IAMaC2021 — 1st Ibero-American Conference on Composite Materials
29th and 30th of July, 2021
FEUP - Porto, Portugal
U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

CEFET/RJ · CNPq · FAPERJ Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro · CA Composites & Adhesives Group

Effect of water on the mechanical and thermal properties of natural fibre and hybrid composites

G. B. de Seixas[1], H. F. M. de Queiroz[1], J. S. S. Neto[1], D. K. K. Cavalcanti[1], M. D. Banea[1]

[1]CEFET/RJ - Federal Center of Technological Education in Rio de Janeiro, Brasil

Abstract

The use of natural fibres presents important advantages, such as: biodegradability, low density and low cost, when compared to synthetic fibres [1]. However, one of the main problems is the absorption of humidity due to the hydrophilic characteristic of the natural fibre, which leads to low interfacial adhesion between the fibre and the hydrophobic matrix and consequently, relatively low mechanical properties [2]. One method to reduce the sensitivity of mechanical and thermal properties of the NFRCs to moisture uptake is the hybridization by using synthetic fibres and/or fillers. The main objective of this work was to measure the water diffusion in natural fibre and hybrid composites and assess the residual strength of water saturated (aged) and desorbed (deaged) composites. Jute and glass fibres were used along with multi-scale synthetic fillers to fabricate the composites. Bulk specimens were used to measure the diffusion coefficient of water in the composites studied. Tensile, flexural and thermal analyses were conducted. SEM images were used to analyse fracture surfaces of the tested specimens. It was found that the moisture uptake decreases by adding the synthetic fibres and the fillers to the NFRCs. The mechanical properties of the composites (the tensile and flexural strength and modulus) tend to decrease with the increase of water content and they are recovered after desorption at the same temperature as the absorption.

Experimental details

Materials: **Resin:** HEX SLOW 135 epoxy resin, Barracuda Advanced Composites (Rio de Janeiro, Brazil). **Fibers:** Jute – bidirectional woven mats supplied by Sisalsul (São Paulo, Brazil). Glass – Glass fiber woven mats supplied by Barracuda Advanced Composites (Rio de Janeiro, Brazil). **Fillers**: Titanium dioxide nanoparticles (TiO2) – supplied by Nanostructured & Amorphous Materials, Inc. (Texas, USA). Glass powder – commercially available glass microparticles. **Methods**: Gravimetric absorption and desorption tests were carried out with distilled water until saturation. The composite specimens were tested in traction with a universal testing machine (INSTRON® model 5966) with a load cell of 10 kN, with a cross-head speed of 1 mm/min. A load cell of 1kN was used for the flexural tests. TGA thermal analysis was carried out via a NETZSCH TG 209 F3 Tarsus machine. SEM analysis was with X-Ray Microanalysis: JEOL - JSM-7100F.

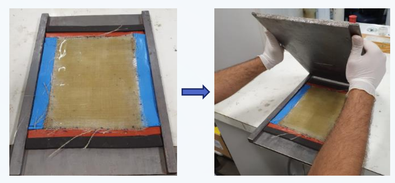
Absorption specimens

$$M_t = M_\infty - M_\infty \frac{8}{\pi^2}\sum_{n=1}^{\infty}\frac{1}{(2n+1)^2}exp\left[-\frac{(2n+1)^2 D\pi^2}{h^2}t\right]$$

$$D = \pi\left(\frac{h}{4M_\infty}\right)^2\left(\frac{M_2 - M_1}{\sqrt{t_2} - \sqrt{t_1}}\right)^2$$

Absorption

$$M_t = \frac{m_t - m_0}{m_0} \times 100\%$$



Filler weight fraction: **3%**

- GFRP: Glass Fibre Reinforced Polymer
- Hybrid GJG: Interlaminar jute/glass hybrid
- JFRP+TiO2: Nanotitanium filler
- JFRP+glass: Micro glass filler
- JFRP: Jute Fibre Reinforced Polymer
- Neat epoxy resin

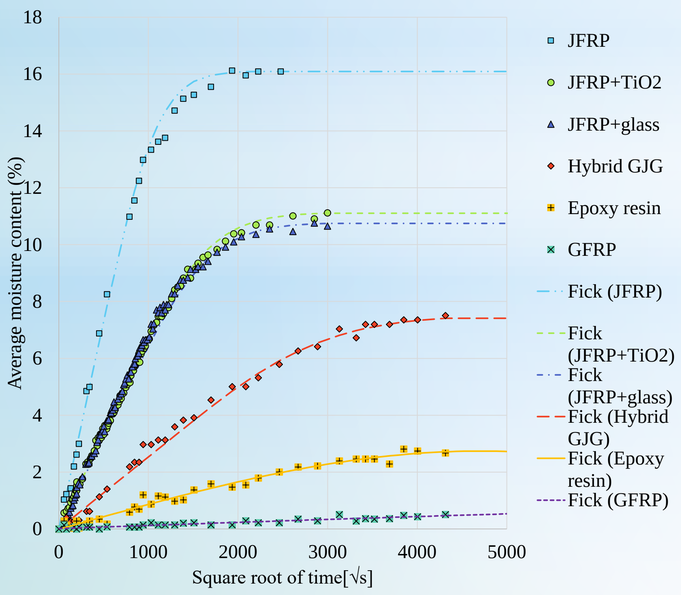
Tested specimens

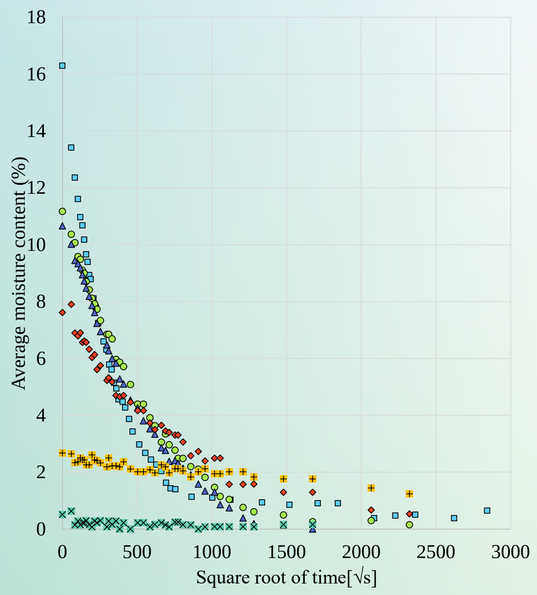
Cases: Unaged; Aged (saturated); Deaged (desorbed)

Composite fabrication → **Ageing tests** → **Mechanical tests** → **SEM analysis**

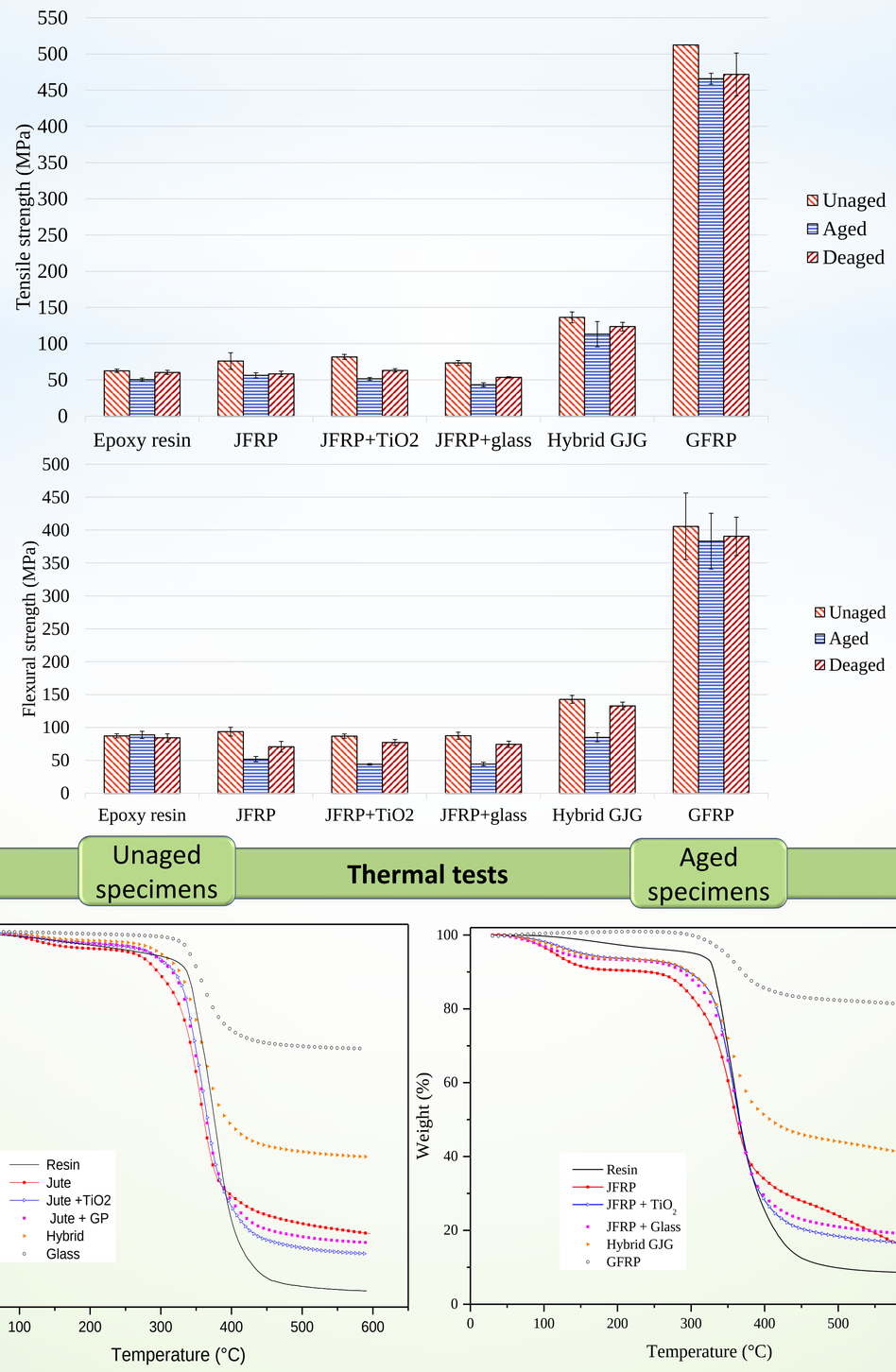
Results

Absorption/desorption



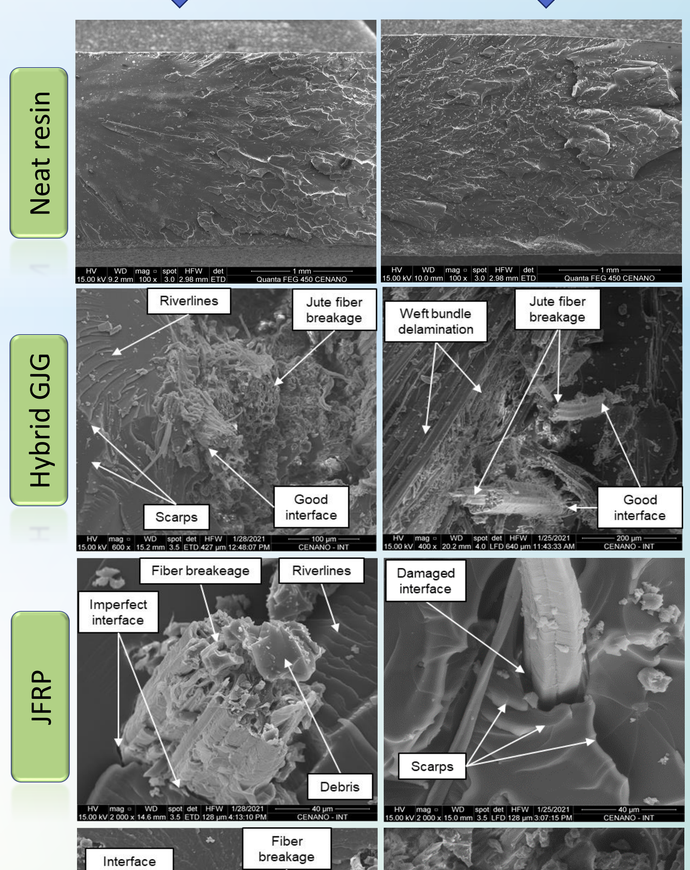


Mechanical tests



SEM analysis

Unaged specimens · Aged specimens



Thermal tests

Unaged specimens · Aged specimens

Conclusions

- The moisture uptake decreases by adding the synthetic fibres and the fillers to the NFRCs.
- The mechanical properties of the composites (the tensile and flexural strength and modulus) tend to decrease with the increase of water content.
- The mechanical properties present a tendency of recovery after desorption at the same temperature as the absorption.
- The thermal analysis showed that the hybridization method improved the thermal properties of the composites.
- SEM analysis showed that the natural fibre/matrix interface is affected by the ageing process for all specimens except the Hybrid GJG and filler agglomerations were present for both filler scales.

References

[1] de Queiroz H. F. M, Banea M. D. and Cavalcanti D. K. K. Applied Adhesion Science. 2021; 9.

[2] Cavalcanti D. K. K., Banea M. D., Neto J. S. S., Lima R. A. A., da Silva L. F. M. and Carbas R. D. S. G. Composites Part B: Engineering. 2019; 175: 107149.