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Effects of Animal Hair Fibre on Polyester Resin

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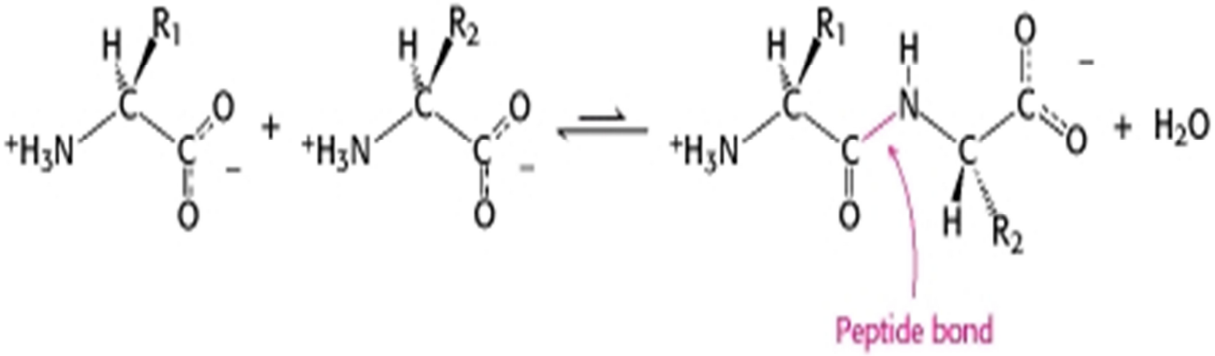
Abstract
The effect of animal hair fibre on polyester resin was examined. The animal hair fibre was obtained from the Hausa – specie she-goat from Abattoir in Awka, Anambra State, Nigeria. The animal hair was washed and dried at 39^{o}C for 3 hours at constant weight. The percentages by weight of animal hair sample used were 3%, 6%, 9% and 12% (w/w). The percentage by weight of the hair fibre was cast into the polyester resin, cured with accelerator and catalyst, stirred and cast into the dumbbell shaped and Teflon mould. The composite cured in the mould at a room temperature for 24 hours after which it was heat treated in the oven at 80^{o}C for one hour for dimensional stability of the composite. From the results, the tensile strength of the composite increased from 3% (16.6698MPa) – 9% (29.3033MPa) with a sharp decrease in 12% (20.4288MPa) volume ratio. The tensile strength of the control sample 0% (30.0991MPa) was higher than the reinforced composites. The Modulus of the composite increased from 3% (541.2377MPa) – 9% (598.1224MPa) with a sharp decrease in 12% (530.1571MPa) volume ratio. The control sample 0% has higher modulus (649.4003MPa) than the reinforced composites. The load at break of the sample increase gradually as fibre loading increases from 3% (709.1161 MPa) to 9% (1084.2570MPa) after which there was a decrease as fibre volume increase to 12% (893.0747MPa). Flexural strength peaked at 6% fibre load (83.1131MPa) while there was variation in the results of flexural modulus with 9% fiber load having the highest value (2329.6509 MPa). The control sample has the value of (75.2204 MPa) for flexural strength and (2231.6092 MPa) for flexural modulus. The hardness result of the sample decreased from 0% (22.0667HV) - 6% (17.6667HV) volume ratio but increased as the fibre load increased from 9% (23.1667HV) – 12% (25.7333HV).
Keywords: Animal hair, Polyester resin, Composite, Fibre.

INTRODUCTION

Nowadays, natural fibre composites have gained increasing interest due to their eco-friendly properties. Natural fibres such as jute, sisal, animal hair and coir are inexpensive, abundant and renewable, light weight with low density, high toughness and biodegradable (Chandra, 2009).

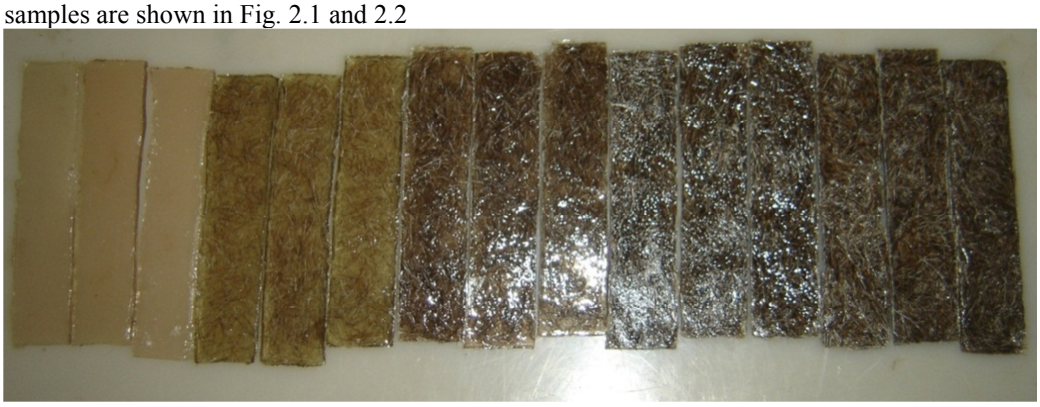
Natural fibre such as animal hair is surprising strong. Cortex keratin is responsible for this property and its long chains are compressed to form regular structure (Valeria et al., 2009). The hair fibre is made of mainly keratin protein with primarily alpha-helix structure. Approximately, 91% of hair is protein made up of long chain of amino acid. The long chain is linked by peptide bond (C(O)NH).



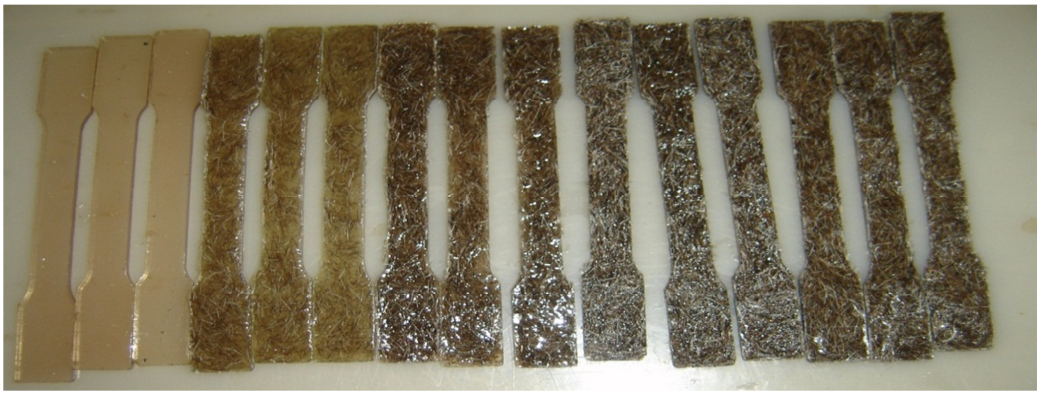
The chemical composition of hair fibres is dominated by carbon which comprises about 45% of the atomic structure of hair. Oxygen accounts for approximately 28%, hydrogen 7%, nitrogen 15% and sulphur 5% (Mohini *et al.,* 2011) Several essential trace elements are also present in hair including iron (20-220ppm), copper (10-20ppm), zinc (190pm), and iodine (0.6ppm) (Wella, 1999). The physical properties of animal hair, stretching, elasticity and hydrophilic power (Juez and Gimier, 1983) makes it suitable to be used as a replacement for traditional reinforcement materials in composite for applications which requires high strength to weight reduction. Natural fibres as actual and potential reinforcement composites offer many advantages: good strength properties, low cost, high toughness, biodegradability. A large number of literatures have been reported on composite based upon these plants-based natural fibres earlier. However, the use of animal-based natural fibres

in composite materials has been rarely reported. Investigation on the mechanical properties of animal hair is inadequate.

EXPERIMENTAL
MATERIALS AND METHOD
Materials
Sample collection
Animal hair Sample was sheared by hand from the Hausa-specie she goat in Abattoir, Awka, Anambra State. Unsaturated Polyester Resin, Cobalt Octoate (Accelerator), Methyl Ethyl Ketone Peroxide (MEKP)-Catalyst and Acetone Poly Vinyl Alcohol (PVA) [mould releasing agent] were bought from the market.
Sample Preparation
The animal hair fibre sheared from the Hausa specie of she goat was washed with detergent to free them from dung, dirt, soil etc. and rinsed many times with distilled water. The samples were dried in an oven at 39^0C for three hours to a constant weight. The dried samples were cut into random short length of between 5mm-10mm. This was used for all the different percentage compositions of polyester resin that were used for the composite preparation.
Composite Preparation
The composites were prepared at different percentage (w/w) of random short length animal hair fibre in the polyester resin matrix. The percentage by weight of Animal hair fibre used for the experiments were 3%, 6%, 9%, and 12%. (w/w). After weighing the appropriate quantity of the animal hair fibre, it was added to the polyester resin matrix, 1% of both catalyst and accelerator were used to cure the mixture. The mixture, was stirred for 2-5 minute depending on the percentage composition, and cast into an aluminum mould which has a dumb bell shape for tensile test, and into a Teflon mould for both flexural and micro hardness test. The mixture was allowed to cure in the mould at room temperature for 24hours, after which the sample was removed from the mould and heat treated in an oven at 80^0C for one hour, to improve the dimensional stability of the composite. The cured samples were removed from the oven and set for mechanical properties determination. The prepared samples are shown in Fig. 2.1 and 2.2



Animal hair polyester composite using the Teflon mould



Animal hair polyester composite using the Dumbbell mould

The following mechanical properties were carried out on the composites, Tensile test, flexural test and micro-hardness test.

RESULTS AND DISCUSSION

The results of the tensile properties of the composites are shown in Table 1, Fig 1

Table 1: Effects of fibre load on tensile properties

Fibre load	Average Tensile Strength (MPa)	Average Modulus (MPa)	Average Load at Break (N)
0	30.0991	649.4003	1113.4860
3	16.6698	541.2377	709.1161
6	22.1165	541.9628	1059.4747
9	29.3033	598.1224	1084.2570
12	20.4288	530.1571	893.0747

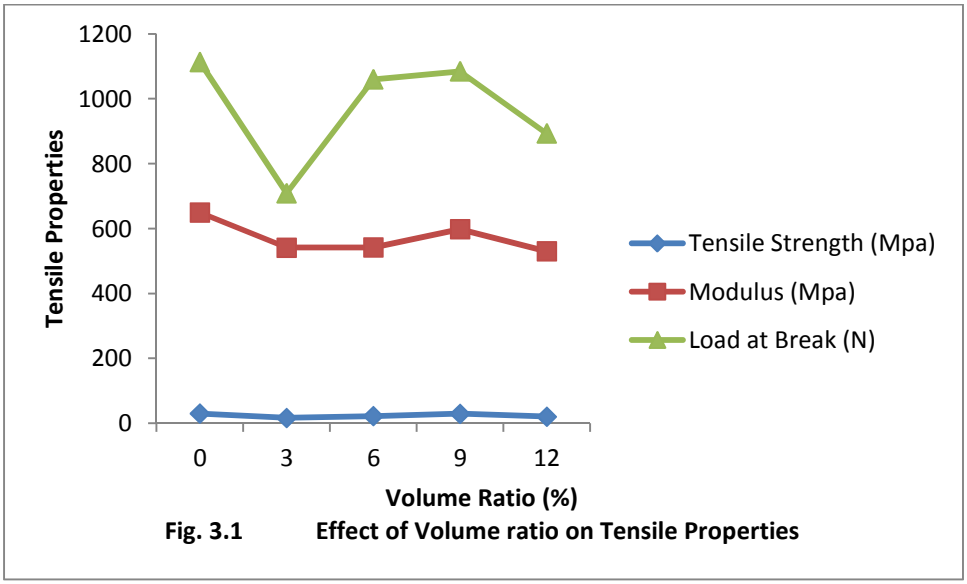


Fig. 3.1 Effect of Volume ratio on Tensile Properties

From the test results, the tensile strength of the composite increased from 3% (16.6698MPa) – 9% (29.3033MPa) with a sharp decrease in 12% (20.4288MPa) volume ratio. The tensile strength of the control sample 0% (30.0991MPa) was higher than the reinforced composites. The Modulus of the composite increased from 3% (541.2377MPa) – 9% (598.1224MPa) with a sharp decrease in 12% (530.1571MPa) volume ratio. The control sample 0% has higher modulus (649.4003MPa) than the reinforced composites. The load at break of the sample increase gradually as fibre loading increases from 3% (709.1161 MPa) to 9% (1084.2570MPa) after which there was a decrease as fibre volume increase to 12% (893.0747MPa). The result of the control sample was higher (1113.4860MPa) when compared with that of the reinforced composites. The maximum fibre tensile strength, modulus and load at break can take is 9% and after which the properties decrease. In all cases the control (0%) composites had better tensile properties than the animal hair reinforced composites. The decrease in mechanical properties at higher volume fraction of fibre loading is due to the increase in fibre- fibre interaction, the fibre not being perfectly aligned with matrix and poor dispersion of fibre in the matrix more over higher void content (which might be due to the presence of moisture in trace amount) and low interfacial strength resulted in a lower efficiency of load transfer with increase fibre loading (Sanjay and Bhawana 2012).

The results of the flexural properties of the composites are shown in Table 2, Fig. 2

Table 2: The effect of fibre load on flexural properties

Fibre load	Flexural Strength (MPa)	Flexural Modulus (MPa)
0	75.2204	2231.6092
3	79.1983	2203.1282
6	83.1131	1757.0890
9	70.1744	2329.6509
12	53.3526	1800.0715

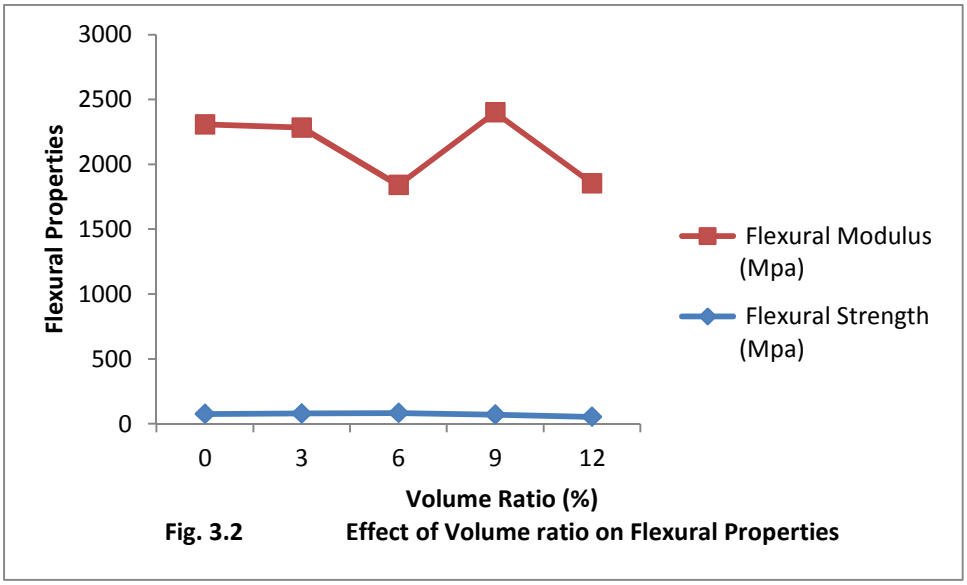


Fig. 3.2 Effect of Volume ratio on Flexural Properties

Results of flexural properties of the composite are shown in Table 2, Fig. 2. It can be seen from the results that as the volume percentage of the fibre increases, the average flexural strength and flexural modulus of the composite increase. Flexural strength peaked at 6% fibre load (83.1131MPa) while there was variation in the results of flexural modulus with 9% fiber load having the highest value (2329.6509 MPa). The control sample has the value of (75.2204 MPa) for flexural strength and (2231.6092 MPa) for flexural modulus. This indicated that the optimum percentage of reinforcement was almost reached. Both properties shows a gradual decrease as fibre loading increase and this can be attributed to the shortage of resin to wet all fibres in the composite as more fibres are added and due to random short fibre distribution inside the composite matrix (Kelvin Loh and Willy Tan, 2011).

Table 3, Fig. 3 shows the micro-hardness of the composites

Table 3: The effect of fibre load on micro hardness

Fibre load	Micro Hardness (HV)
0	22.0667
3	20.3667
6	17.6667
9	23.1667
12	25.7333

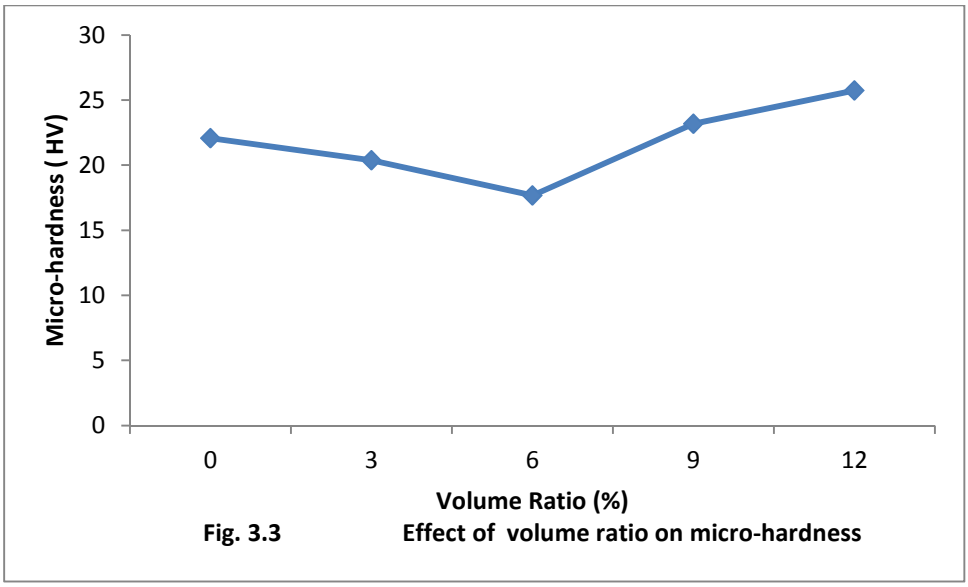


Fig. 3.3 Effect of volume ratio on micro-hardness

Hardness value test is widely used in industries and laboratories as a useful tool for determining the mechanical properties of materials because it provides an easy, inexpensive, and nondestructive method of

characterizing properties from small volumes of materials. Recently, micro-hardness test has been used for studying; the trend of the elastic properties in functionally graded epoxy composites and relative creep resistance of polymers. The result shows a gradual decrease from 0% (22.0667HV) - 6% (17.6667HV) volume ratio but increases as the fibre load increases from 9% (23.1667HV) – 12% (25.7333HV). This is due to the fact that in the low fibre-load region, the resistance to indention resulted from the fibre–matrix interaction thus the property of the composites is linearly dependent on the fibre load but as the fibre load is high, there will also be the fibre-fibre interaction in addition to fibre-polymer interaction, which increases significantly the resistance to flow of materials thus causing deviation from linearity (Suwanprateeb *et al.,*1998). The increase in micro-hardness as fibre load increases might also be attributed to higher hardness of animal hair fibre compared to polyester resin.

CONCLUSION AND RECOMMENDATIONS

This research can be concluded as: Tensile properties (Tensile Strength, Modulus, Load at Break) and Flexural properties (Flexural Strength and Flexural Modulus) decreased at high fibre load.
At high fibre load, the Micro-hardness increased.

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