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Influence of water ageing on mechanical properties and damage events of two reinforced composite materials: Flax–fibres and glass–fibres

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ABSTRACT

Moisture absorption and durability in water environment are major concerns for natural fibres as reinforcement in composites. This paper presents a study on the influence of water ageing on mechanical properties and damage events of flax–fibre composites, compared with glass–fibre composites. The effects of the immersion treatment on the tensile characteristics, water absorption and acoustic emission (AE) recording were investigated. The water absorption results for the flax–fibre composites show that the evolution appears to be Fickian and the saturated weight gain is 12 times as high that the glass–fibre composites. Decreasing continuously with increasing water immersion time, the tensile modulus and the failure strain of flax–fibre composites are hardly affected by water ageing whereas only the tensile stress is reduced regarding the glass–fibre composites. AE indicate that matrix–fibres interface weakening is the main damage mechanism induced by water ageing for both composites.

1. Introduction

For several years, new composite materials appeared in the manufacturing industries, particularly automotive, construction and packaging. Environmental requirements and new regulations on the recycling of composite materials urged the industrialists to develop new materials stemming from renewable resources. The introduction of natural fibres in polymer matrices (biodegradable or not) can bring notorious advantages with regard to fibres traditionally used in composites (as glass–fibres). Natural fibres such as flax, hemp, sisal, jute and bamboo indeed establish a renewable and naturally biodegradable resource, arranging numerous high technical qualities, such as low density, good specific strengths and modulus, moderate costs, reduced dermal and respiratory irritation.

However, these materials present some disadvantages, such as the variable quality of natural fibres according to its origin, the adhesion between fibre and matrix which requires appropriate use of physical and chemical treatment and the susceptibility to moisture absorption.

Due to their hydrophilic character, natural fibres play an important role in the ageing of biocomposites in a wet atmosphere or by immersion in water. Water absorption is a brake in the development of the use of natural fibres in composites since the mechanical properties of composites degrade and decrease in wet conditions. The possibility for using these new materials in outdoor applications requires to study and to analyze their mechanical behaviour in an aggressive or hostile environment, particularly in a moisture environment, during a long time.

Several studies show that the biocomposite lose tensile stiffness and strength progressively as water enters the material and that the loss is directly related to water absorption. The sisal fibres reinforced polypropylene composite specimens were subjected to hot water immersion treatment at 90 °C for different durations were investigated by Chow et al. [1]. The longer water immersion time was, the more the tensile modulus and strength of the composites decreased. From pull-out test, Chen et al. [2] specified exposure of the bamboo/vinyl ester composites to water caused significant damage to the interfacial shear strength. Le Duigou et al. [3] noticed the loss of mechanical properties for a flax–fibre reinforced biopolymer composite aged in natural seawater at different temperatures. Arbelaiz et al. [4] investigated the influence of water absorption on the sorption characteristics of flax–fibre bundle/polypropylene (PP) composites by immersion in distilled water at room temperature. The results showed that water absorption increased with the increasing fibre bundle content, what is also noticed for mechanical properties. The use of maleic anhydride–polypropylene copolymer as coupling agent modifying PP matrix slightly decreases composite affinity to water. Other research

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