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Effects of Fillers on Mechanical Properties of Composites

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Abstract - *The research undertook the fabrication of composite materials by incorporating rice husks (RH) as fillers within an unsaturated polyester resin (UPR) matrix. In an effort to unravel the relationship between filler content and mechanical attributes, as well as water uptake capabilities of the composites, varying proportions of filler loadings (10%, 15%, 20%, and 25% by weight) were employed. The investigation yielded several noteworthy outcomes. The tensile strength of the RH-filled UPR composites demonstrated a general decline with increasing filler content. However, an intriguing departure from this trend emerged at a 25% wt RH loading, where the tensile strength exhibited a moderate augmentation. Similarly, the study revealed the behavior of Young's modulus—often indicative of material stiffness. This modulus experienced a substantial upswing at 15% wt RH, suggesting heightened rigidity. In contrast, this positive trend reversed as the RH percentage further increased to 25% wt. In addition to mechanical properties, the research also encompassed water absorption evaluations. The outcomes of these tests indicated that composites absorbed progressively greater amounts of water with escalating proportions of RH filler. This tendency was ascribed to the innate capacity of the RH filler to absorb water. this study contributed to the production of polyester composites using rice husk fillers.*

***Key Words*:** Rice husks, unsaturated polyester resin, water absorption, tensile strength.

1. INTRODUCTION

In recent years, significant efforts have been directed towards enhancing the mechanical properties of polymer composites by incorporating various synthetic reinforcing fillers. This approach aims to align composite characteristics with practical application demands. In this context, the utilization of natural fillers as reinforcements has garnered growing interest across both academic and industrial domains. Natural fillers possess notable advantages over their synthetic counterparts, including their lightweight nature, cost-effectiveness, machinery-friendly attributes, and non-toxic qualities.

The landscape of natural fillers under exploration for industrial use is diverse, encompassing materials such as flax, hemp, wood, wheat, barley, and oats. These alternatives are rapidly evolving as potential substitutes for traditional inorganic or synthetic materials in a range of applications, including automotivecomponents and building materials.

Rice husks, specifically, have emerged as advantageous fillers due to their distinctive attributes. Unlike mineral fillers, rice husks are non-abrasive, necessitate less energy-intensive processing, and contribute to reduced composite density. This unique set of properties has positioned rice husk-filled composites as a subject of intense scrutiny, increasingly recognized for their potential to yield cost-effective, lightweight, and environmentally friendly composite solutions across diverse industries.

Experimental Procedure

The process began with the collection of finely milled rice husks from a local rice mill. Since these husks carry impurities like dust, small rice particles, and fine sand, a cleaning step was essential to obtain pure rice husks. This involved washing the rice husks with water, followed by sun-drying for 8 hours. The husks were then weighed as per the required weight percentages (10%, 15%, 20%, and 25% by weight).

Subsequently, an amalgamation of unsaturated polyester resin and methyl ethyl ketone peroxide (MEKP) catalyst was prepared in a container, thoroughly stirred for 3 to 5 minutes. To ensure even dispersion of fibers within this gel-like mixture, the rice husks were gradually introduced and stirred. Before the mixtures were poured into molds, the molds themselves were treated with a release agent to prevent the composites from adhering. Lastly, once the mixture was placed into the molds, it was allowed to sit at room temperature for a complete duration of 24 hours. This time span enabled the mixture to fully cure and solidify, ensuring the final composite achieved its desired characteristics.

2. Mechanical and Physical Testing

The test was conducted using a Universal Testing Machine at a fixed crosshead speed of 2 mm/min. Test samples were prepared according to the ASTM D3039 standard with dimensions of 250 × 25 × 2.5 mm. Physical properties, such as water absorption, were investigated according to the ASTM D570 standard.

3. RESULTS AND DISCUSION

Tensile Test

Figure 1 shows the results of the tensile tests of RH-filled UPR composites using various filler loadings. Figure 2 shows the tensile fracture surfaces of the RH-UPR composites using various filler loadings. The graph from Figure 1 shows that the tensile strength of the composites slightly decreased with increasing filler loading due to the poor interfacial bonding. The weak bonding between the hydrophilic filler and the hydrophobic matrix polymer obstructs the stress propagation and thus, causes the tensile strength to decrease when the filler loading increases. In addition, poor dispersion causes agglomeration of the fillers as well as decreasing the tensile properties. From the graph, we can see that there was a moderate increase in tensile stress for the 25 wt % filler loading. This is believed to be due to the filler used acting as a flaw at higher filler mass fractions, because there was a lack of resin that can wet the filler. These results in inefficient stress transfer, leading to a decrease in tensile strength followed by a modest increase with increasing filler contents. In addition, an increase in the filler content also increases the micro-spaces between the filler and the matrix, which weakens the filler-matrix interfacial adhesion. As a result, the values of tensile strength decreased with an increasing filler content in the composite.

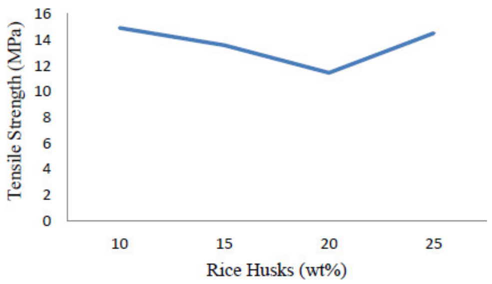

Figure 1. Tensile strengths of RH-filled UPE composites with various filler loadings.

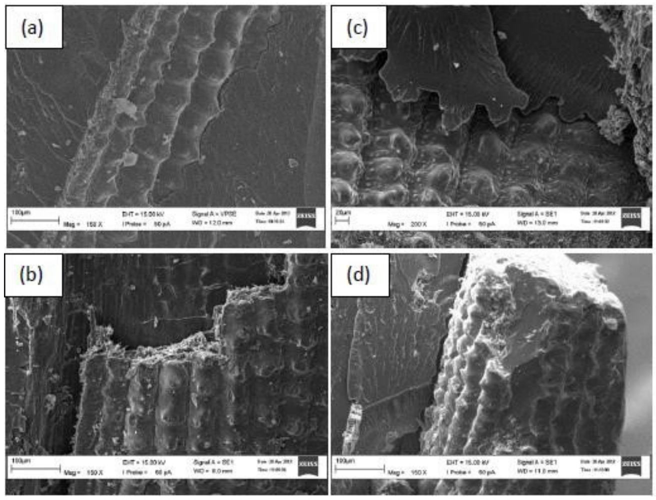

Figure 2. Tensile fracture surfaces of the RH-UPR composites: (a) 10 wt % of RH-UPR, (b) 15 wt % of RH-UPR, (c) 20 wt % of RH-UPR, (d) 25 wt % of RH-UPR.

Water Absorption

Figure 3 shows the percentage of water uptake for the RH-filled UPR composites at different filler loadings. The water absorption also increased when the filler loading increased. This is due to the presence of voids in the natural filler polymer composites. These voids form because of the poor adhesion between the matrix and the filler, which in this case was the rice husks, also known as lignocellusoic material. When the natural filler composites are exposed to moisture, the hydrophilic rice husks swell, which leads to the micro cracking of the brittle thermosetting resin. As the composites crack, the capillarity becomes active and hence, the water molecules are actively attracted to the interface, which in turn results in the de-bonding of the filler and matrix. The high cellulose of the rice husks contribute to additional water penetration into the interface through micro-cracks induced by swelling of the filler, which also creates stress and ultimately, leads to failure of the composite.

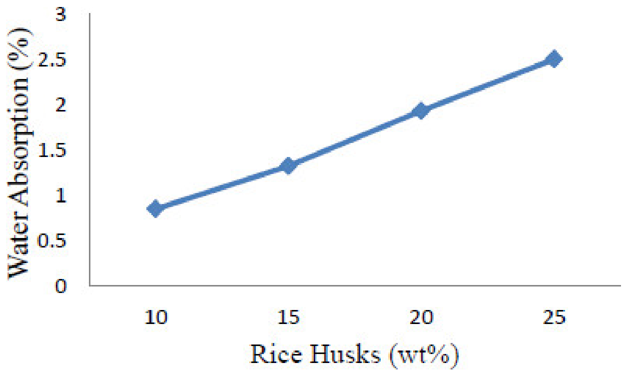

Figure 3. Young modulus of RH-filled UPE composites with various filler loadings.

4. CONCLUSION

From this study, it can be concluded that the tensile strength of the composites decreased when the filler loading was increased. This is due to weak interfacial adhesion between the filler and the matrix caused by porosity and micro cracking. The Young modulus also decreased when the filler loading was increased, except for a loading of 15 wt %, at which point the Young modulus increased remarkably. Additionally, as the filler loading was increased, the composites tended to absorb more water because rice husks are known as a lignocellusoic material.

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