FGRP manufactured with spray-deposited MFC fiberglass fabrics.

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Abstract

This study presents the obtained hierarchical composites with unidirectional (UD) fiberglass fabrics deposited with MFC dispersed in water, acetone, and isopropanol by spray-up coating. The monolayer laminates manufactured via resin infusion. AFM analysis showed morphology modification on the surface of the fiberglass after MFC deposition. The maximum flexural stress and flexural modulus evaluated with a three-point bending test was 18% and 22%, to the MFC dispersed in water, 13%, and 17% by dispersion in acetone, and 11% and 13% to dispersion in isopropanol in comparison with the fabric without deposition.

Keywords: Composites; Hierarchical; MFC, Spray-up coating; Fiberglass.

Introduction

The introduces of nanomaterials into conventional fiber-reinforced polymer composites to create a hierarchical reinforcement structure to improve mechanical properties has been a promising way [1].

The microfibrillated cellulose (MFC) is a bio-friendly, sustainable, and renewable alternative nanomaterial [2] to applies like a hierarchical reinforcement to enhance the mechanical properties of composites [3-5].

Two different strategies have beeing to obtain a hierarchical structure. First, the dispersion of nanomaterials in the composite matrix [3], and the second way is a direct fixation on the surface of the primary fiber [4, 5].

The MFC is generally obtaining in water dispersion due to its hydrophilic nature. It is necessary to perform the solvent exchange process to replace water with another solvent, such as acetone, to be possible disperses MFC in hydrophobic systems, like an epoxy resin [2].

On the other hand, to be deposited on the fiber surface can be used MFC dispersed in water or another solvent of interest by different deposition methods. The reports in the literature showed that when unidirectional (UD) glass fiber coating with a dispersion of 7.5%wt MFC in NaOH using a drawbar, enhanced the interlaminar fracture stress in 31% of L-bend joint [4]. Composite laminates manufactured with fiberglass fabrics treated by dipping in 0.1% wt MFC aqueous dispersion, showed improvement of 38% in flexural modulus and 27% in maximum flexural stress [5]. Thus, the deposition of MFC in the reinforcing fibers still presents forms to be explored, as other scalable techniques may be employed.

The present work carried out the deposition of dispersed MFC in water, acetone, and isopropanol in unidirectional fiberglass (UD) fabrics by spray-up and manufacture of monolayer epoxy matrix laminates by resin infusion under flexible tooling (RIFT). The

MFC deposition morphology on the surface of fiberglass analyzed via AFM and the mechanical properties of laminates by a three-point bending test.

Experimental Procedure

The MFC used was Exilva F 01-V, content 10% wt MFC aqueous paste, gently supplied by Borregaard. The dispersion of 0.1% wt made using distilled water and an Ultra Turrax disperser. 0.1% w MFC dispersions in acetone and isopropanol obtain by the solvent exchange process.

The UD fiberglass fabrics supplied by Owens Corning were sprayed with 50ml on each side of the fabric, using a spray gun at a distance of ~ 20 cm and then dried at 100 ° C for 3h in a hot air drying oven. The epoxy resin system used was the EPIKOTE MGS RIMR 035c, with Epikure Curing Agent RIMH 037, supplied by Hexion Indústria e Comércio de Epóxi LTDA. The monolayer composites were manufactured by RIFT. The curing step was performed in a hot air drying oven using heating steps: 30 ° C (1h), 50 ° C (1h), and 70 ° C (3h).

Tapping Mode AFM analysis was made in a Bruker Dimension® Icon™ Scanning Probe Microscope (SPM) to investigate the morphological modification cause by MFC deposition on the surface glass fiber. Mechanical properties were also investigated using the three-point bending test in a universal testing machine EMIC DL200, according to ASTM D790 [6].

Results and Discussion

Atomic Force Microscopy (AFM)

A sample of MFC-deposited fiberglass by spray-up an aqueous suspension was analyzed via AFM (Figure 1).

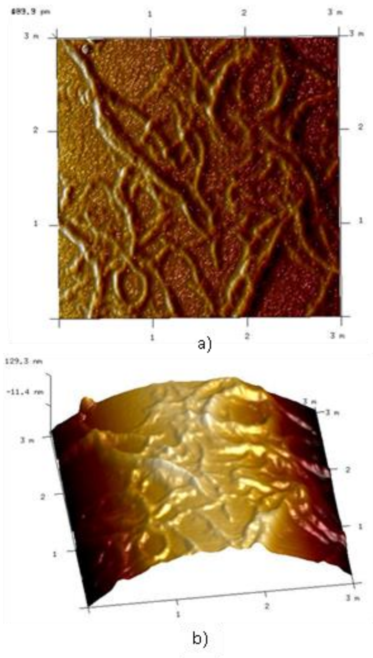
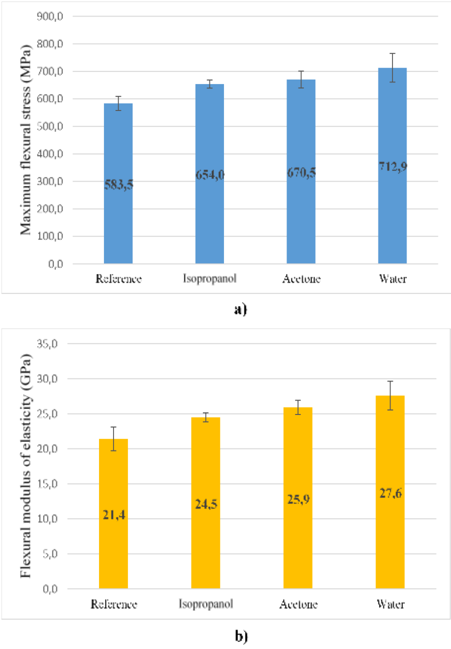


Figure 1 - AFM images of the surface of a spray-deposited MFC fiberglass: a) 2D image and b) 3D image.

The fiberglass serves as a substrate for MFC deposition (Figure 1a) and a change in the surface morphology of the fiberglass (Figure 1b).

Three-Point Flexural Test.

During the test, surlyn films were used between the specimens, the loading nose, and the supports. Thus, it was possible to compare the maximum flexural stress and flexural stiffness modulus of monolayer laminates of untreated with the fabrics treated by MFC dispersed in the different solvent (isopropanol, acetone, and water).



Graphic 1 – a) Maximum flexural stress and b) flexural modulus of elasticity of unidirectional fiberglass monolayer laminates: untreated and sprayed with 0.1% wt MFC dispersed in isopropanol, acetone, and water.

An increase in the maximum flexural stress and flexural modulus of 18% and 22%, respectively, was observed in the sample sprayed with aqueous dispersion, followed by dispersion in acetone, 13%, and 17%, and dispersion in isopropanol with 11% and 13% comparing with the fabric without deposition.

Conclusions

Composites made of MFC-deposited fiberglass fabrics showed an increase in flexural mechanical properties compared to non-MFC fabrics, especially those sprayed with MFC in aqueous dispersion. The AFM analysis showed the morphological modification on the fiberglass surface due to the MFC, which acted as a reinforcing agent at the composite fiber/matrix interface.
Further studies need to be performed to understand better the effect of dispersion media on MFC deposition and what adhesion mechanisms involved between fiberglass / MFC / epoxy.

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