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# Fabrication and Characterization of Locally Woven Polyester Fibre Reinforced Polyester Composites

***[1]M. T. Isa, [2]P. A. P. Mamza, [1]T.K. Bello and [1]A.U. Ndanusa**
**[1]Department of Chemical Engineering, Ahmadu Bello University, Zaria**
**[2]Department of Chemistry, Ahmadu Bello University, Zaria**
**[*Corresponding Author: mtisa@abu.edu.ng or mtisaz@yahoo.com]**

**ABSTRACT:** Properties of composite moulded using locally woven polyester fibre were studied. The results showed that though properties of polyester resin were improved upon, but were far lower than composites obtained using fibre such as glass. The density of the composite was low compared to glass fibre reinforced composite. The composite moulded at pressure of 388.132kN/m$^2$has the best properties; tensile strength 85MN/m$^2$, modulus of elasticity 1.846GN/m$^2$, impact strength 227.5kJ/m$^2$ and modulus of rupture 9.910GN/m$^2$.

## INTRODUCTION

Composite material is one in which two or more materials are combined to form a single structure with an identifiable interface. The properties of the new structure are dependent upon the properties of the constituent materials as well as the properties of the interface (Argwal and Lawrence, 1980; Hull and Clyne, 1996). Fibre reinforced plastic composites (FRP) which constitute a class of composite materials are extensively used in aero space, automobiles, defence, households and have other applications (Lawrence and Richard, 1974).

Composite materials have advantageous characteristics of high specific modulus, high specific strength and the capability of being tailored for specific applications (Thanomslip and Hogg, 2002). These materials have exceptional formability, high corrosive resistance, outstanding durability and fast replacing traditional engineering materials such as metals and ceramics because of these outstanding properties (www.epp.goodrich.com).

The most commonly used FRP is the glass fibre reinforced plastics. Glass fibres have high stiffness and are cheap when compared to other fibres. However they have low strength and high density. The requirements in the aerospace, automobiles, defence and some recreational application of composites include weight saving (Callister, 1997), hence the need to investigate the use of other lighter fibres. Single polymer composites are a new type of composites material where both the reinforcing phase and the matrix phase are the same polymer.

The aim of this work was to mould single polymer composite of polyester using locally woven fabric and hand lay up method.

## METHODOLOGY

### Characterization of Locally woven fibre

The polyester fibre used in this work was locally woven and the properties were not known, therefore the need to characterize it. The woven fibre was characterized for ultimate tensile strength, and modulus of elasticity at the Standard Organisation of Nigeria, Textiles Materials Laboratory, Kaduna. Universal tensile strength machine (INSTRON) was used according to NIS79: 1980 UDC 667.017.424.5 standard. 10 tensile test samples of 150mm each were taken and conditioned for 24 hours at 27$^o$C and 67% relative humidity, in order to attain equilibrium. The test was conducted with the machine speed of 60mm per second. The mean load which sample ruptured was used to evaluate the tensile strength.

**Mould Preparation**

The composite samples were fabricated using the hand- lay up method in a metallic mould of internal dimensions of 21cm x 16cm x 4cm. The mould was cleaned and dried to remove all dirt. The cleaned mould was coated with melted candle wax with the aid of 2.5 inch pure Bristles brush. Vaseline was applied to the candle coat for easy removal of the material from the mould.

**Preparation of the Polyester Fabric**

The locally woven fabric mat was cut to dimensions of the mould in length and breadth using scissors. Several layers of the fabric were cut out of the roll.

**Preparation of Polyester Mix**

200cm$^3$ of polyester resin were measured with a beaker and 4cm$^3$ of methyl ethyl ketone peroxide catalyst were added, the mixture was stirred with a glass rod. 4cm$^3$ of cobalt accelerator were then added to the mixture and further thoroughly stirred for about 2 minutes.

**Moulding the of the Composite Material**

A thick coat of the polyester mix was applied by brush on the cleaned metallic mould. After which the first layer of the cut polyester fabric was gently placed on the coat. Another coat of polyester mix was applied to the fabric to ensure that the fabric was totally coated with the mix. The procedure was repeated for subsequent layers of fabric. It was observed that 3 layers of the polyester fabric were enough to give the required thickness (4mm) of the test sample for the tensile strength. The mould was covered and load applied on it for compression and left for six hours to cure. The material was removed and transferred to the oven for another six hours at temperature of 60$^o$C. The same procedure was adopted for the 7 layer samples required for the impact and bending tests. Some sets of samples were moulded with application of load for compression.

**Determination of Material Properties**

The samples were cut into standard test sample shapes and sizes close to ASTM D 3039-76 for the tensile strength test, while the dimensions reported by Werner (1960) were adopted for the Charpy impact test. The tensile strength test was conducted using *Monsanto Tensometer* W: (Made in England) at the Kaduna Polytechnic, Kaduna. The impact test was conducted using *Avery* Impact Testing Machine Type 6703 capacity: 163 Nm -299 Nm. The dimensions of the samples used were as reported by Werner (1960) for Charpy impact test. The density of the material was determined using the procedure outlined in Hull and Clyne (1996).

## RESULTS AND DISCUSSION

**Table 1:** Properties of Locally Woven Polyester Fabric

| Property | Value |
|---|---|
| Mean breaking load(N) | 45.480 |
| Mean extension at break (mm) | 5.736 |
| Percentage elongation (%) | 3.824 |
| Specimen cross sectional area (m$^2$) | 1.257x10$^{-7}$ |
| Ultimate tensile strength (MN/m$^2$) | 361.918 |

Mean value of six samples taken for the test were reported in Table 2. The coefficients of variance were 1.37%, 3.2%, 0.59% and 1.42% for the ultimate tensile strength, modulus of elasticity, impact strength and the modulus of rupture respectively. The coefficient of variance for the ultimate tensile strength, modulus of elasticity, impact strength and modulus of rupture in Table 2 were 1.38%, 3.4%, 0.48% and 1.40% respectively. The tensile strength determined for the locally woven fabric as 361.918 $kN/m^2$ is far lower than that of other fibres such as glass with tensile strength of 3.4 $GN/m^2$ and Kevlar 49 with tensile strength of $3.1GN/m^2$. Fibres are easily damaged if not properly handled, probable damages would have set in during the process of weaving. More so, the locally woven fabric was not chemically treated. Treatment improves the mechanical properties of materials thereby eliminating structural defects (Weatherhead, 1980). The manual weaving adopted may also have contributed to the low mechanical properties of the fabric. It may not promote homogeneity and compactness of the fibre, hence generating non- uniform stresses which reduce material properties.

The mechanical properties of the composite moulded using compressive force were higher than those moulded without pressure. This may be attributed to the removal of air bubbles in between layers of the composite during compression and impaction of strong adhesive bond between fibre and matrix.

**Table 2:** Properties of the Composite Moulded using

| Property | Compressed (at a Pressure of 388.132kN/$m^2$) | without Compression |
|---|---|---|
| Ultimate tensile strength ($MN/m^2$) | 85 | 78 |
| Modulus of elasticity ($GN/m^2$) | 1.846 | 1.362 |
| Charpy impact strength ($kJ/m^2$) | 227.5 | 203.8 |
| Modulus of rupture ($GN/m^2$) | 9.910 | 3.502 |
| Density ($kg/m^3$) | 1320 | 1320 |

The properties of the moulded composite were lower compared to the composite obtained from glass fibre with modulus of elasticity of 103-310 $GN/m^2$ and tensile strength of 206-344 $MN/m^2$ (Smith, 1990). The already low mechanical properties of the fibre used would have caused the wide difference in values. However, the fibre incorporated improved the strength of the polyester resin and the modulus of rupture. The density of the composite was determined to be 1320 $kg/m^3$. This value is lower than that of glass fibre reinforced composite which has a value of density of 2066 $kg/m^3$ (Isa, 2003). The impact strength of the composite moulded was higher compared to Modmor II graphite- epoxy and 2024- T3 aluminium of Charpy notched impact strength of $114kJ/m^2$ and $84kJ/m^2$ respectively and lower than Kevlar –epoxy and 4130 steel alloy with impact strength of 694 $kJ/m^2$ and $593kJ/m^2$ respectively (Argwal and Lawrence, 1980).

This material can be considered for applications where weight saving, high impact strength is required and high tensile strength is not much of concern.

## CONCLUSION

From the work, the following conclusion can be drawn. Some mechanical properties of polyester resin were modified. The composite moulded using the locally woven polyester fabric had lower mechanical properties compared with literature values of composites developed from other fibres. The composite mould had density of $1320kg/m^3$, which is far lower than that of glass fibre reinforced composite. The composite moulded using compression had better properties compared to the one without compression.

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