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SILANE MODIFICATION OF THE FLAX/EPOXY SYSTEM INTERFACE

Aitor Hernandez Michelena[a,c]*, Jasper Graham-Jones[a], John Summerscales[a] and Wayne Hall[b]

*e-mail: aitor.hernandezmichelena@plymouth.ac.uk ;

web page: http://www.plymouth.ac.uk/pages/view.asp?page=38937

[a]*Advanced Composites Manufacturing Centre (ACMC), School of Engineering, Faculty of Science and Engineering, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK.*
[b]*Griffith School of Engineering, Griffith University, Gold Coast campus, Gold Coast, Queensland 4222, Australia.*
[c]*"5'TX", Bardenas Reales 70, 4B, 31621, Sarriguren, Spain*

Abstract

Natural fibres (NF) are normally subjected to pre-treatment to ensure good fibre to matrix bonding and consequent mechanical properties and durability. To enhance the sustainability of NF composite systems, it would be sensible to minimise processes that incur environmental burdens. This research considers that addition of silane coupling agent to epoxy resin hardener may be an alternative to the direct chemical pre-treatment of NF before composites manufacture. The current study indicates that silane-in-hardener can eliminate the pre-treatment of fibres and generates composites with optimum mechanical properties.

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Keywords: silane; interface; flax; epoxy.

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1. Introduction

Good mechanical (stiffness and strength) performance in a composite system is normally achieved when the fibres are well-bonded to the matrix. In glass fibre reinforced unsaturated polyester resin, the fibres are coated with a coupling agent where the molecule has a silane group to bond to the fibre and a vinyl group to react with the unsaturation in the resin. The coupling agent will often have an oleophilic/hydrophobic end in the resin and an oleophobic/hydrophilic end at the fibre matrix interface.

1.1. Silanisation of natural fibres

For natural fibre composites, chemical treatment of the fibres with silanes (silanisation) is often used to enhance the fibre/matrix interfacial bonding. Xie et al. [1] have reviewed direct silanisation of natural fibres (broadly flax, sisal and hemp). The creation of covalent bonds over the whole fibre surface occurs by reaction between hydroxyl (OH) groups on the fibre surface and those in the silane molecule (Fig.1). This reaction should lead to natural fibre composites with improved mechanical properties and durability.

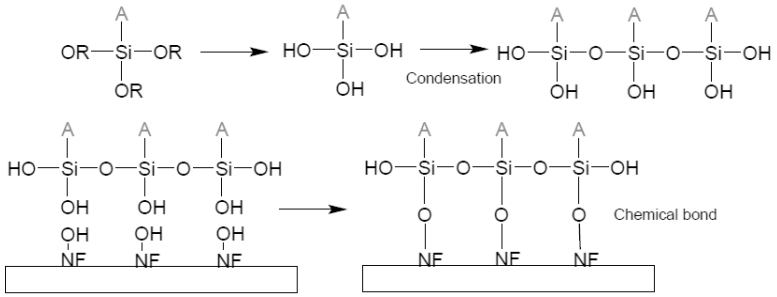

Fig. 1. Si-O-Si bonding scheme

Van de Weyenberg [2] studied different fibre pre-treatments for flax fibre. All the methods started with mercerisation (1, 2 or 3% NaOH solution for 20 min at RT) of the fibres. The fibres were then thoroughly washed in cold water, then acidified water (20 drops of 0.1 M HCl/litre of water) to neutralise the NaOH. The fibres were again rinsed in cold water, then dried in an oven at 80°C for 8 h. The silanisation involved soaking fibres in a 1% solution of 3-aminopropyl trimethoxy silane in equal volumes of acetone and water for 2 h. The fibres were again dried in an oven at 80 °C for 8 h. The longitudinal modulus and strength were increased by ~58% and ~38% when the fibre was treated with 1% NaOH solution then 3% epoxy resin solution. The longitudinal modulus and strength were increased by 46% and 4% respectively after treatment with 1% silane. The transverse modulus and strength were increased by 400% and 110% respectively after silane treatment.

Xie et al. [1] reviewed the use of silane coupling agents (generally trialkoxysilanes) in NF/polymer composites to improve the interfacial properties. The generic chemical structure of the silane coupling agents is $A_{(4-n)}$-Si-$(R'X)_n$ (n = 1,2) where A is alkoxy (alkyl ether), X represents an organofunctional group, and R' is an alkyl bridge. The alkoxy normally reacts with the NF surface and the R' organofunctional group is compatible with the organic polymer matrix due to their similar polarities. The organofunctional entities in the silane may be amino-, mercapto-, glycidoxy-, vinyl-, or methacryloxy- groups. Aminosilanes, especially γ-aminopropyltriethoxysilane (APS), are most commonly reported coupling agents used for natural fibres in polymer matrices.