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Mechanical Behaviors of Rice Husk and Red Mud Hybrid Bio Particulated Coir-Polyester Composites

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Abstract: Many attempts have been made by researchers in the past to replace wood and plastics by natural fiber reinforced polymer composites. In this study, the industrial and agricultural residues such as red mud and rice husk particles were reinforced with the polymer to form novel bio-based composites. Composite sheets were fabricated by randomly reinforcing coir fibers and bio particles in polyester matrix. The weight content of reinforcements was varied within 40% and the prepared composites were characterized for its mechanical properties according to ASTM standards. The morphological studies on fractured specimens were carried out using Scanning Electron Microscope (SEM). The results of this study showed that composite could be successfully developed using natural fibers and particles which would be a substitute for plastics and wood-based materials in Engineering applications.
Keywords: coir; polyester; red mud; regression analysis; rice husk; scanning electron micrography.

Introduction and Experimental:

In the polymer based natural particulate composites, the thermoplastic or thermoset material act as a matrix and the natural based particles act as the filler [1]. The type of particles used in the composites decides the load carrying capacity of the composites [2]. The fillers used in the composites provide high strength and high stiffness as well as resistance to bending and breaking under the applied stress [3]. A number of natural occurring fillers and fibers used in composite have been studied over the years. These includes wood fillers, wheat straw, almond husk, ash, rice husk, pineapple leaf, [4] etc. The effect of red mud addition with bamboo fiber and glass fiber reinforced epoxy matrix composites was studied and their mechanical properties showed improvement by the addition of red mud [5]. Therefore a possible incorporation of red mud as particles along with natural fillers and fibres in a polymer matrix could provide a synergism in terms of improved properties. The objective of this research work is to investigate the mechanical properties of rice husk and red mud hybrid bio particulated coir-polyester composites. The mechanical properties evaluated were compared with the red mud and termite mound hybrid bio particulated coir-polyester composites and the effect of rice husk hybridization was studied.

The unsaturated Polyester resin mixed with 1.5 % of Cobalt Octoate and 1.5 % of Methyl Ethyl Ketone Peroxide was used as matrix material. The coir fibers, red mud and rice husk were used as reinforcement fibers and boi-particles respectively. The composite was prepared with coir fibers of different length (10,20,30,40 & 50mm) reinforced with unsaturated general purpose (GP) polyester resin filled with red mud and rise husk of different composition (5,10,15, 20 & 25%). The weight percentage of coir fibers are varied such that the total weight percentage of the reinforcement is equal to 40 %. The specimens were fabricated using compression moulding technique at a pressure of about 2.6 MPa for 45 minutes to ensure proper curing at room temperature. The flexural, tensile and impact samples were cut according to ASTM D-790-10, ASTM D-638 and ASTM D-256 respectively. A total of five samples were examined for each test, and the average value was determined.

Results and Discussion:

It was observed that there is a gradual increase in the tensile, flexural and impact properties of the composites with the increase in particulate content and fiber length. But when the particulate content is increased beyond 15% and 30 mm respectively an undesirable effect was inferred which is due to agglomeration of particles in the matrix. The maximum value of tensile, flexural and impact strength obtained was 40.5 MPa, 42.6 MPa and 51.8 kJ/m^2 respectively.

The composite fabricated without particulates suffered uneven matrix breakage which was not observed in the tensile fractured specimen of hybrid particulate filled coir –polyester composites as shown in the Fig.1.This is due to presence of randomly distributed particulates over the matrix area. The flexural fractured specimen shown in the Fig.2 revealed that there were small discontinuities and a reasonably uniform distribution of rise husk and red mud particles which arrested the crack growth better than coir fiber –polyester. The Fig.3 confirms matrix crack and separation in the impact botched composites fabricated without particulates. This problem was controlled by reinforcing hybrid particulate which renders crystalline structure to the matrix, arresting larger matrix cracks near failure zone.

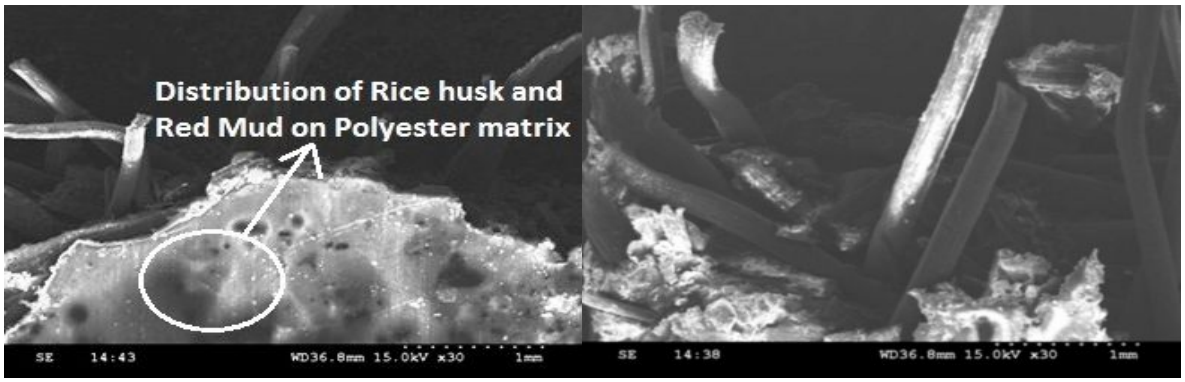

Fig. 1. SEM image of coir –polyester composites with and without hybrid particulate after tensile fracture.

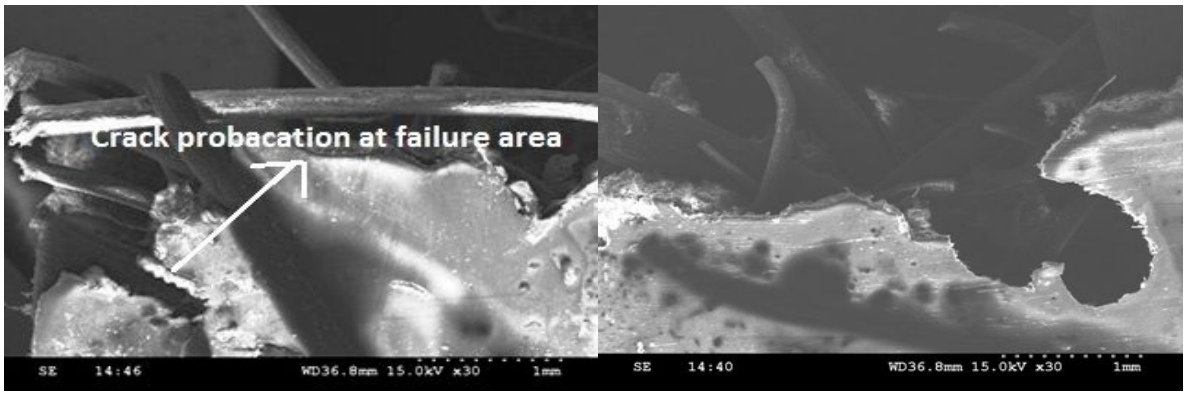

Fig. 2. SEM image of coir –polyester composites with and without hybrid particulate after flexural fracture.

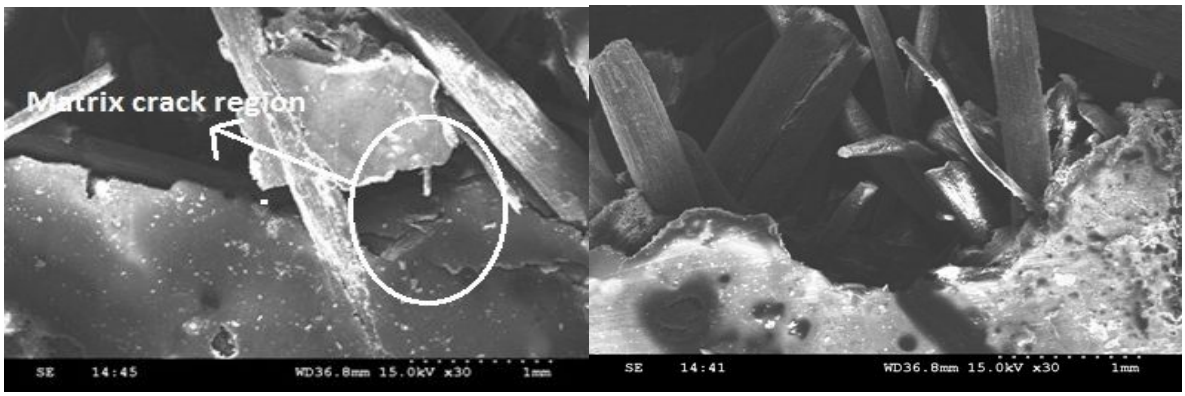

Fig. 3. SEM image of coir –polyester composites with and without hybrid particulate after impact fracture.

The maximum value of tensile strength obtained with termite mound hybrid particulates was 35.1 MPa, but the strength was increased by 14% with the replacement of rice husk instead of termite mount particulate. The flexural strength of termite mound soil hybrid particulates coir-polyester composites (38.4 MPa) was bit low compared to that of rice husk hybrid particulate coir polyester composites, The better value of impact strength was obtained with 20% of termite mound soil hybrid particulates whereas only 15% particulate content is required in case of rice husk hybrid particulate coir polyester composites. Therefore, the inclusion of rice husk and red mud in the polyester matrix has enriched the crystalline structure of the matrix which in turn resulted in better mechanical properties. The SEM images confirmed the increase in interfacial bond and adhesion between reinforcement materials and polyester resin. Hence, rice husk can be suggested as better hybrid particles than that of termite mound particles in red mud particulated coir-polyester composites.

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