ICCM22
MELBOURNE
AUSTRALIA
11-16 AUGUST 2019
22nd International Conference
on Composite Materials

# THERMAL AND MECHANICAL BEHAVIOUR OF FLAX YARNS MODIFIED WITH GRAPHENE OXIDE

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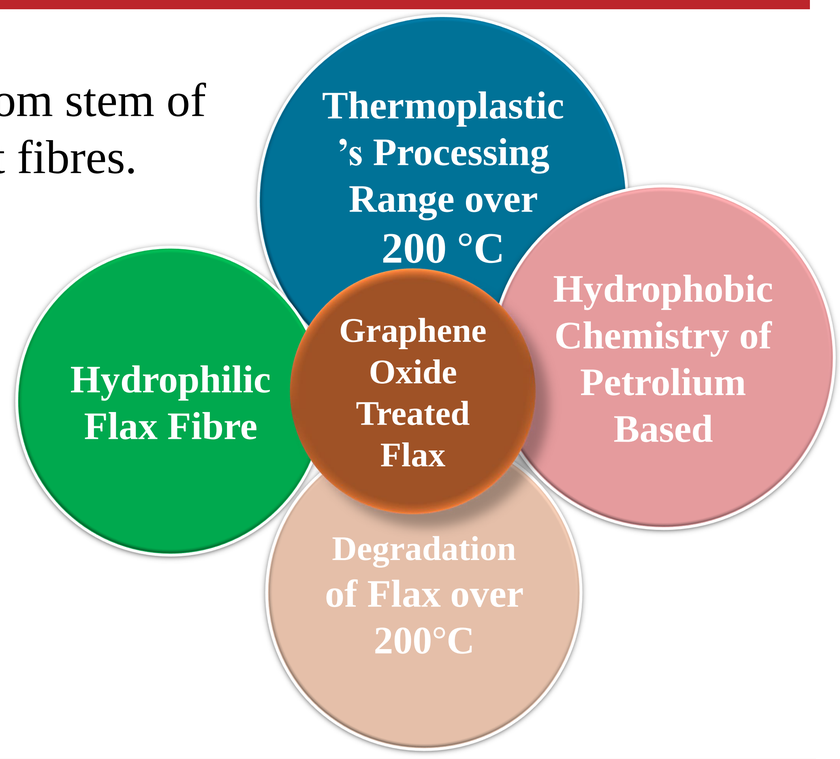
## Introduction and Objective

- **What is flax fibre?**

Flax fibres are hierarchical structures made of biopolymers which are extracted from stem of flax plants. Flax has among the highest specific mechanical properties among bast fibres. It has good damping properties and specific strength approaching glass fibre.

- **What is the objective for this study?**

Flax fibre bundles are modified with Graphene Oxide (GO) to increase the affinity between highly hydrophilic flax fibres and epoxy resin. GO has oxygen-containing functional groups such as hydroxyl and epoxide, which can facilitate bonding through flax/epoxy interphase. Furthermore, the potential of GO treatment to alter the thermal stability of flax fibre bundles in processing temperatures over 200°C is studied.

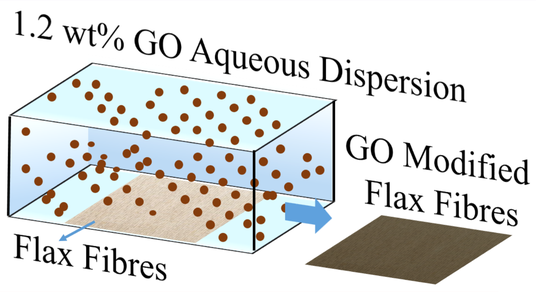



## Methodology

- Flax fibre bundles are extracted from UD non-crimp fabric AmpliTex. Extracted bundles are immersed in 1.2 wt% GO aqueous solution for 24 hr and dried at 80 °C for 2 hr and 48 hr at 60 °C

Graphite Flakes —Oxidation→ Graphite Oxide

The oxidation step of graphite flakes is based on Hummers and Offeman,1957 in presence of: 98% $H_2SO_4$, $NaNO_3$, $KMnO_4$




## Back-Calculated Tensile Stiffness and Strength

Impregnated Fibre Bundle Test (IFBT) Results

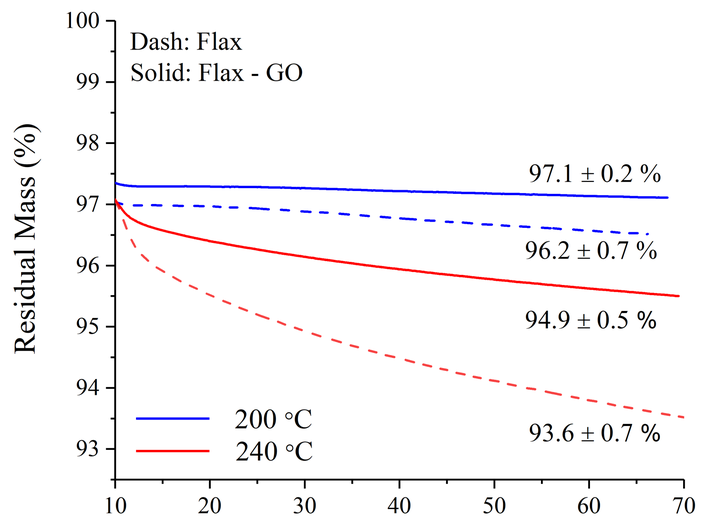
$$V_f = 40\% = \frac{m_f/\rho_f}{V_C} \quad E_f = \frac{E_C - E_m(1-V_f)}{V_f} \quad \sigma_{uf} = \frac{\sigma_C - \sigma_m(1-V_f)}{V_f}$$

| Material | $E_{f0.1\,\%}$ GPa | $E_{f0.3-0.5\,\%}$ GPa | $\sigma_f$ MPa |
|---|---|---|---|
| Flax | $48 \pm 5$ | $31 \pm 3$ | $546 \pm 54$ |
| Flax - GO | $54 \pm 2$ | $36 \pm 1$ | $592 \pm 22$ |
| Flax 10 min at 240 °C | $47 \pm 2$ | $34 \pm 2$ | $234 \pm 34$ |
| Flax – GO 10 min at 240 °C | $47 \pm 2$ | $34 \pm 1$ | $267 \pm 17$ |

Resin system: Epikote 828 with Dytek DCH-99 hardener

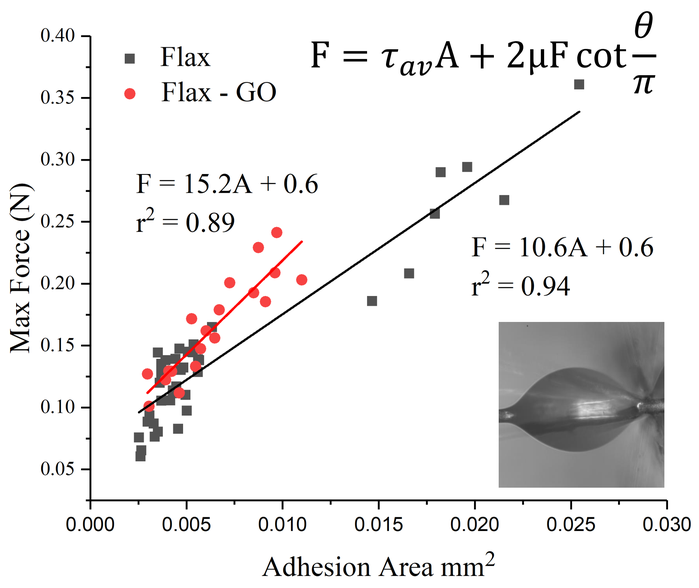
## Thermal Stability of Flax Yarns

Isothermal Thermal Thermogravimetric Analysis (TGA) of Flax Yarns




## Interfacial Shear Strength

Microbond Test Results of Forty Elementary Flax Fibre – Epoxy Droplets




## Conclusions

- For the first time, 43% improvement in the apparent interfacial shear strength of flax /epoxy with GO treatment is reported.
- Based on the isothermal TGA results at 200 °C and 240 °C for 1 hr, thermal stability of GO modified flax fibre bundles are slightly higher than neat flax fibres
- Tensile stiffness and strength of back-calculated flax technical fibres before and after heat treatment is in the same range as GO treated flax technical fibres

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 764713*