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Original Article

Comparison between tensile behavior of epoxy and polyester matrix composites reinforced with eucalyptus fibers[☆]

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ABSTRACT

Investigations and uses of composites reinforced with natural fibers have been growing over the last decades. These composites offer economical, technical, societal and environmental advantages. As a consequence, they became promising alternatives to replace synthetic fibers from non-renewable sources. In this way, the study of the properties of these natural composites is of utmost importance to enable its use. The present work compares the tensile mechanical behavior of polymeric composites reinforced with natural eucalyptus fibers. Two matrices widely applied in the industry were used: epoxy and polyester. The results showed that in both cases the introduction of eucalyptus fibers had minor effect on the matrix reinforcement.

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1. Introduction

The current economic growth and technological development are motivating the search for new materials to meet modern technological challenges and, at the same time, preserve the environment. Thus, a demand for high-performance and environmentally friendly materials has been growing in recent decades. Polymeric matrix composites are one of the most important materials nowadays, with applications

ranging from sports to automobile and aeronautic industries. These composites are usually reinforced with synthetic fibers, such as glass and carbon fibers [1]. However, these composite materials are obtained from non-renewable resources, which are related to inherent environmental disadvantages. In particular, glass fiber composites are associated with intense processing energy using non-renewable fossil petroleum derivatives [2,3]. By contrast, the modern society requires materials that preserve the environment. Natural lignocellulosic fibers have been studied as composite reinforcement

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alternative, due to their lower density, lower cost, renewability, biodegradability and relevant mechanical properties [4–16].

The use of natural fibers as reinforcement to polymeric matrix is of interest for several industries. Indeed, natural fiber composites are today used in automobile parts, building panels and furniture [17–20]. In order to find new possibilities to this research field, the eucalyptus fibers have been recently studied as an alternative of reinforcement material and showed significant potential for polymer composites [20–22]. These fibers are extracted from the bark of the *Eucalyptus citriodora* tree, which is extensively cultivated in Brazil [23]. A more detailed investigation on the mechanical properties of eucalyptus fiber composites is still needed for possible engineering applications. Therefore, the objective of this work is to investigate the tensile behavior of epoxy and polyester matrix composites reinforced with continuous and aligned eucalyptus fibers.

2. Experimental procedure

The material used in this work was untreated eucalyptus fibers. The fibers (Fig. 1b) were obtained from the bark (Fig. 1a) of the eucalyptus tree. Eucalyptus plantations are common in Brazil and barks were supplied from a paper industry located in the state of Minas Gerais.

Composites with different volume fractions (30, 40 and 50 vol%) were confectioned by laying the fibers in a steel mold and pouring liquid resin, either DEGEBA/TETA epoxy or methyl-ethyl ketone hardened orthophthalic polyester, under pressure of 3 MPa. The specimens were cured for 24 h at room temperature and then tested in an universal Instron machine, model 5582, at 298 K (25 °C). Finally, the fracture surface was analyzed by scanning electron microscopy (SEM) under an acceleration voltage of 15 kV.

3. Results and discussion

Fig. 2 shows some examples of the load vs. elongation curves obtained from the Instron machine software. These curves display a typical elastic line followed by a sudden fracture for all the compositions, which discloses the brittle behavior of the matrix as well as of the composites. It is important to mention that the polyester matrix composites presented similar behavior.

The tensile strength and elastic modulus results for epoxy and polyester composites with different percentages

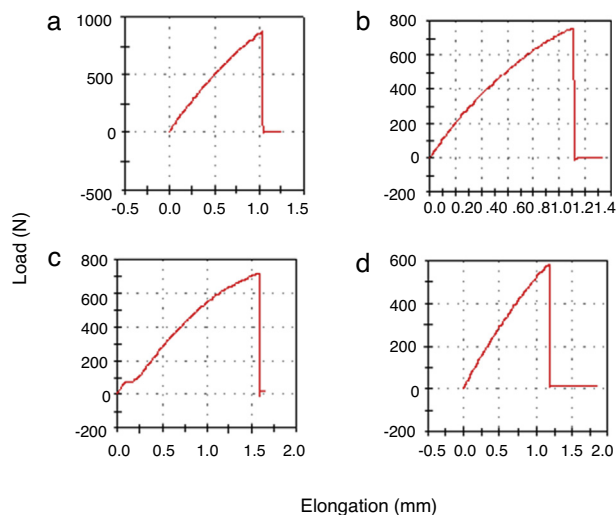


Fig. 2 – Typical load vs. elongation curves: (a) epoxy matrix, (b) 30 vol%, (c) 40 vol% and (d) 50 vol% of eucalyptus fibers.

of eucalyptus fibers are shown in Figs. 3 and 4, respectively. It is possible to note that, within the standard deviation, the presence of eucalyptus fibers did not affect the tensile strength but increased the elastic modulus of epoxy matrix composites. Indeed, the value of elastic modulus increased approximately 50% for epoxy matrix composites. By contrast, for polyester matrix composites, within the error bars, the introduction of eucalyptus fibers slightly decreased the tensile strength, while the elastic modulus remains constant.

The decrease observed in the tensile strength for both epoxy and polyester matrix composites is due to the very low adhesion between the matrix and the fibers. It is worth noting that the natural fibers, eucalyptus particularly, have high amounts of water on their surfaces, aggravating this effect.

Figs. 5 and 6 show by SEM the fracture surfaces of the epoxy and polyester matrix composites, respectively, after tensile testing. In these figures, it is possible to observe some voids in the interface between the fiber and the matrix, evidencing the detachment of the fiber from the matrix. It occurred to both matrices. As mentioned, this is attributed to the low adhesion between both matrix and fibers, which is frequently observed in natural fibers composites [15]. It is a consequence of high amounts of water in the natural fiber surface and their

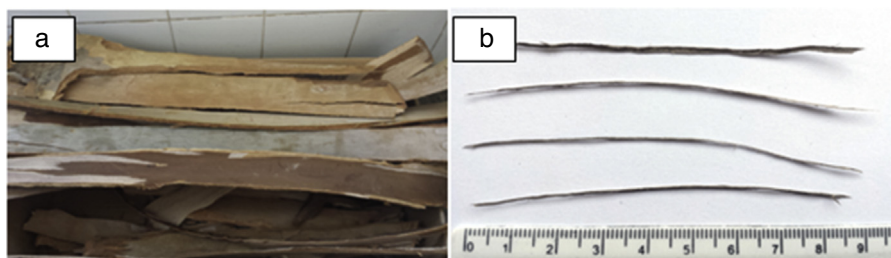


Fig. 1 – Eucalyptus tree bark (a) and eucalyptus fibers (b).

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