Effect of the temperature on the mechanical properties of jute fabric reinforced epoxy composite

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Résumé :

Ce travail présente une évaluation expérimentale de l'effet de la température sur les propriétés thermiques et les propriétés mécaniques d'un composite tissu de jute/époxy chauffé à différentes températures. Le tissu de jute / époxy est préparé à la température ambiante et avec une fraction volumique fixe de jute (quatre couches de tissu) en utilisant la méthode d'infusion. Le composite est chauffé à différentes températures afin d'examiner l'effet de la température. Les propriétés mécaniques du tissu de jute / époxy chauffé à différentes températures sont soigneusement étudiées. Les résultats montrent que les composites exposés à des températures élevées ont tendance à avoir des propriétés mécaniques les plus faibles. A la température (80°C), le composite montre une grande capacité de déformation due au ramollissement de la matrice ce qui réduit la cohésion entre l'époxy et le tissu de jute. Ce dernier est la raison de la diminution de la contrainte de traction. De plus, le ramollissement de la matrice augmente avec l'augmentation de la température de chauffage. La contrainte de traction la plus faible (réduction de plus de 58 %) est déterminée dans le cas du composite chauffé à la température de 80°C. Les résultats de cette recherche confirment la limitation de l'utilisation du composite dans différentes applications, en particulier à haute température.

Abstract:

This work presents an experimental evaluation into the effect of the temperature upon the thermal properties and the mechanical properties of jute fabric / epoxy composite heated at different temperatures. The jute fabric / epoxy was prepared at the ambient temperature and fixed volume fraction of jute (four fabric layers) using infusion method. To examine the effect of the temperature, the composite was heated at different temperatures. The mechanical properties of the jute fabric / epoxy heated at different temperatures were carefully investigated. The results shows that the composites exposed to the high temperature are prone to the lower mechanical properties. At the temperature (80°C), the composite shows a high ability to deformation due to the matrix softening which reduces the cohesion between the epoxy and the jute fabric, which is the reason for the decrease of the tensile stress. Moreover, the matrix softening increase with an increase of heating temperature. The lowest tensile stress (reduce by more than 58 %) was determined in the case of the composite heated at the temperature

80°C. The results in this research confirm the limitation of the composite use in different applications, especially at high temperature.

Keywords: Jute fabric, epoxy, composite, thermal properties, mechanical properties.

1 Introduction

Because of increasing environmental alertness, vegetal fibers have become the most requested materials by researchers and in the industry as reinforcement for polymer resin. The vegetal fibers have many advantages such as environmentally friendly, low cost, availability in all world region, renewability and good mechanical properties [1]. The composite reinforced by vegetal fibers are used in many applications such as automobile, aerospace and construction. However, the composites reinforced by the natural fibers are exposed to the environmental conditions such as temperature and humidity. These conditions influence the mechanical properties of composites. This changers in the properties due to the changers on their mechanical properties of the components of the composite. Bensmail et all [2] investigate the effects of the heat treatment on the mechanical properties of the jute yarns. The results found shows that the tensile stress and modulus of elasticity are influenced by water evaporation and reduce at the heated temperature 100°C. In this investigation, the effect of the heat treatment on the mechanical properties of the composite jute fabric / epoxy is evaluated and the specimens are exposed to the temperature less than 100°C [2]. the tensile tests are effectuated to determine tensile strength, modulus of elasticity and elongation at break for each specimen based on the temperatures. The thermal stability of the jute fabric, epoxy and composite are also evaluated.

2 Materials and methods

2.1 Materials

The jute fabric is extracted from fabric used for the manufacturing of agricultural products bags in the southeast of Asia. The epoxy is Resoltech 1800 ECO/1804 ECO it is 34% biobased on the mix from resoltech: advanced technology resin, French. The manufacturing process of the specimens is summarized in the figure 1.

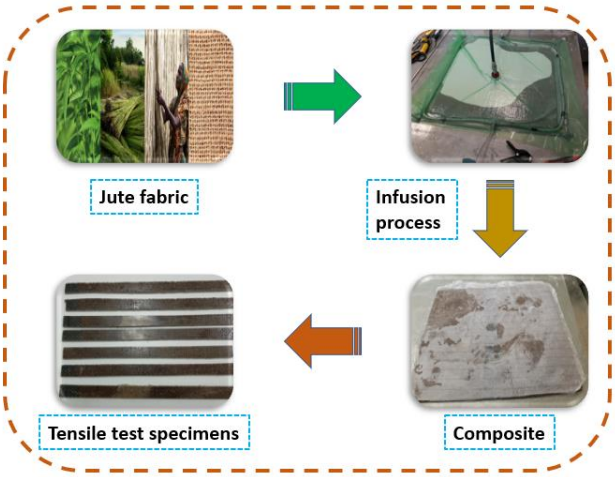

Fig .1: Fabrication process of the composite Jute fabric/epoxy.

2.2 Thermal analysis

The thermal stability of the simples was determined by thermogravimetric analysis (Shimadzu TGA device). The samples weight loss is between 3 and 8 mg of epoxy, jute fabric and composite. Each specimen was examined under air atmospheric with the heating speed at 10°C/min from the ambient temperature to 600°C.

2.3 Mechanical testing method

The mechanical properties of the jute fabric and the composite at different temperatures was carried to studies the mechanical performance of the simples. The jute fabric dimension estimated are 1mm x 20mm x 50 mm and the composite dimension are 4 mm x 20mm x 50 mm. the tensile test speed of the specimens is 2 mm/min. before each test the samples are heated at different temperatures for 24 hours.

3 Results and discussion

3.1 Thermal analysis

The thermal stability curves of the jute fabric, epoxy resin and the composite jute fabric/epoxy are shown in figure 2 (a). The first weight loss below 100°C is due to water evaporation. The second decomposition occurred at the temperature range of 240-350°C due to degradation of the hemicellulose and α-cellulose. The third decomposition occurred at the temperature range of 350-450 which is due to the degradation of the cellulose and non-cellulosic substances [1] [2]. The matrix decomposition occurs on the main steps: the first one occurs at the temperature range of 200-350 °C due to volatilization of epoxy by random chain scission and intermolecular transfer demanding tertiary hydrogen extractions from the polymer. The second decomposition is the degradation of the residue formed after degradation takes place at higher temperatures. The composite is less stable than the matrix epoxy and their decomposition occur on three steps: the first decomposition is due to water release, the second decomposition in due to decomposition of the jute fibers and the volatilization of the matrix epoxy [3] [4]. The last decomposition is due to the degradation non-cellulosic substances and the residue of the polymer degradation. The DTA curves confirm the degradation occurred during the decomposition of the materials used in this study (figure 2 (b)).

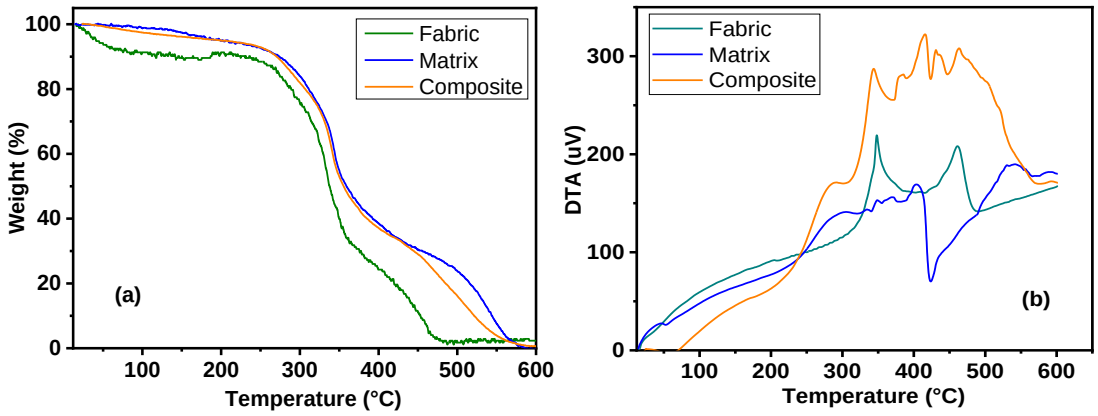

Fig. 2. TGA (a) and DTA(b) curves of jute fabric, epoxy matrix and composite jute/epoxy.

3.2 Tensile properties of jute fabric

The tensile stress-strain curves of the jute fabric are presented in the figure 3 (a). the results show a dispersion of the mechanical properties due to the natural composition of the jute fibres, the jute yarns which are constituted of continuous and discontinuous fibres and number of the fibres in each jute fabric.

The figure 3 (b) show the typical tensile stress-strain curve. The curve can be divided into four zones: the first zone (Z_1) is due to the alignment of the jute yarns and the fibres lose their twisted. The second zone (Z_2) is the elastic zone used on the determination of the Yong modulus. This aligned zone is followed by a third zone (Z_3) which is characterised by non-alignment of the curve and damage of the fibres. The last zone (Z_4) where occur a gradual drop of tensile stress until the total rupture of the jute fabric specimens. The table (table 1) plot the mechanical properties average of ten specimens of the jute fabric [5].

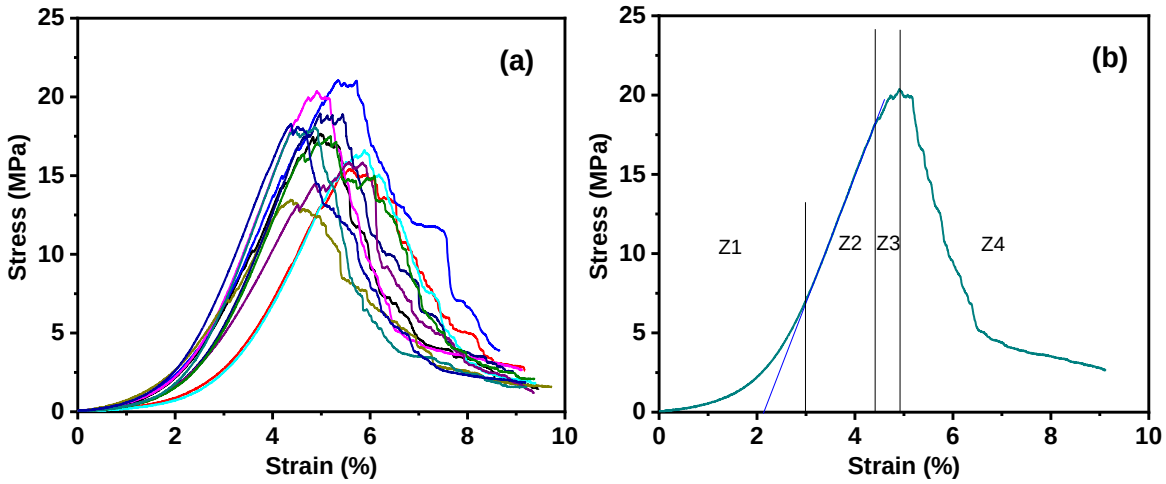

Fig. 3. (a) Stress-strain curves of ten specimens and (b) typical experimental curve stress-strain of jute fabric.

Table 1. The average mechanical properties of ten jute fabric specimens.

Tensile Stress (MPa)	Modulus of elasticity (GPa)	Tensile Strain (%)
17,98	**0,72**	**5,16**

3.3 Tensile properties of composite

The heat treatment effect on the mechanical properties of the composite jute fabric / epoxy is evaluated in this study. The stress-strain curves of the composite jute fabric/epoxy at ambient temperature which are used to determine the mechanical properties are presented in figure 4 (a). The figure 4 (b) plot the effect of heat treatment on the tensile strength of the composite. The results show that the tensile strength of the composite is less than that of the pure matrix due to several factors: the tensile strength of the fabric is less compared of that of the matrix, the adhesion between the matrix and the jute fabric and the cavity content on the composite. The tensile strength of the composite reduces with the increase of the heated temperature due to the softening of the matrix. The module of elasticity decreases with the increase of temperature due to the composite deformation caused by the softening of the matrix and the loads are transferred by jute fabric which have a module of elasticity less than that of the pure matrix (figure 4 (c)). The tensile strain increases with the increases of the temperature due to the ability of deformation of the composite caused by softening of the matrix (figure 4 (d)).

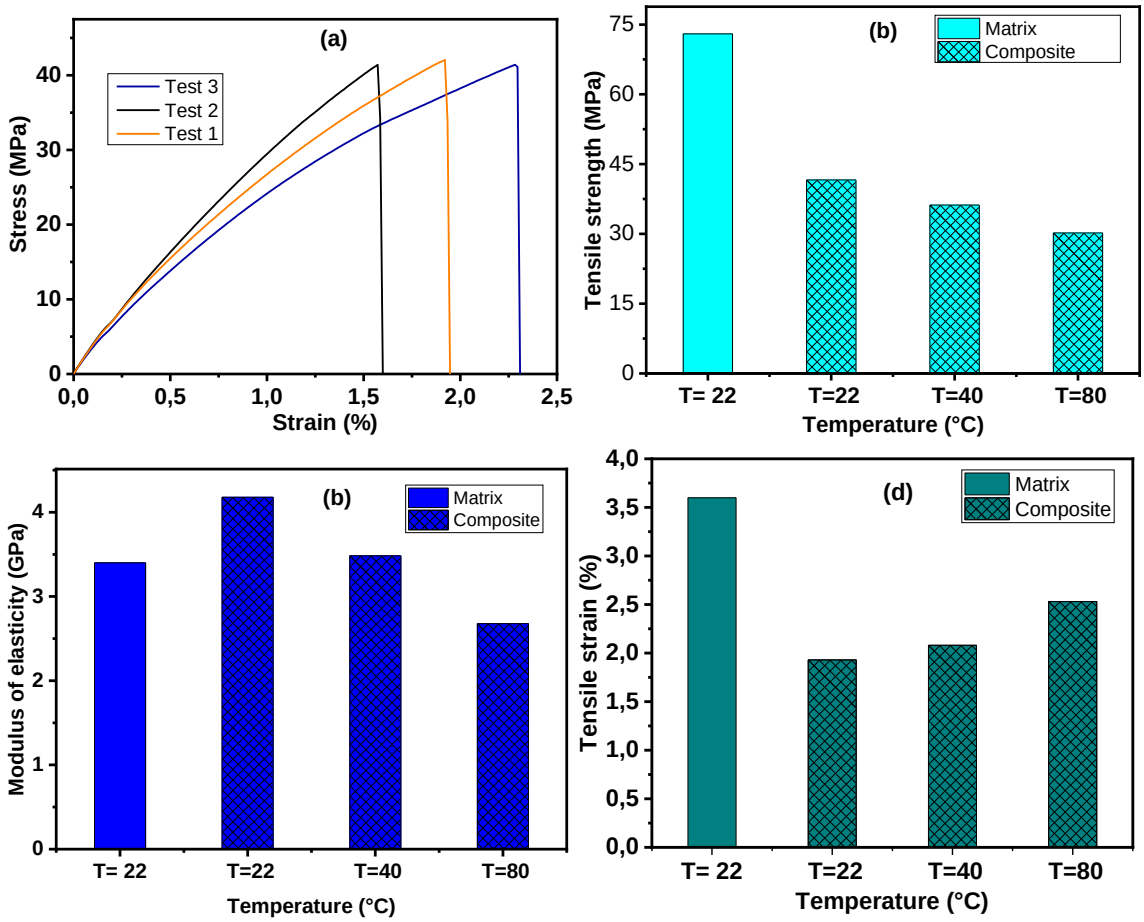

Fig. 4. (a) Stress-Strain curves of composite at temperature 22°C; (b) tensile stress, (c) modulus of elasticity and (d) tensile strain of the composite as function of the temperature.

Conclusion

The effect of the heat treatment on the mechanical properties and thermal stability of matrix epoxy and jute fabric/epoxy composite were investigated and the conclusion drawn are the tensile strength and modulus of the elasticity reduce with the increase of the heated treatment temperature of the composite, whereas the tensile strain decreases with increase of the temperature. This explained by the softening of the matrix epoxy. Furthermore, to benefit of the mechanical properties of the composite the most possible their use must be at the low temperature.

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