Tribological and thermogravimetric analysis of pineapple fibre reinforced epoxy composite

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Abstract Natural fibre composites are preferred for various static and dynamic applications owing to its biodegradable capacity and strength. Pineapple fibres obtained by the retting process from pineapple leaf were successfully reinforced with epoxy resin with different fibre volume percentage. The wear rate and the thermogravimetric analysis of the polymer composite were studied. It was discovered that 30% reinforcement of pineapple fibre resulted in better wear and higher glass transition temperature due to the optimal fibre volume fraction and enough wetting of the resin on the fibre.

1. Introduction

Natural resources are God’s gift to mankind. Natural fibres have gathered the attention of researchers due to its biodegradable nature after its usage lifetime, which is an essential lookout in today’s polluted world. However, the usage of natural fibres gets limited due to its less strength when compared to synthetic tailored fibre, attack by microorganisms particularly when it is exposed to moist conditions, the non-uniformity in the thickness, length and composition of each fibre as it is not man made. Hence the configuration of the fibre can be expressed as a wider range rather than a numeric value with precision unlike synthetic fibres.

However, the alarming threat of pollution and the call of the hour to reinvent man made materials have pushed the researchers to optimise these natural fibres tailoring to suit the needs of the society, without harming its natural integrity. Natural fibres extracted from jute, coir, hemp, cotton, banana etc., have been in use for more than a decade in the domain of composite materials. The search for new natural fibres has not exhausted and particularly in natural fibres in research is the pineapple fibre extracted from the leaves of the pineapple plant.

Pineapple leaf fibre is glossy, smooth and has a subtle surface than other natural fibres [1]. They have high specific strength, flexural and torsional rigidity equal to jute fibres [2]. Pineapple fibres have proved to surpass the previous mechanical properties of polymer-based composite [3]. However, the water absorbing nature of the fibres need to be addressed with suitable surface modification process [2,3]. Ahmad et al [4] have performed tensile, bending and shear tests on pineapple fibre reinforced polyester matrix and concludes that different concentrations in fibre gives rise to different mechanical properties. Pineapple fibres were reinforced in polypropylene matrix and studied for its mechanical properties. It was observed that the tensile strength is higher than the pure resin while the flexural strength was lower due to fibre-fibre interactions, voids and less dispersal [5]. Composites of pineapple fibres mixed in High density polyethylene were fabricated and tested for its water absorption properties.
The advancement in the fibre volume fraction led to the increase in moisture absorption which decreased the durability of the composite [6].

To manage the water absorption property of the pineapple fibres, it is mandatory to perform at least two successive chemical treatments, to deliver high mechanical properties. Additives and binders can be added to enhance adhesion [7]. Higher cellulose content in pineapple fibres increase the tensile strength of the fibre. A homogenous distribution of compatibilizers reduce the hydrophilic effect of cellulose and hinders fracture propagation and thereby maintains the tensile strength [8].

This paper approaches towards the study of tribological and thermogravimetric analysis of the pineapple fibre reinforced epoxy samples.

2. Materials and Methods

2.1. Fabrication of the composite material

Pineapple fibres were refined with NaOH solution and dried were used for the study. The fibres were procured from Go green products, Chennai. The fibres were checked for uniformity in length and the experimental procedure was done.

| Property         | Specification | Unit   | Araldite LY556 | Aradur HY951 |
|------------------|---------------|--------|----------------|--------------|
| Viscosity at 25°C| ISO 12058     | Mpa.s  | 10,000-12,000  | 10-20        |
| Density at 25°C  | ISO 1675      | Gm/cc  | 1.15-1.20      | 0.97-0.99    |
| Flash point      | ISO 2719      | °C     | >200           | >180         |

For preparation of the specimen, wet hand lay-up method was used. The mylar sheet was kept in the mould followed by the application of epoxy resin in the mould. The epoxy LY556 resin having the density of 1.15-1.20 with hardener HY951 of the density 0.97-.99, was mixed in the ratio of 1:10. Initially the resin is applied in the mould, followed by keeping the pineapple leaf fibre having the specific gravity of 1.3 gm/cc in horizontal direction. Again, the epoxy resin is applied and with the assistance of roller the epoxy resin is impregnated in the fibres. In all three layers of pineapple was sandwiched into one to make a firm layer. Later the specimen was kept at 25°C for 24 hrs. The preparation of the composite sample is shown in Figure 1.
Two samples were produced where Sample A consisted of 50% of pineapple leaf fibre and 50% epoxy resin and the Sample B consisted of 30% of pineapple leaf fibre and 70% epoxy resin. After hardening the specimen was cut by the means of water jet machining into 25mm diameter and 10mm height. The specimens used for wear test is shown in Figure 2.

![Specimen A and B](image)

Figure 2. Samples for wear testing.

### 2.2 Wear test

The dry sliding wear studies were conducted using pin on disc machine shown in Figure 3. The composite material was taken as the disc and the pin made up of carbon steel.
The settings on the pin on disc wear testing machine is given in Table 2.

**Table 2.** Wear testing parameters.

| Parameter               | Setting |
|-------------------------|---------|
| Applied load (N)        | 10      |
| Sliding velocity (m/sec)| 1.5     |
| Sliding distance (m)    | 500     |
| Sliding diameter (mm)   | 46      |
| Speed (rpm)             | 623     |
| Time (Secs)             | 333.33  |

3. Results and Discussions

3.1. Wear testing
It was concluded that sample A (50% pineapple leaf fibre and 50% epoxy resin) whose initial weight was 14.181 gm and after the test the final weight was 13.502 gm which shows about 4.7880% wear loss. Whereas the sample B (30% pineapple leaf fibre and 70% epoxy resin) the initial mass was 17.263gm which after the test it was found 17.122gm that is 0.816775% wear loss. Sample B was denser than Sample A as the resin volume was higher.

With the advancement in the time, the volume of wear of sample A increases from 0 to 700, whereas it increases from 0 to 200 for sample B. The coefficient of friction of sample A was found increasing from 0 to 0.99 but it was 0 to 0.2 for sample B. The frictional force of sample A was 15N whereas it was found 2N for sample B. This describes that sample B (30% pineapple and 70% epoxy resin) is much durable. Figures 4-6 shows the results obtained from the Wear test. On an average the coefficient of
friction of Sample A was found to be 0.83 and for Sample B it is 0.17. The lesser the fibre content, less the coefficient of friction leads to more durability.

**Figure 4.** Coefficient of friction of the samples.

**Figure 5.** Wear volume of the samples.

**Figure 6.** Frictional force in the samples.
3.2 Thermogravimetric Analysis: Thermogravimetric analysis was conducted using ASTM D-3418 standard with an increase of 2°C/min rate of heating. Figure 7 shows the heat flow Q across various temperatures for Sample A and Sample B. It could be observed that the Sample A yields around 52°C. Epoxy has been proved to take up between 105 to 135 ºC (9). The reason of drastic reduction is the nonbonding or non-adhesiveness of the pineapple fibre with the epoxy resin. And also the higher weight percentage of fibre leaves the sample starved of the resin leading to lesser adhesiveness. Whereas Sample B yields at 2 points- one at 67.15 ºC and another at 108.27 ºC. The presence of two T_g points show that the two materials yields at two different points independently. The fibre yields at lesser temperature well before epoxy. However, fibres in Sample B shows better performance than Sample A because of better boding due to the enhancement in the resin content.

![Sample A](image1.png) ![Sample B](image2.png)

**Figure 7.** TGA graphs for the samples.

4. Conclusion

Samples of pineapple reinforced epoxy composite were prepared using hand lay-up process and tested for wear and thermal properties. It was confirmed that the sample with 30% of fibre reinforced had better performance and results compared to 50% of reinforcement. However, the optimal amount of reinforcement can be decided only after testing few more samples with different reinforcement percentages.

5. References

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