# OPTIMIZATION OF BIO-COMPOSITE HELMET

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**Abstract:** *The primary aim of our project is to increase the safety of helmet users and also to reduce the usage of plastic. This led us to the idea of BIO-COMPOSITE HELMET. Generally, bio-composite materials are synthesized using natural fibers as reinforcements together with matrix due to their low density with high specific mechanical strength, availability, renewability, degradability. The present work attempts to make an improvement in the existing helmet manufacturing process. The materials that are used have better mechanical properties in order to enhance the compatibility between fibers and the matrix. The bio-composites are prepared using unsaturated polyester matrix and fibers such as coconut coir and areca using hand lay-up method with appropriate proportions to result in helmet shell structure. The fabricated helmets will be evaluated for their mechanical properties such as hardness, impact strength and compression strength. Thus, we constructed the bio-composite helmets that has highly strong and environment friendly.*

***Key Words***: **Coconut coir, Areca, Epoxy resin, Adhesive making, Surface treatment of fibres, Hand lay-up method, Mechanical Properties.**

## 1. INTRODUCTION

Recently, the major environmental problem faced today is the non-degradable plastic wastes. The tremendous production and use of plastics in every segment of our life has increased the plastic waste in huge scales. The waste disposal problems, have directed great part of the scientific research to eco-composite materials that can be easily degraded or bio assimilated. Natural fibers have advantages such as low cost and very light weight. However, they suffer from lower Mechanical properties compared to glass fibers. To overcome this drawback, hybrid fibers could be a potential solution and investigated by few researchers. Nowadays biodegradable polymers, the number of polymer matrices that could be used in eco-based composite formulations are significantly increased. The research field of biodegradable polymers is still in its early stages, but is growing in popularity every day. In the present study, an attempt has been made to reinforce, epoxy resin matrix with multiple natural fibers and to characterize its mechanical performances to evaluate their suitability for helmet applications.

## 2. MATERIALS AND METHODS

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The raw materials used in this work are

### 2.1. MATERIALS USED

- ✓ *Loctite Tough x1 Epoxy Resin*
- ✓ *Loctite Tough x2 Hardener*
- ✓ *Natural Fibers (Areca, Coconut Coir)*
- ✓ *NaOH Solution*
- ✓ *Adhesive*

**Table 2.1: Properties of Natural Fiber**

| Properties of Natural Fiber | | | |
|---|---|---|---|
| **Plant Fibers** | **Density (Kg/m3)** | **Tensile Strength (MPa)** | **Young's Modulus (GPa)** |
| **Coconut Fiber** | 1150 - 1250 | 106 - 175 | 6 - 8 |
| **Areca Fiber** | 800 - 1050 | 65 - 95 | 3 - 5 |

### 2.2. METHODOLOGY

#### 2.2.1. Step 1: Selection of matrix material

Loctite Tough x1 Resin belonging to the Epoxide family was used for bonding the fiber. Loctite Tough x2 Hardener was used as the hardener.

#### 2.2.2. Step 2: Selection of reinforcement and Natural fibers

Natural fibers such as Coconut coir, Areca were taken to fill as reinforcements in the Polymer composite.

#### 2.2.3. Step 3: Extraction of fibers

**Coconut Coir Fiber:**

Coconut coir and Areca fiber was gathered and soaked in NaOH solution and then in water.

**Fig -2.1**: **Coconut Coir Fiber**

**Areca Fiber:**
Areca fiber reinforced epoxy composites were studied under 40%, 50%, 60% and 70% fiber loadings. Impact strength increased with increase in fiber loading up to 60% and then showed a decline for all untreated and chemically treated areca fiber reinforced epoxy composites. The acrylic acid treated areca fiber reinforced epoxy composites with 60% fiber loading showed highest impact strength of 28.28 J/mm2 amongst all untreated and chemically treated areca/epoxy composites with same 60% fiber loading. Mechanical behavior of areca composites was studied by few investigators and they found to have a good flexural strength and adhesion tensile properties at 60% fiber loading. Chemical interlocking at the interface was enhanced and better adhesion with the matrix was observed after potassium permanganate treatment of natural lignocellulose fibers with 6% and 33% improvement on tensile strength and moisture resistance properties.

**Fig -2.2**: **Areca Fiber**

### 2.2.4. Step 4: Mould making

**Fig -2.3: Mould Making**

A mould was prepared for fabrication of helmet using white cement and plaster of Paris. The mixture was poured in a full faced helmet and was left to dry. Then the mould was obtained by breaking the helmet.

### 2.2.5. Step 5: Preparation of Adhesive

A special type of adhesive comprised of polystyrene and petrol was made by us to see if it could enhance the bonding of the material. When polystyrene is soaked in petrol, it dissolves and forms adhesive mixture. This mixture was used to bond the material.

**Fig -2.4: Adhesive Making**

### 2.2.6. Step 6: Surface treatment of fibers

Freshly drawn fibers generally include lots of impurities that can adversely affect the fiber matrix bonding. Consequently, the composite material made from such fibers may not possess satisfactory mechanical properties. There-fore it is desirable to eliminate the impurity content of the fibers and perhaps enhance the surface topography of the fibers to obtain a stronger fiber-matrix bonding. The fibers were left to treat with 5% NaOH for 3-4 hrs. Later they were drawn and dried under sunlight for 1-2 hours.

**Fig -2.5: Surface Treatment with NaOH**

### 2.2.7. Step 7: Wet Hand lay-up technique

Hand lay-up technique is the simplest method of composite processing.

**Fig -2.6: Sample preparation by wet hand lay-up process**

## 3. SAMPLE COMPOSITIONS

### 3.1 Sample compositions

**Specimen** -1: Coconut Coir- 70%; Areca Fiber 30%
**Specimen** -2: Coconut Coir - 30%; Areca Fiber 70%
**Specimen** -3: Coconut Coir- 50%; Areca Fiber 50%

## 4. Compositions

**Table 4.1: Compositions**

| S.no | Material | Composition |
|---|---|---|
| 1 | Coconut coir | 70% |
| 2 | Areca fiber | 30% |

## 5. TESTING AND RESULTS

### 5.1. Impact test results

The following tables provide the details of the Impact test results obtained for various combinations of Natural fibers reinforced bio-composites.

**Table 5.1. Impact test result**

| Specimen | Impact energy absorbed joules |
|---|---|
| Sample-1 | 6 |
| Sample-2 | 4.9 |
| Sample-3 | 5.8 |

### 5.2. Hardness test results

**Table 5.2. Hardness test result**

| Specimen | Rockwell Hardness Test |
|---|---|
| Sample-1 | 30 |
| Sample-2 | 25 |
| Sample-3 | 27 |

### 5.3. Compression Test Results

**Table 5.3. Compression test**

| Specimen | Compression Test (Kgf) |
| --- | --- |
| Sample-1 | 140 |
| Sample-2 | 130 |
| Sample-3 | 120 |

### 5.4. Test Result of Bio Composite Helmet

The impact, compression and hardness test are conducted, from the results we concluded the test specimen 70% coconut coir and 30% areca fibers were given better results compared to other two test specimen so we are decided to make a composite helmet by using 70% coconut coir and 30% areca fibers composition.

**Table 5.4. Test results**

| Specimen | Impact | Compression | Brinell hardness |
| --- | --- | --- | --- |
| Sample 1 | 6 | 140 | 30 |
| Sample 2 | 4.9 | 130 | 25 |
| Sample 3 | 5.8 | 120 | 27 |

### 5.5. Fabrication of bio-composite helmet

Fabrication of the helmet was carried out by adopting the following hand lay process procedure. Initially a layer of adhesive (mixture of polystyrene and petrol) is coated over the mold shown in, which will act as an adhesive for a bottom layer of coconut coir. Over the coconut coir once again a layer of epoxy is applied, subsequently the natural fiber reinforcements such as chopped areca fiber, coconut coir fibers are placed respectively. A layer coconut coir is placed as a top layer. Subsequently, allowed for settling time of about 12 – 24 hours. The coconut coir used prevents the de-bonding of the fibers. After releasing well cured and dried helmet from the mold, The Loctite Tough x1 Resin and the Loctite Tough x2 Hardener mixture were applied over the helmet to enhance the bonding and the finishing. The extra projections were cut, filed and smoothened with help of sand paper to achieve the desired shape.

**Fig -5.1: Bio Composite Helmet Fabrication**

## 6. CONCLUSIONS

In the present work, bio-composite with multiple natural fibers such as Coconut coir, Areca fibers have been successfully reinforced with the epoxy resin by simple and inexpensive hand lay-up technique. The mechanical testing results of fabricated bio-composite helmet indicate that concept of using multiple natural fibers is viable for helmet application. However, there is a scope to optimize the volume fraction of natural fibers as reinforcements to achieve enhanced mechanical properties of helmet. So it is clearly indicated that reinforcement of natural fibers has good and comparable mechanical properties as conventional composite materials.

## 7. Scope of Future Improvement

In future, the bio-composite helmets may find their application for two-wheeler users and bicycle riders. They may also be widely used as safety precautions in production industries factories and construction sites. The bio-composite helmets may be made completely biodegradable and environmentally friendly in the future. With the research in the bio composites these helmets may be made with higher strength and affordability in the future. The weight of the helmet can be reduced in the future. With further developments and improvements in performance new opportunities and applications are likely to be arised. Bio technology is being used to modify and/or increase the yield of specific triglycerides and oils in crops for producing resins. These resins will also be inexpensive compared with those available today and, if suitably modified would be biodegradable. There are also opportunities for hybrid helmets by using bio resins and bio plastics as adhesives in place of current fossil-based adhesives.

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## Final Product