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Influence of surface treatments on the mechanical properties of fibre reinforced thermoplastic composites

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Abstract

This work compares the effect of different types of surface treatments of natural fibrous materials, particularly flax, on the mechanical properties of thermoplastic polymer composites for application in automotive sector. The application of surface treatments on fibrous materials can improve the compatibility with polymeric materials. Different surface treatments were applied, namely: cleaning (L); alkali (A); coupling of different functional groups, such as benzoyl (B), amino (SA), epoxy (SE); corona (C). After the application of surface treatments, the fibrous materials were combined with polymeric materials, particularly thermoplastic polyolefin (TPO), by compression moulding. The mechanical tests were performed to evaluate the influence of different surface treatments on flax fabrics on the mechanical properties of TPO combined with these fibrous materials. The experimental results show that the surface treatments on the flax fabrics strongly affect the mechanical properties of the final composite materials, mainly breaking elongation and Young's modulus. Composite materials with flax fabrics subjected to a L+A and L+A+SE treatments show the lower values of Young's modulus corresponding to larger elongation values for the same load. For these set of treatments, the elongation was increased more of 100%, comparing to a composite material with flax fabric without any surface treatment. These results allow to conclude that the surface treatments can increase the elongation capacity of the flax fabrics reinforced TPO, without loss of mechanical properties.

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Keywords: Surface treatments; Flax fibre; Composites; Mechanical properties.

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1. Introduction

Nowadays, the use of natural fibrous materials has gained large interest of application in various sectors, namely in the automotive area. The sustainability of resources is one of main trends in this area, related to the weight reduction of the vehicles. Typically, composite materials used in vehicles manufacturing use synthetic fibres, such as carbon or glass. However, the replacement of these fibres by natural fibres allows to reach the desired target, because natural fibres present lower density as compared to the synthetic ones. Consequently, the weight reduction of vehicles allows lower fuel consumption, which is an important factor for environmental sustainability, due to reduction of greenhouse gases emission. On the other hand, the natural fibrous materials are also biodegradable and recyclable, when used with thermoplastic matrices, characteristics which are equally important for sustainability. Besides these advantages, low cost and lower health hazards, comparing to synthetic fibres, are also to be considered [1].

However, the combination of natural fibres with polymeric materials has some constraints related to the compatibility between both materials. Vegetal natural fibres are composed mainly by cellulose and hemicellulose, which are hydrophilic, and lignin on the surface, which is hydrophobic. This causes poor wettability of the natural fibres by polymers and, consequently, weak compatibility and adhesion at the interface between both materials [2] [3]. In this context, surface treatments on these materials for partial extraction of lignin become important to improve the compatibility with polymeric materials. These surface treatments, besides removal of fats and ash, lead to formation of new functional groups. Several studies have already been carried out on these materials, in the form of randomly oriented fibres, such as sisal, jute, hemp, coir, flax, among others. Natural fibre composites can exhibit very different mechanical performances and environmental aging resistances, depending on their interface properties [1]. The main function of the interface is to efficiently transfer the stress from fibre to fibre, across the matrix [4]. In automotive components manufacturing it is sometimes looked for greater elongation capacities. Several authors have focused their studies on the treatment of fibres to improve the bonding with polymeric materials. However, depending of the applied surface treatment and its concentration, different mechanical properties can be modified. In this context, an understanding of what occurs in the morphological structure is fundamental [5].

For instance, an increase of about 200% in elongation and a decrease of 55% in the Young's modulus were reported, after the alkali treatment of sisal fibres [6]. In another study, with hemp fibres, it was reported a slight decrease on tensile strength, after the alkali treatment [7]. Moreover, Zille et al. refer approximately a 25% drop in tensile strength after a low-pressure argon plasma modification in jute fibres [8].

In this paper, which describes the development of TPO composites reinforced with flax fabrics, it was intended to study the influence of different kinds of flax fabrics surface treatments, on the mechanical properties of composite materials, namely their elongation properties. The composite materials were produced by compression moulding and subsequently characterized by tensile tests.

Nomenclature

L	cleaning treatment
A	alkali treatment
B	benzoyl peroxide
SA	amino silane
SE	epoxy silane
C	corona
TPO	thermoplastic polyolefin elastomer
PP	polypropylene
PA	polyamide