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IZOD IMPACT TESTES IN POLYESTER MATRIX COMPOSITES REINFOCED WITH FIQUE FIBERS*

Maria Carolina Andrade Teles[1]
Giulio Rodrigues Altoé[2]
Marcos Vinícius Fonsceca Ferreira[3]
Djalma Souza[4]
Frederico Muylaerte Margem[5]
Sergio Neves Monteiro[6]

Resumo

Uma fibra natural apresenta características interfaciais com matrizes poliméricas que favorecem a absorção de alta energia de impacto da estrutura compósita . Este trabalho procura avaliar a resistência ao impacto deste tipo de matriz de poliéster com reforço de fibras naturais. As fibras de Fique foram misturadas com resina de poliéster sob pressão em um molde metálico, e curada à temperatura ambiente durante 24 horas . Amostras padrões foram preparadas até 30% em volume de fibras Fique alinhadas ao longo de todo o seu comprimento, estas amostras foram então testadas com ensaio de impacto Izod do pêndulo e as superfícies de fratura examinadas por microscopia eletrônica de varredura, MEV. A resistência ao impacto aumenta substancialmente com a quantidade relativa de fibra de Fique como reforço do compósito . Isto pode ser atribuído a uma descolagem preferencial da interface fibra / matriz , o que contribui para uma elevada energia absorvida.
Palavras-chave: Compósito; Fique, Fibra, Poliéster.

ENSAIOS DE IMPACTO IZOD EM COMPÓSITOS DE MATRIZ POLIÉSTER REFORÇADOS COM FIBRAS DE FIQUE

Abstract

A natural fiber presents interfacial characteristics with polymeric matrices that favor a high impact energy absorption by the composite structure. This work attempts to evaluate the impact resistance of this type of fiber reinforcing polyester matrix. The Fique fibers were mixed with polyester resin under pressure in a metallic mold, and cured at room temperature for 24 hours. Standard samples were prepared up to 30% by volume of Fique fibers aligned along its entire length, these specimens were then tested in Izod pendulum impact and the fracture surfaces examined by scanning electron microscopy, SEM. The impact resistance increased substantially with the relative amount of fique fiber reinforcing the composite. This can be attributed to a preferential debonding of the fiber/matrix interface, which contributes to an elevated absorbed energy.
Keywords: Composite; Fique; Fiber; Polyester.

[1] *Graduating in Metallurgical and Materials Engineering, Student, LAMAV, State University of Northern Rio de Janeiro/UENF, Campos dos Goytacazes, Rio de Janeiro, Brazil.*
[2] *Graduating in Mechanical Engineering, Master, Mechanical Engineering Departament, Pontifical Catholic University/PUC, Rio de Janeiro, Rio de Janeiro, Brazil.*
[3] *Graduating in Metallurgical and Materials Engineering, Student, LAMAV, State University of Northern Rio de Janeiro/UENF, Campos dos Goytacazes, Rio de Janeiro, Brazil.*
[4] *Doctor in Materials Engineering, Doctor, Professor, LAMAV, State Univerity of Northern Rio de Janeiro/UENF, Campos dos Goytacazes, Rio de Janeiro, Brazil.*
[5] *Doctor in Materials Engineering, Doctor, Assistant teacher, Science Center in Engineering, Redentor College, Itaperuna, Rio de Janeiro, Brazil.*
[6] *PhD in Material Engineering, Emeritus Profesor, Departament of Materials IME, Rio de Janeiro, Brazill*

1 INTRODUCTION

Due to growing concern about the ambient impacts from industrial activities, our society is ever more searching for environmentally friendly materials. In this regard, cellulose-based natural fibers, known as lignocellulosic fibers, become a promising solution. Nowadays, they are being considered as a substitute for synthetic fibers, such as glass fiber, used by the industry on a large scale [1-13]. In fact, others benefits are motivating the substitution of natural fibers for glass fiber in polymer composites[14],such as technical, economical and societal advantages[15].
The use of composites reinforced with natural fibers is a reflection of the concerns with environmental issues such as pollution caused by waste that is not biodegradable or cannot be incinerated and climate change due to CO2 emissions associated with the processes of intensive energy [16-18]. Additionally, it is worth also remembering that these fibers come from renewable sources, in addition to being abundant, inexpensive and have a relevant set of mechanical properties [19].
The objective of this study was a preliminary assessment, through tests of Izod impact energy, together with the microstructural characteristics associated with the fracture of polyester matrix composites incorporated with continuous and aligned Fique fibers.[20]

2 EXPERIMENTAL PROCEDURE

The basic material used in this work was the fiber extracted from the leaf of Fique plant (*Furcraea Andina),* Figure I (a), supplied by a producer in Colombia. No treatment was applied on Fique fibers, Figure I (b).

Figure 1. Fique plant (a) and its fibers (b).

The Fique fibers were mixed in amounts of 0, 10, 20 and 30% by volume with unsaturated polyester resin to prepare the composites. Plates of the composites with 10 mm thickness were fabricated in a rectangular steel mold with dimensions of 152 x 125 mm. The fibers were maintained aligned along the dimension of 125 mm, corresponding to the final length of the test specimens. The still liquid polyester resin, together with 0.5% catalyst based on methyl ethyl ketone, was poured into the Fique fibers inside the mold. The composite thus formed was allowed to cure for 24 hours at room temperature. The plate of each different composite was then cut according to the direction of fiber alignment in bars measuring 10 x 125 x 12.7 mm. These bars were used for preparation of samples for Izod impact test, according to ASTM D256.

The samples were impact tested in a PANTEC pendulum with Izod configuration. The impact energy was obtained using an 11 J power hammer for composites with 0, 10, 20 and 30% of fibers. For each condition, relative to a certain volume fraction of fibers, 12 specimens were used and the results were statistically interpreted.

3 RESULTS AND DISCUSSION

Table I shows the results of the values of Izod impact energy with their respective standard deviations for pure polyester and composites with different volume fractions of Fique fiber.

Table 1: Energy Impact Izod for polyester matrix reinforced with banana fibers.

Fiber Content (%)	Impact Energy (J/m)
0	13.00 ± 2.00
10	165.70 ± 29.70
20	231.10 ± 35.30
30	303.91 ± 42.50

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From the data in Table I, the graph of the energy absorbed in the Izod impact vs. the corresponding volume fraction of Fique fibers in the polyester matrix was plotted, as shown in Figure II. This figure shows a significant increase in the Izod impact energy with the amount of Fique fibers.

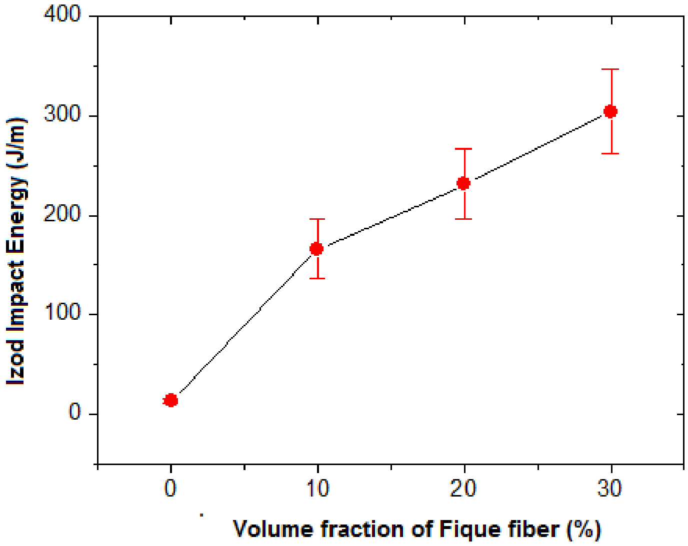

Figure 2: Variation of the Izod impact energy with the amount of fiber in the composites.

This figure displays that the Fique fiber incorporated into the polyester matrix extensively increases the toughness of the composite Izod notch. Values shown are consistent with the results described in the literature for lignocellulosic fibers as well as synthetic fibers. Table II compares Izod impact energy values polymer composites with different lignocellulosic fibers.

Table 2: Izod notch toughness of polymer composites reinforced with natural fibers.

Composite	Amount of Fiber (%)	Izod Impact Toughness (J/m)	Reference
Fique/ Polyester	30 (aligned)	303.91	this work
Sisal/ Polyester	30(aligned)	2956	[26]
Ramie/ Polyester	30 (aligned)	538	[24]
Coir/ Polyester	30 (aligned)	121	[25]
Curaua/ Polyester	30 (aligned)	190	[23]
Coir/ Polypropylene	30 (short and random)	46	[23]
Jute/ Polypropylene	30 (short and random)	39	[23]
Curaua/ Polypropylene	30 (short and random)	54	[23]
Flax/ Polypropylene	30 (short and random)	38	[23]

Figure III shows the macrostructural appearance of broken specimens with different amounts of Fique fibers, from 0 to 30% in volume. It is important to note that only the pure polyester specimen was completely separated in two parts, which means that the polyester matrix without the addition of Fique fiber is brittle. A non-occurrence of rupture on impact indicates a high toughness of the composite as if the rupture occurred, the absorbed energy would be even higher.

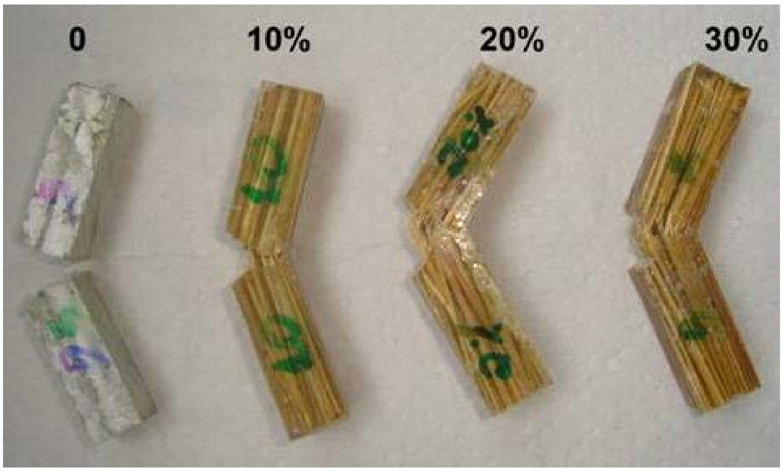

Figure 3: Macrostructural aspects of rupture by Izod Impact composite polyester matrix with different volume fractions of Fique fibers.

For most lignocellulosic fibers, the increase in the Izod impact energy is directly related to the increase in the fiber volume fraction[21]. Other lignocellulosic fibers present the same behavior[22], which is due to the heterogeneous nature of these fibers, causing substantial dispersion in the composites properties. Even considering the error bars, it is possible to interpret the increase of impact energy, as following a linear relationship. When using long fibers for the same proportion, there is a greater area of adhesion between the fiber and the matrix. Fibers embedded in matrix have a greater capacity to absorb the impact and distribute energy throughout its length in a short time interval, consequently, there is less decoupling between the fiber and the matrix. Thus, the fiber in the composite absorbs a large amount of power, leading to an increased impact resistance.

4 CONCLUSION

- The incorporation of Fique fibers in polyester matrix, increases the toughness of the composite, if compared with the pure resin.
- The Izod impact testing fiber in the composite shows that continuous and aligned Fique fibers work with reinforcement in polyester matrix , increasing the ductility linearly.
- Along with the retention of some whole banana fibers upon impact, low interfacial resistance results in greater energy absorbed due to the propagation of cracks in the fiber / matrix interface, allowing the formation of a higher longitudinal fracture area in relation to a transverse fracture, which should occur in the matrix for breaking the fibers.

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