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CORRELATION BETWEEN ACCELERATED AGING AND NATURAL AGING OF A BIO-SOURCED FLAX FIBER / UNSATURATED POLYESTER COMPOSITE

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ABSTRACT

Accelerated aging tests were carried out on flax fibers, unsaturated polyester and the composite combining these two constituents in order to study their degradation mechanisms. From these tests correlations were derived between the behavior of the composite and those of its constituents under different hydrothermal conditions. The results indicate that accelerated aging tests parameters used for synthetic fiber composites are not always suitable for studying the natural aging of plant fiber composites.

INTRODUCTION

Despite the high specific mechanical properties of plant fibers, their use for the manufacture of semi-structural composite parts is reluctant because of their thermal and hydric properties. Indeed water absorption of the fibers activates physical and chemical mechanisms identical to those usually reported for polymers (swelling, plasticization, leaching). It follows that composites incorporating plant fibers are much more sensitive to hydrothermal conditions than are materials incorporating synthetic fibers (Azwa, 2013). This is manifested by anisotropic dimensional variations and degradation of mechanical properties (Li, 2016).

The study focused on flax fiber rovings (Aretha variety), unsaturated isophthalic polyester (NORESTER 823) and the quasi-unidirectional biosourced composite combining these two constituents ($V_f = 32\%$; density 220 g/m^3 , 7% porosity). Accelerated ageing consisted of immersion in deionized water at 23°C or 70°C for a maximum of 70 days. For natural aging, the materials were exposed to natural conditions on the roof of the laboratory for 24 months.

RESULTS AND CONCLUSIONS

The volume of water absorbed by the composite immersed in water at 23°C as well as the induced swellings are represented as a function of time in Figure 1. The strong dimensional anisotropy observed is explained by the orthotropic hydro expansion behavior of the plant fibers and the elastic deformation recovery in wet environment related to the process of implementation of the composite (Gamstedt, 2016). The analysis of the damage mechanisms of the composite and the results of tensile mechanical tests show a similarity between accelerated aging in water at 23°C and natural ageing even if the reduction of properties is less severe in the latter case (Fig.2). On the other hand, the accelerated ageing in the air at 70°C induces very different damages from those recorded for a natural aging and the reduction of properties are much more important. These differences are explained by the hydrothermal behavior of flax fibers and more precisely relate to the nature of organic compounds on the surface of the fibers.

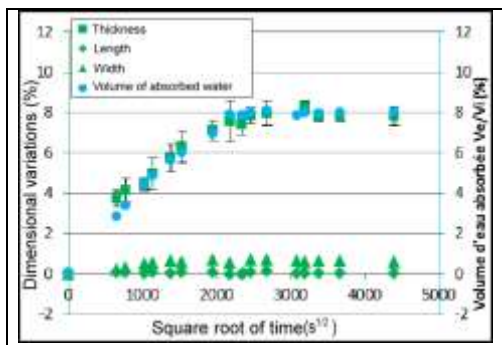


Fig.1 Dimensional variations (green symbols) and volume of water absorbed (blue circle) by the composite during accelerated ageing in water at 23°C

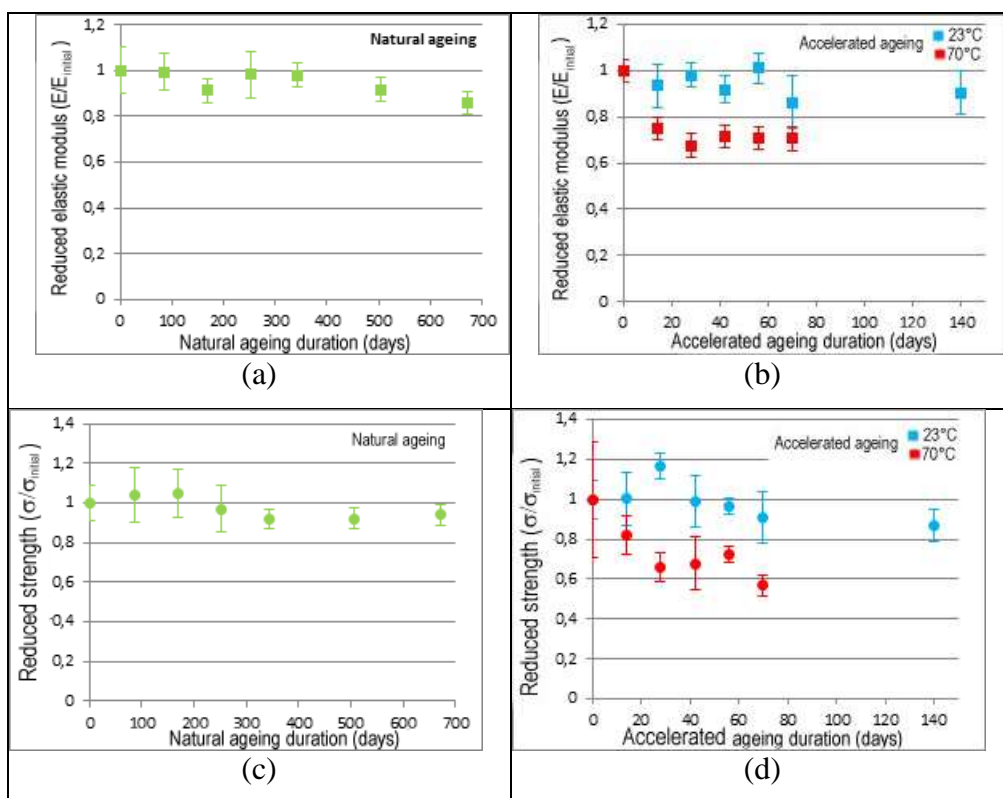


Fig.2 Comparisons of relative variations of modulus of elasticity (a and b) and strength (c and d) as a function of accelerated aging or natural aging time

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