DEVELOPMENT OF BONE PLATE FOR FRACTURE FIXATION USING NATURAL COMPOSITE MATERIALS

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ABSTRACT:

Owing to the frequent occurrence of bone fractures, it is important to develop fracture fixation plate materials for fractured bones. Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. These materials have to be lightweight, compatible with human tissues and ought to allow stiffness. Natural fibres have the advantage that they are renewable resources, high strength, stiffness, acoustic isolation, no skin irritation and low cost. By using these advantages the development of bio composite materials based on bio epoxy resin, Hardener and natural fibres such as Musa sepientum (Banana); Hibiscus sabdariffa (Roselle) and its application in bone grafting substitutes. These materials are fabricated in desired shape with the help of various structural patterns and calculating its material characteristics such as tensile strength, hardness, water absorption and thermal analysis.

KEYWORDS:

Natural fibres, Orthopaedic implants, Bio epoxy Resin, Mechanical properties.

1. INTRODUCTION:

Orthopaedic surgeons have been using metallic plates for the fixation of bone fractures. These metallic plates made of titanium, stainless steel, cobalt chrome and zirconium. It has the several disadvantages like metal incompatibility, corrosion, magnetism effect, and anode-cathode reactions. The natural fibre reinforced polymer (NFRP) overcomes these problems which are arising by metallic materials. An NFRP composite material uses pure natural fibres and polymers that are less rigid than metals.

Mechanical properties are closer to bone mechanical properties. Composites material comprise of reinforcement and matrix. Reinforcement is a strong load carrying material which provides strength and low rigidity and helping to support structural load. The matrix maintains the position and orientation of the reinforcement. Composite material provides better mechanical properties compared to single conventional materials.

The natural fibres such as Banana and Roselle have to be used as a replacement for reinforcement materials in composites. These fibres have low density, high toughness, reducing tool wear, ease of separation, low energy of fabrication, impact resistance and flexibility. The main advantages of natural fibres are biocompatibility and biodegradable. The bio epoxy resin Grade 3554A and Hardener 3554B used as matrix because of their higher adhesion and less shrinkage. Strength and stiffness of fibre composites depend on fibre concentration, fibre aspect ratios, fibre matrix adhesion, as well as fibre Orientation.

2. MATERIALS:

Natural fibres have many advantages such as low density, appropriate stiffness, mechanical Properties, high disposability and renewability. Moreover, they are recyclable, biodegradable and have high cellulose and lignin content. Natural fibres such as Banana and Roselle possess good reinforcing capability when properly compounded with polymers.

2.1. BANANA:

Banana plant belongs to Musa family which has high strength and good mechanical properties. It is the largest herbaceous flowering plant. Fibre obtained from the pseudo-stem of Banana plant which is clustered, cylindrical aggregation of leaf stalk bases. All parts of the Banana have been used in medicinal applications.

2.2. ROSELLE:

Roselle is annual herbaceous shrub or woody-based shrub, belonging to the family Malvaceae, growing to 2–2.5 m tall. It is an annual plant, and takes about six months to mature. Fibres are extracted from the stem of Roselle plant. Hibiscus, specifically Roselle, has been used in folk medicine for cardiac and nerve diseases and cancer.

Table 2.3 Materials

Materials	**Type**
Reinforcement	Banana, and Roselle fibres
Matrix	Bio epoxy resin
Catalyst	Bio epoxy hardener
Releasing agent	Poly vinyl alcohol

3. PROCESSING STEP:

The extraction of fibres carried out from Banana and Roselle plant.

3.1. CHEMICAL TREATMENT:

The fibres were cleaned normally in clean running water and dried. A glass beaker was filled with 6% NaOH and 80% of distilled water which make a solution. After the adequate drying of the fibres in normal shading for 2–3 hours, the fibres were taken and soaked in the prepared NaOH solution. Soaking is carried out for different time intervals, depending upon the strength of the fibre required. For our project the fibres are soaked in the solution for three hours. After completing the soaking process, the fibres are taken out, washed in running distilled water and dried for another 2 hours. The dried natural fibres are cut in the length of 500mm by manually. The cut natural fibres are used in fabricate the natural fibre reinforced epoxy composite material.

4. MOULDING TECHNIQUE:

4.1. COMPRESSION MOULDING:

Different compositions of the composite materials have been selected for the characterisations of composite materials such as proportion 75% bio epoxy resin with 25% of hybrid materials (Banana & Roselle), and 65% bio epoxy resin with 35% of hybrid materials (Banana & Roselle). The resin and hardener were taken in different ratio. The working surface was cleaned with thinner to remove dirt and a thin coat of wax is applied on the surface to get smooth finish. Then a thin coat of polyvinyl alcohol (PVA) is applied for easy removal of mould. The process of compression moulding is starts with an allotted amount of releasing agent placed over or inserted into a mould. Afterward different composition of natural fibres with epoxy resin is heated (150 to 200°c) to a pliable state by the mould. After the fabrication of composite materials that are cut to required dimension for test the specimen. . All test specimens were moulded and prepared according to ASTM standard to avoid edge and cutting effect, thereby minimizing stress concentration effect. The advantage of compression moulding is fast settling time, good surface smoothness, and capable of large size parts beyond the capacity of extrusion techniques.

5. RESULT AND DISCUSSION:

5.1 WATER ABSORPTION TEST:

Water absorption is used to determine the amount of water absorbed under specified conditions. Initially the Composite materials were dried in an air oven at 50 °C. Then these conditioned materials were immersed in distilled water, acid solution and alkaline solution at 30 °C for about 24 hours. The material were removed from water and wiped with filter paper to remove surface water and weighed with digital balance of 0.01 mg resolution. The weighing was done within 30 s in order to avoid the error due to evaporation. The test was carried out according to ASTM D570 to find out the swelling of specimen. Gain rate was calculated by the formula

$$M\% = \frac{M1-M0}{Mo} \text{ x } 100$$

Where M= Moisture content in percentage

M1= Moisture content of wet sample

Mo= Initial weight of sample

Table 5.1.1 Water absorption

Composite material	**%gain of water**
Banana	0.097
Roselle	0.135
Hybrid (Banana & Roselle)	0.058

5.2 THERMAL ANALYSIS:

Thermal analysis of composite material gives a good thermal stability and degradation of the material can be analysed. Materials were carried out in a cleaned atmosphere. The materials are heated from 50°c to 200°c by increasing

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10°c and the effect of the material are analysed at different temperature.

5.3 DENSITY TEST:

Density test is used to calculate the relationship between weight of the substance and its size. It can be calculated by using the formula,

$$D = \frac{M}{v}$$

Where D=Density of the composite material

M= Mass of the composite material

V= Volume of the composite material

Table 5.3.1 Density Test

Composite material	Mass [gm]	Volume [mm³]	Density [10^{-4} gm/mm³]
Banana	7.0	49087.38	1.426
Roselle	7.10	49087.38	1.446
Hybrid (Roselle and Banana)	7.16	49087.38	1.458

5.4 TENSILE TEST:

Tensile strength of the natural fibre is the maximum load that a material can support without fracture when being stretched and divided by the original cross-sectional area of the material. The tensile tests were conducted according to ASTM D 638 with a Universal Testing Machine. Tests were performed at a crosshead speed of 2 mm/min and at room temperature and the results were shown in the table.

Table 5.4.1 Tensile Test

Materials	Cortical bone	Stainless steel	Hybrid (Banana and Roselle)
Tensile strength	133	586	520

6. CONCLUSION:

A composite material contains various natural fibres as the reinforcement phase and the properties of fabricated natural fibre reinforced composites were observed. It is found that Hybrid reinforced natural composites is the best natural composites among the various combination. In future, the final composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone.

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