IMPACT PROPERTIES OF JUTE FIBER MATS REINFORCED UNSATURATED POLYESTER MARTIX COMPOSITES

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1 Abstract

Jute fiber mats-reinforced unsaturated polyester matrix composites having different fiber weight contents (11, 22, 32 wt%) were fabricated by modifying the hand lay-up technique with resin pre-impregnation into the jute mats in vacuum. This modification showed a better impregnation of resin throughout the jute mats and lower voids contents in the composites. Two types of impact tests, swing pendulum (Izod) and drop weight (impulse) were carried out to evaluate the effect of fiber contents on the impact properties of these composites.

The Izod impact strength and impulse impact energy increase as the fiber content increases and the improvement had occurred at 11 wt% fiber content compared to that of the neat resin. Moreover, the fracture surface has demonstrated that fiber pull out mechanism is the predominant failure mode for different fiber weight contents. The total energy increases with fiber contents of 11 and 22 wt% to about three times, whereas the total energy increases at 32 wt% to about four times compared to total energy of neat resin. Multiple matrix cracking with fiber pull-out mechanism was revealed from the impulse impact test of the composites.

2 Introduction

Recently, the strict environmental regulations have forced the composite industry to find alternatively eco-friendly reinforcements and resin systems to produce environmentally friendly composite materials. These natural composites could be used in automotive industry as interior parts and in constructions sector as walls and roofs. Natural fibers reinforced composite materials have been subject of many intensive studies due to the considerable characteristics of the natural fibers, such as biodegradability, abundance, renewability, low cost, low specific gravity, and high specific strength, etc. However certain drawbacks, such as incompatibility with the hydrophobic polymer matrices, the tendency to form aggregates during processing, and poor resistance to moisture absorption, reduce significantly the mechanical properties of the natural fibers reinforced composite materials [1-3].

Amongst the natural fibers used as composite reinforcements, jute fiber constitutes large area of investigation. This is because the good mechanical properties of jute fibers when compared with other natural fiber, such as sisal, coir, and ramie [1]. Several authors have studied the continuous jute fiber composites from different aspects, e.g., mechanical properties [4-7], the effect of fiber treatments on mechanical properties [6,7], dynamic mechanical properties [8], physical properties [5], processing and microstructures [9].

As well known, the jute bags at the end of their longevity will be as waste materials, moreover the remaining short slivers of jute fibers yielded from the jute cloth fabrication aren't yet reused efficiently. Therefore, in this research the used jute bags are recycled by mincing them and mingled with short jute slivers to produce jute mats. These jute mats ware produced by applying slightly compressive load on short jute fibers to be packed together in form of mat which can be used later as reinforcements for valuable polymeric composite structures with certain degree of green. So, this work aims to recycle the used jute and reuse of the jute slivers by using jute mats for the fabrication of jute fiber mat-reinforced unsaturated polyester matrix composites using a modified hand lay-up technique, and to study the effect of fiber weight contents on the impact properties of these composites.

3 Experimental

3.1 Preparation of the Composites

Jute fiber mats consisting of 50% jute slivers and 50% recycled jute were prepared by Yano Co.LTD, Japan. Unsaturated polyester, Rigorac™ was obtained from Showa Denko K.K., Japan and the curing agent is

Methyl ethyl ketone peroxide (PERMEK® N) obtained from NOF Corporation, Japan.

The jute mats were dried for 6 h at 100^0C and were completely submerged in unsaturated polyester resin bath. The next step which differentiates the modified technique over the conventional technique is that the jute mats were degassed in a vacuum for 20 minutes at room temperature to remove the entrapped air bubbles. After that the jute mats were cured under a pressure of about 15 kg/cm^2 at room temperature for 24 h with the presence of a 6 mm spacer to produce the composite on the same thickness for different fiber contents. The composite was then post-cured at 100^0C for 2 h and finally it was allowed to cool naturally to room temperature for about 30 minutes. Sheets were prepared with different fiber contents (11, 22, 32 wt%) and the specimens of required dimensions were cut from them and used for testing.

3.2 Mechanical Characterization

Izod impact test on unnotched specimens with dimensions 62×12.7×6 mm was done according to ASTM D 256-05 using an I5.5J digital pendulum impact tester, TOYOSEIKI, Japan. Impulse impact test was done with sample dimension 102×102 mm using instron dynatup 9250 HV.The fracture behavior of the composites of the different mechanical tests was studied using a JEOL-5200 scanning electron microscope (SEM).

4 Results and Discussions

The effect of the fiber content on izod impact strength is shown in Fig. 1, it can be observed that as the fiber content increases the impact strength increases. The impact strength was slightly improved by 8% at 11 wt% fiber content compared to the value of the neat resin because the fiber content is very low and so the effect of the jute reinforcement in the matrix is low. SEM micrographs of izod impact fracture surface at 11 wt% is shown in Fig. 2(a), it can be observed that some holes result from deboning and complete pull out occurring along the fiber indicating the weak interface between the fiber and the matrix, and the fracture surface is mainly smooth and level indicating that the fracture is brittle and mainly occurred through the brittle matrix.

As the fiber content increases to 22 wt% value of the impact strength was also slightly enhanced by 12% with respect to the value of neat resin. SEM micrographs of izod impact fracture surface at 22 wt% is shown in Fig. 2(b), it can be observed that fewer holes result from deboning and complete pull out occurring along the fiber indicating that the interfacial properties between the fiber and the matrix were improved. As the fiber content increases to 32 wt%, the impact strength was improved by 43% with regard to the value of the neat resin. The nature of the natural fiber is porous and can be considered as a composite of hollow cellulose fibrils held together by a lignin and hemicelluloses, this nature displays absorbing mechanism for the impact energy. By increasing the fiber content to 32 wt%, fewest holes result from deboning and complete pull out occurring along the fiber as shown in Fig. 2(c). This indicates that the interfacial properties between the fiber and the matrix were improved and the fracture surface became more uneven and bumpy indicating that the energy was increased and so the composites have higher toughness to withstand the sudden loads compared to that of the neat resin.

However, the addition of the jute fiber to the unsaturated polyester resin has a positively large effect on the impulse total impact energy. Load-deflection and energy-deflection curves of the composites for different fiber contents and neat resin are indicated in Fig. 3. It can be observed that the neat resin is brittle material with very little ductility and so it has low value of total energy as shown in Fig. 3(a). By the addition of the fiber, the load-displacement curve is corrugated for different fiber contents for the three regions as shown in Fig. 3(b, c, d). These figures show that the area of plastic region of the composites of different fiber contents is larger than that of the neat resin, and so the toughness and the Impact energy were improved compared to the value of neat resin.

As a result of that, the addition of the jute fiber to the unsaturated polyester resin enhanced significantly the total impulse impact energy of the jute fiber mat reinforced unsaturated polyester matrix composites as shown in Fig .4 which indicates the effect of fiber weight content on the total impulse impact energy. It can be observed that the total energy was increased with the addition of 11 wt % and 22 wt % fiber weight contents to about three times, while the total energy was increased at 32 wt % fiber weight content to about four times compared to the value of the neat resin. This was also reflected from the fracture surfac of the composites as shown in Fig. 5(a,b,c). It can also be observed that the fracture surface is uneven and bumpy for different fiber contents as shown in Fig. 5(a,b,c) due to the effect of jute fiber reinforcements. Multiple matrix cracking with fiber pull-out mechanism was revealed for different fiber weight contents. This indicates that as the fiber content increases the energy was improved compared to that of neat resin and so the

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composites have higher toughness to withstand the sudden loads compared to that of the neat resin

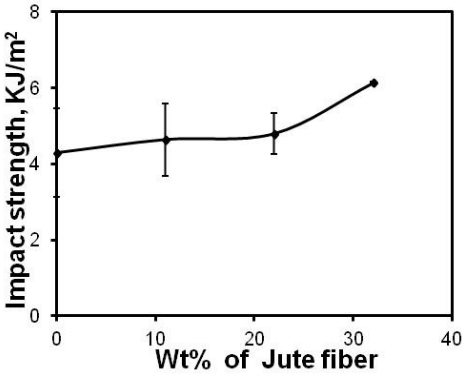
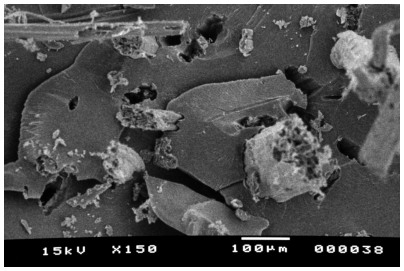
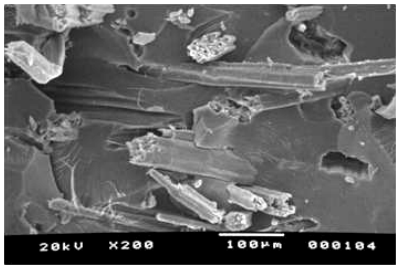


Fig.1. Effect of fiber weight content on izod impact strength



(a)



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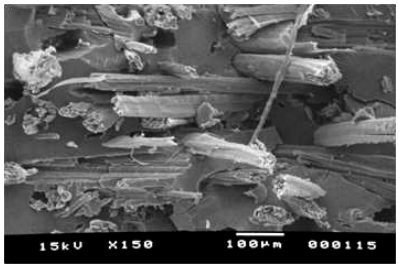
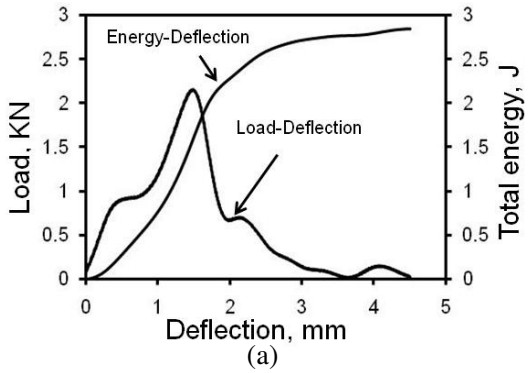
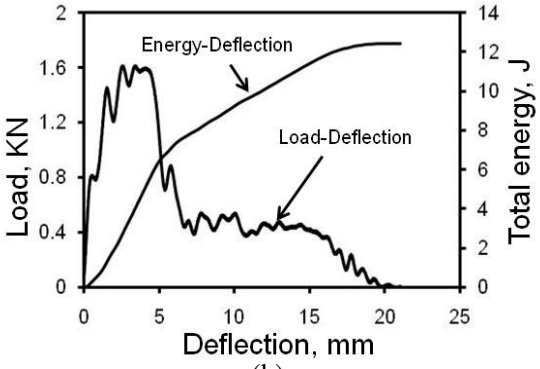


(c)

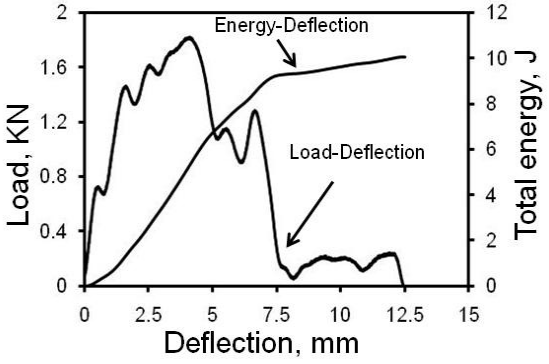
Fig.2. SEM micrographs of izod impact fracture surface of the composites (a) 11wt% (b) 22 wt% and (c) 32 wt%.



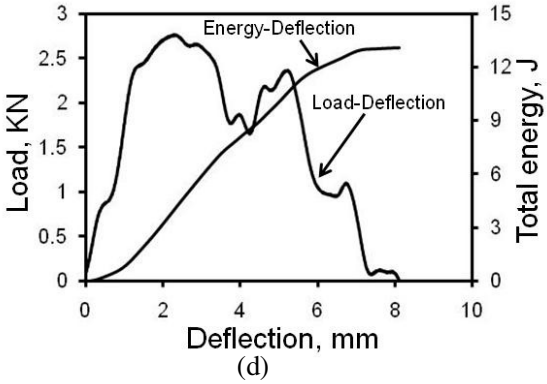
(a)



(b)



(c)



(d)

Fig.3. Load-displacement and Energy-displacement curves of impulse impact test of the composites for (a) neat resin (b) 11wt% (c) 22 wt%, (d) 32 wt%

Finally, it can be concluded from this study that both izod and impulse impact properties can be improved by adding 11 wt% of jute fiber mats as reinforcements to unsaturated polyester matrix composites.

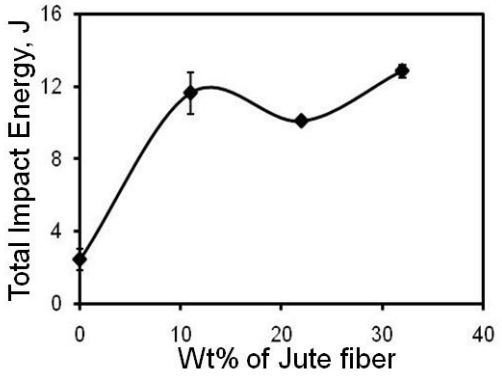
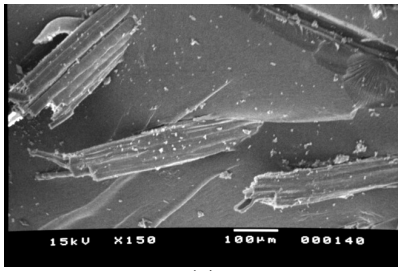
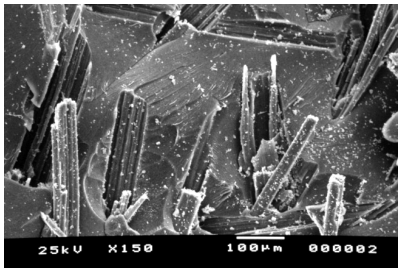


Fig.4. Effect of fiber weight content on total impulse impact energy.



(a)



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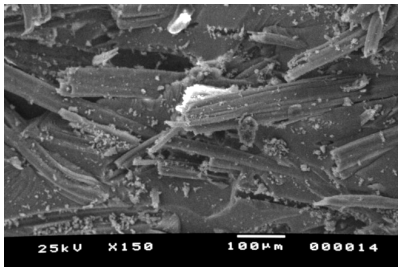

(c)

Fig.5 SEM micrographs of impulse impact fracture surface of the composites (a) 11wt% (b) 22 wt% and (c) 32 wt%.

5 Conclusion

Jute fiber mats-reinforced unsaturated polyester matrix composites having different fiber weight contents (11, 22, 32 wt%) were fabricated by a modified hand lay-up technique. The Izod impact strength and impulse impact energy increase as the fiber content increases and the improvement had occurred at 11 wt% fiber content compared to that of the neat resin. Moreover, the izod fracture surface has demonstrated that fiber pull out mechanism is the predominant failure mode for different fiber weight contents. The total energy increases to about three times at 11 and 22 wt%, whereas the total energy increases to about four times at 32 wt% compared to total energy of neat resin. Multiple matrix cracking with fiber pull-out mechanism was revealed from the impulse impact test of the composites.

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