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Mechanical and impact characterisation of flax and basalt fibre vinylester composites and their hybrids

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Abstract

The present experimental investigation is aimed at performing an analysis of mechanical and impact properties of flax and basalt fibres and their hybrids using a vinylester resin to produce reinforced thermosetting composites. Laminates were fabricated by hand lay-up and resin infusion. Cure processes were accelerated and controlled by applying heat and pressure in autoclave. Tensile, flexural and falling weight impact tests were carried out, the latter with energies of up to 40 J. The results indicated that hybrid laminates did not mostly offer properties to the level predicted by an application of the rule-of-mixtures, especially as regards flexural performance. On the other side, advantages provided concerned in particular reducing the brittleness of basalt offering some evidence of plastic behaviour, especially related to the fact of flax fibre reinforced laminated providing a quite long period at quasi constant load during impact tests, therefore resulting in delayed failure, while extensive damage is produced. The results tend to challenge the idea that basalt/flax fibre hybrid laminates would offer a good performance only with the presence of basalt fibres in the outer layers and would suggest the possible adoption in future of more complex stacking sequences, involving intercalation of flax and basalt layers.

1. Introduction

Currently, a large interest and considerable research activity is dedicated to elicit solutions to minimize the environmental impact in the production and use of composite materials, leading therefore to their improved sustainability [1]. New environmental regulations and evolving governmental attitudes are a powerful key-driver, stimulating the research of more environmentally friendly products and processes [2]. As a reinforcement, natural fibres (as flax, hemp, kenaf, wood, bamboo, etc.) are largely investigated as an alternative, involving total or partial substitution, to synthetic fibres (mainly to glass, since carbon and Kevlar offer more specific properties, in terms of mechanical performance) [3-4]. The aforementioned “partial substitution” of glass fibres is normally obtained by hybridization, normally achieved by stacking layers reinforced with glass fibres with other layers reinforced with vegetable fibres, such as hemp, jute, etc. [5-8].

In recent years, basalt fibres have often been proposed as an alternative to glass, in view of some significant advantages: these include the fact that basalt is directly spun from the molten rock, and then finished with the application of sizers not dissimilar from those applied on glass fibres. In addition, the surface of basalt fibre fibres contains groups taking part in ionic exchange, such as hydrogen-bound silanol, which form active adsorption sites and can interact with components of the sizing agent [9]. In some cases, the improved resistance of basalt to acid environments has also been revealed, much more than what had been reported in the case of their exposure to basic environments [10]. In other studies, the reverse was reported, hence that the exposure to alkali