Studies of some Mechanical Properties of Maize Cob Particles/Unsaturated Polyester Resin Composites

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Abstract— Composites of Unsaturated polyester Resin and Maize Cob (MC/UPR) were prepared at different filler loading and some of their mechanical properties tested. It was found that as the filler content was increased, the composites could not form above 20% filler loading due to saturation of the UPR. It was also observed that as the filler content increased, the tensile strength, impact strength, hardness and flexural strength all decreased. The values obtained are within acceptable range to allow for the use of MC/UPR composites to be used in areas where strength is not of paramount importance.

Keywords— flexural strength, hardness Maize cob, tensile strength, Unsaturated Polyester Resin

I. INTRODUCTION

Increasing concern about global warming and depleting petroleum reserves have made scientists to focus more on the use of natural fibres such as Jute, bagasse, coir, sisal, etc. Many research articles have been published to justify the utility and to establish advantageous features of such natural fibres. This has resulted in creation of more awareness about the use of natural fibres based materials mainly composites. In past decade there have been many efforts to develop composites to replace the petroleum and other non-decaying materials based products. The abundant availability of natural fibres gives attention on the development of natural fibre composites primarily to explore value-added application avenues [1]. Reinforcement with natural fibre in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of preparation, enhanced energy recovery, CO\(_2\) neutrality, biodegradability and recyclable in nature [2].

Unsaturated polyester (UPE) resin is used for a wide variety of industrial and consumer applications. In fact, more than 0.8 billion kg was consumed in the United States in 1999. This consumption can be split into two major categories of applications; reinforced and non-reinforced. In reinforced applications, resin and reinforcement, such as fibre glass, are used together to produce a composite with improved physical properties.

Typical reinforced applications are boats, cars, shower stalls, building panels, and corrosion-resistant tanks and pipes. Non-fibre reinforced applications generally have a mineral “filler” incorporated into the composite for property modification. Some typical non-fibre reinforced applications are sinks, bowling balls, and coatings. Polyester resin composites are costs and the physical properties can be tailored to specific applications. Another advantage of polyester resin composites is that they can be cured in a variety of ways without altering the physical properties of the finished part. Consequently, polyester resin composites compete favourably in custom markets [3].

Indian corn or maize, Zea mays, is America’s main contribution to the important group of cereals. Maize had nee though to have originated in a wild state in the lowlands of southern Mexico and central America from which it spread to the Andes where it cultivation goes back to prehistoric time. The ancestor was probably teostinte a primitive ancestor that bore a single row of kernels in a husk. Selection in southern Mexico resulted in a longer cob or ear familiar as the maize found in the tombs of the Incas in Peru represent several different varieties sod that the plant must have grown for many centuries prior to even to the period of the moved northward again and played a prominent role in the civilization of the Mayas and Aztecs.

Maize cob is obtained after removing the maize seeds from the cob. The corn cob is made up of cellulose and lignin. One of the most important characteristic of corn cob products is their absorbency—their capacity to hold up to four times their weight in fluid. This absorptive quality enables corn cob products to be used to absorb finishing fluids, oil and water in industrial applications and to clean up industrial or environmental spills. The abrasive quality of corn cob particles makes them valued for their use as industrial abrasives. Corn cobs, as well as other biomass resources, have the potential to be transformed into valuable bio--products for industrial and consumer use.
Compelled by environmental concerns and the desire to reduce the use of imported oil, government and private research is producing technological advances that continue to redefine the potential for corn and its components to be converted into products as diverse as structural materials, chemicals, fabric and fuels [4].

This work is aimed at preparing composites of maize cob in particulate form with Unsaturated Polyester Resin and evaluating some physical and mechanical properties of the composites.

II. METHODOLOGY

A. Composites Preparation
Maize cobs were obtained from Samaru village of Zaria local government area, Kaduna state Nigeria. It was first pounded with mortar and pestle and later grinded into powdered form and sieved to particle size of 300µ.

To prepare the composites, calculated amount of Unsaturated Polyester Resin (UPR) was carefully mixed with the required accelerator and catalyst in clean beaker. The prepared UPR with the corresponding amount of Maize Cob (MC) in particle form were thoroughly mixed and poured in to a glass mold of 200x100x40[mm]. The amount of maize cob and UPR was varied from 0 to about 20% of the maize cob content when the UPR was saturated and the composites could not form. The set up was allowed for 7mins to start pre hardening then a glass and foil paper sheet were placed on the setup and little pressure were applied on the mold and allowed to stand for an hour to cure the composite properly and to prevent void formation.

B. Tensile Strength Test
The test samples in dumb-bell shape of the required standard dimensions according to ASTM638 were clamped between the upper and lower jaw of the type "W" Tensometer and the machine loaded Manually. The samples were stretched gradually with the application of force until they reached their breaking point. Reading of maximum load and elongation at break were taken accordingly.

C. Impact Strength
The impact strength was determined using the Cat Nr.412 Charpy Impact Testing Machine 15 joules capacity. The tests were conducted according to ASTM D-256. Samples were cut into length not less than 10cm with uniform width, the samples were placed on the machine and held tightly with the aid of knots, while the ends were observed to be of equal length.

The hammer of 15 joules energy capacity was raised and then released to hit the sample, which led to breaking of the sample. The work done in breaking the test samples were recorded.

D. Hardness Test
The “Indentech Universal Hardness Testing Machine Model 8187.5 LKV “B” Rockwell HRF indenter (1/16” steel ball) with minor load 10kg and major load 60k was used in measuring the hardness using the shore scale according to ASTM2240. The samples were placed on the flat surface and the indenter forced on the surface of the specimen, the load was maintained at maximum time of 10 to 15seconds, and the averages of each tests result were recorded.

E. Flexural Strength
The three point bending test was conducted according to ASTM D790 with Cat Nr.261 Universal Material Testing Machine-100KN. Three rectangular beam samples were tested at a support span length of 70mm. The samples were center loaded in 3-point bending as a simply supported beam, using 3mm diameter supports and loading bar. The deformation in mm and load in KN were recorded accordingly. The flexural strengths were calculated using the following equation:

\[ \text{Flexural Strength}=\frac{3PL}{2bd^2} \text{ (MPa)} \]

Where: \( L \) =Span length, \( P \)=applied force, \( b \)=width of sample, \( d \)=thickness of sample.

III. RESULTS

A. Tensile Strength
The tensile strength of a material is the maximum load applied to a specimen in stretching it to rupture.

From the results in figure 1, it was observed that the tensile strength and elongation decreases with increasing fibre content. Sample A which content 0% of filler has the highest tensile strength and elongation which implies more load will be needed to break the interfacial bonding. However, the tensile strength and elongation declined considerably with increasing fibre content up 15% of jute fibre and 20% of maize cob particles, this could be due to agglomerate formation which would result in the formation of stress centers in the composites contributing to initiate failure of the composites on application of stress. Similar results have been reported in the literature [5].

**B. Impact Strength**

Impact strength is the ability of the composites material to withstand shock. From figure 2, it was observed that the impact strength of the composites slumps with increase in filler loading. This is mainly due to reduction in elasticity of the material due to filler addition and thereby reducing the deformability of matrix. An increase in filler content reduces the ability of the matrix to absorb energy thereby reducing the toughness of the composites which resulted in decrease in impact strength. Further, increased polymer-filler interaction will decrease interfacial tension and reduce chances of crack initiation at the interface. Similar results have been observed while studying the mechanical properties of maize cob/urea formaldehyde composites, [6].

**C. Hardness Property**

Figure 3 shows that the Shore hardness value decreases as the fibre content increases with the control having the highest value. However, as the fibre content increases the polymer morphology is disturb thereby, decreasing the resistance of the composite to indentation. The control sample is likely more resistance to deformation. The MC/UPR composites show improved hardness compared to the composites of JF/UPR and that of JF+MC/UPR with composite of 0% filler having the highest hardness. However, the slumps in hardness might be due to the formation of incoherent interface between the filler and the matrix so, a larger number of dislocations are generated at the interface which reduces the resistance of the composites to deformation.

**D. Flexural Strength Properties**
From figure 4 it is clear that the flexural strength decreases with increasing filler content. This can be explained on the basis of agglomerate formation at higher concentrations of the filler, which was also reflected in the tensile behavior of the composites. Similar results have been reported in the literature [7].

REFERENCES


