by reduction of fibre content. Uniform weight loss per time could be observed in all the cases.

VII. Conclusions

7.1. Influence of roselle fibres on mechanical properties

The roselle fibres content has an influence on mechanical properties. It was observed in roselle fibres /matrix composites that increasing the amount of fibre resulted in increasing the flexural strength, elastic modulus and tensile strength. An improvement in strength and stiffness combined with high toughness were achieved in without moisture by varying the fibre content. So to attain required mechanical properties such as flexural, tensile and impact, this research work were done using roselle fibres as reinforcements with polyester matrices.

7.2. Influence of processing conditions on composites

It was shown that the mechanical properties roselle fibres reinforced polyester compounds could be improved by optimizing the material compositions. In choosing the correct processing parameters (amount of catalyst, accelerator, curing time, etc), good mechanical properties can be achieved. Taking these influences into considerations parts made from natural fibre reinforced composites can be manufactured successfully by hand molding process. The major problem experienced was pouring the polyester, catalyst and accelerator mixtures in the molding box due to the bulk density of the fibres.

VIII. References

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