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The Impact of Short and Long-Term Ageing in Glycol Water Mixture on Mechanical Behaviour of Polyamide 6/Glass Fibers Materials and Recovery of Properties After Desorption Process

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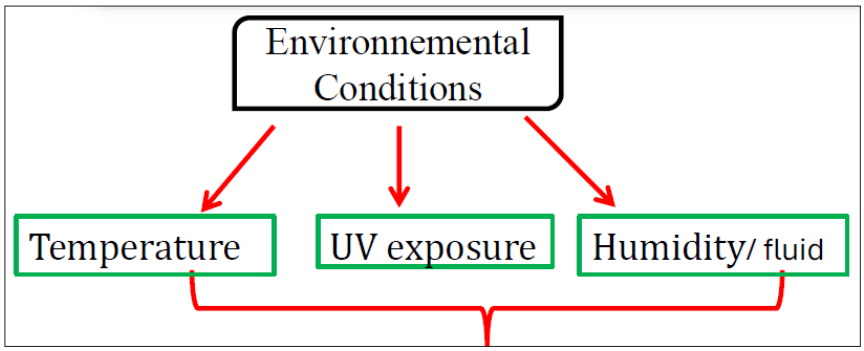
Introduction

Polyamide materials (PA) and their composites have known a widespread use that has percolated in almost all the sectors especially in automobile industry owing to their ease of manufacturing, high mechanical strength, low density, and chemical resistance.

Thus, they are used for many components either in under the hood applications such as intake manifold, coolant expansion tank or for interior components as steering wheel, clutch pedals, door handles, seat frames, etc.



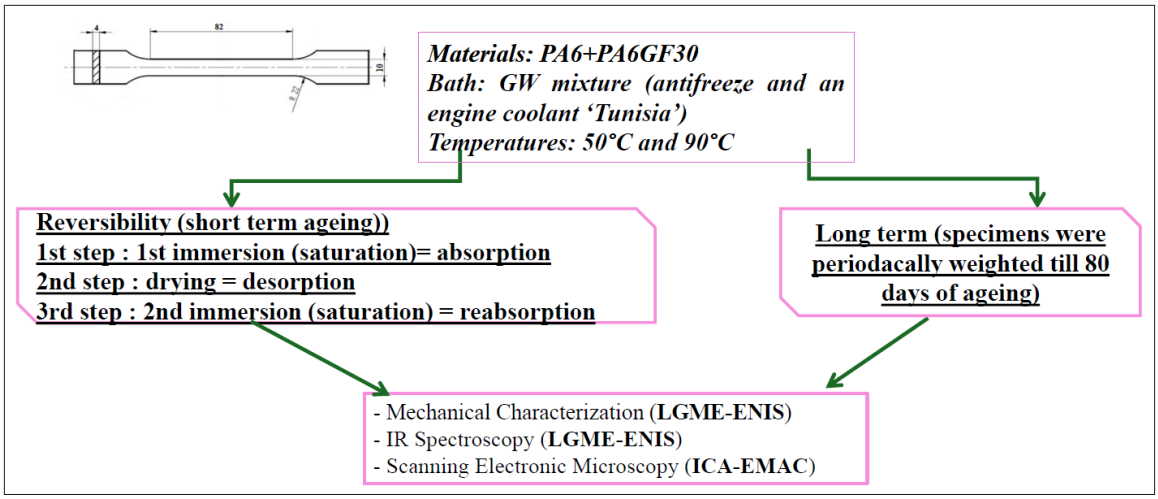
→act separately or simultaneously and decrease their performance and durability

The short term and long-term ageing of Polyamide 6 (PA6) and Polyamide 6 reinforced with 30% of short glass fibers (PA6GF30) under glycol water (GW) mixture (20:80) at 50°C and 90°C for up to 80 days is studied.

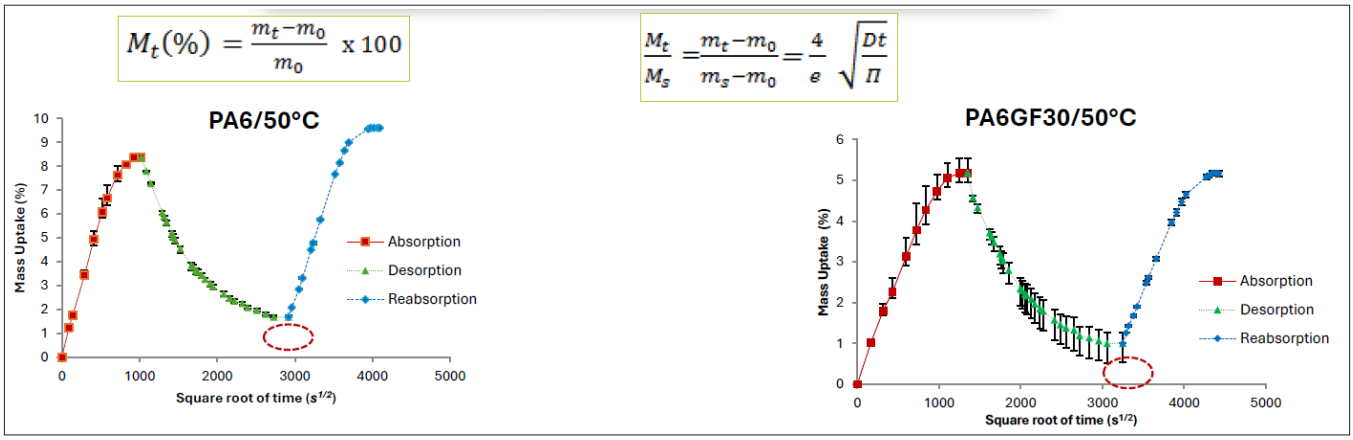
Plan

1. Materials and ageing procedure
2. Reversibility of sorption process
3. Effect of long term ageing on reinforced and unreinforced PA6
4. Conclusion

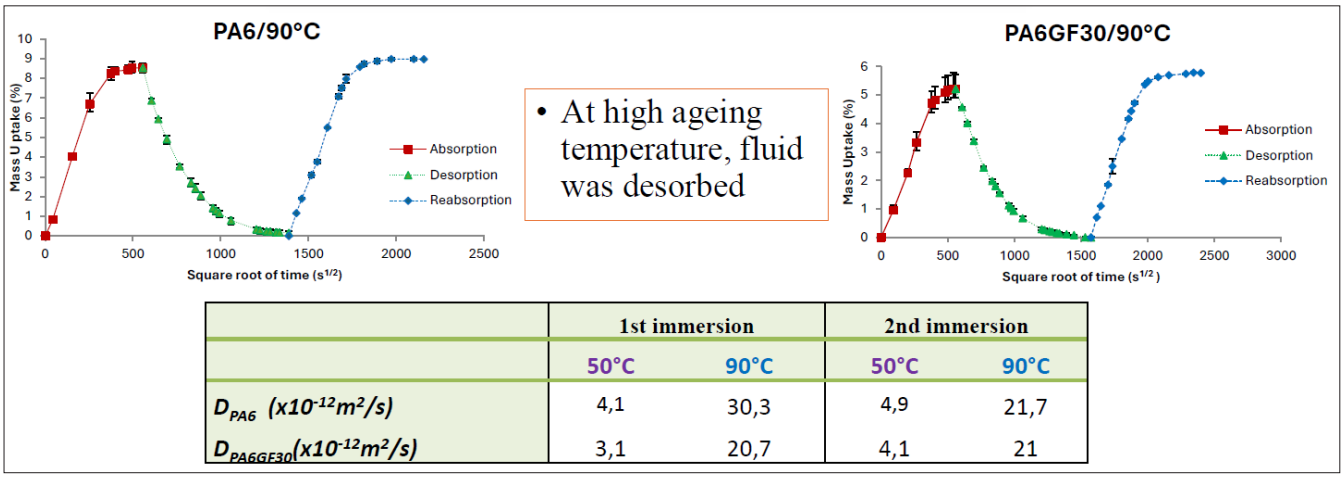
Materials and Ageing Procedure



Reversibility of Sorption Process



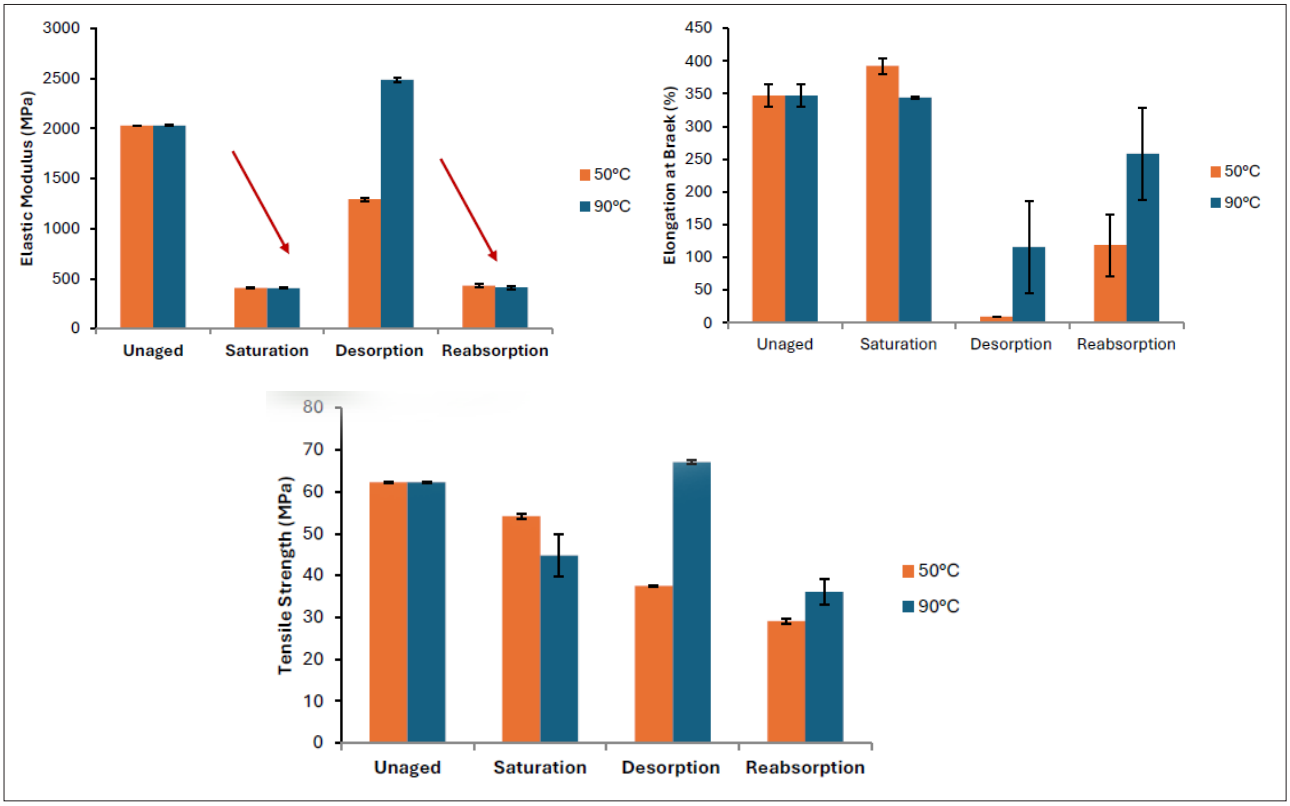
- The shape of the water uptake curves is consistent with Fickian diffusion for both materials
- At low ageing temperature, residual fluid was detected (the presence of humidity)



	1st immersion		2nd immersion	
	50°C	90°C	50°C	90°C
D_{PA6} ($x10^{-12}m^2/s$)	4,1	30,3	4,9	21,7
$D_{PA6GF30}$($x10^{-12}m^2/s$)	3,1	20,7	4,1	21

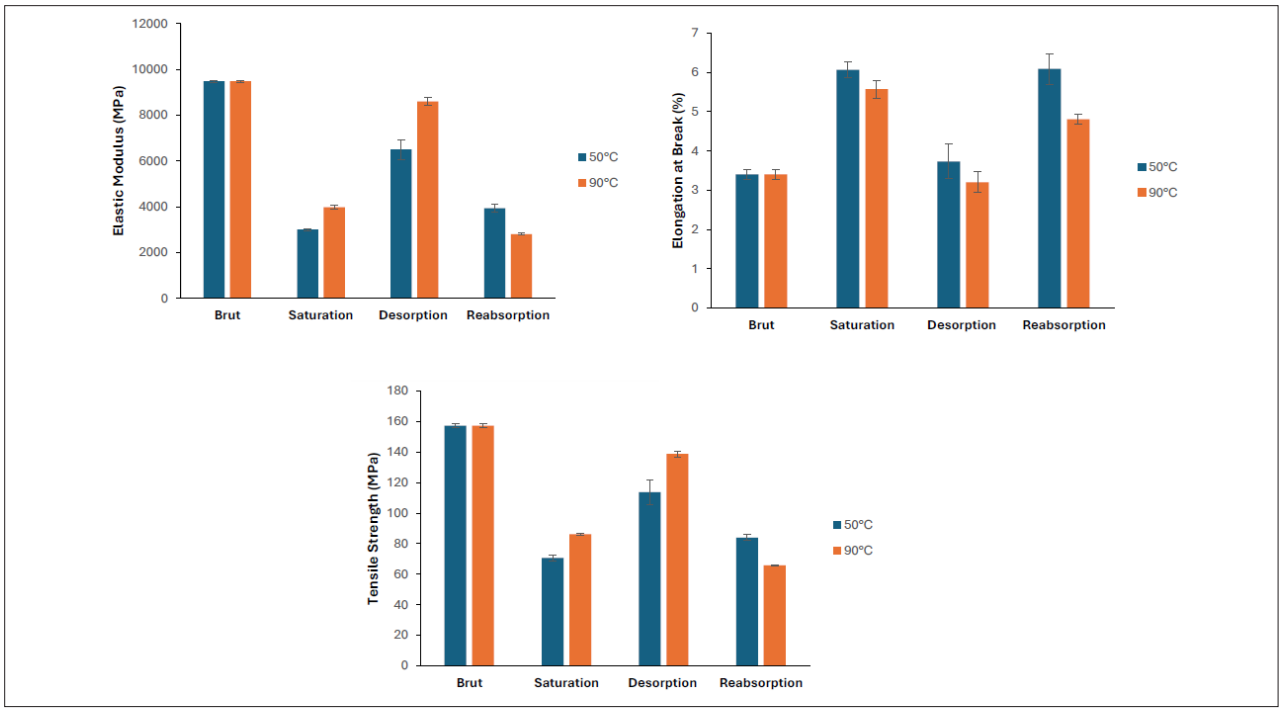
- Sorption process rises linearly with the conditioning temperature.
- The network structure of aged material has already been changed after absorption and desorption which can increase/decrease the free volume of the polymer.

Mechanical Properties: PA6



- Tensile strength and Elastic modulus decrease after the first immersion and the second whatever the ageing temperature (Elastic Modulus falls catastrophically) →destruction of hydrogen bonds
- Properties were totally recovered at 90°C (at 50°C : the residual fluid)
- Elongation at break increases at 50°C (after the 1st immersion) →plasticizer effect of fluid

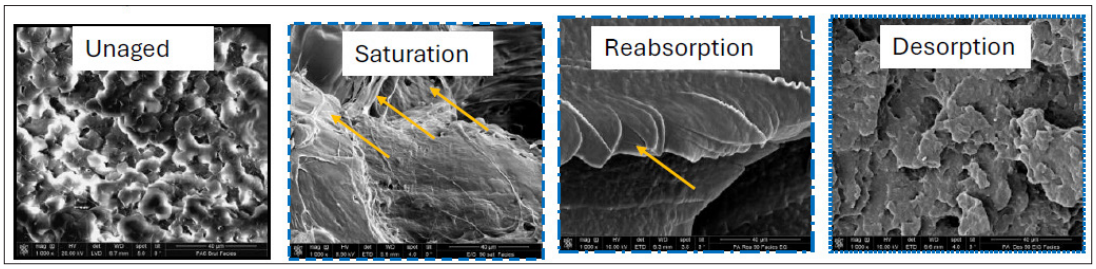
Mechanical properties:PA6GF30



- Tensile strength and Elastic modulus decrease after the first immersion and the second whatever the ageing temperature →destruction of hydrogen bonds and interface debonding
- Only 80% of Properties were recovered: destruction of the interface is an irreversible phenomenon
- Elongation at break increases at 50°C (after the 1st immersion) → plasticizer effect of fluid

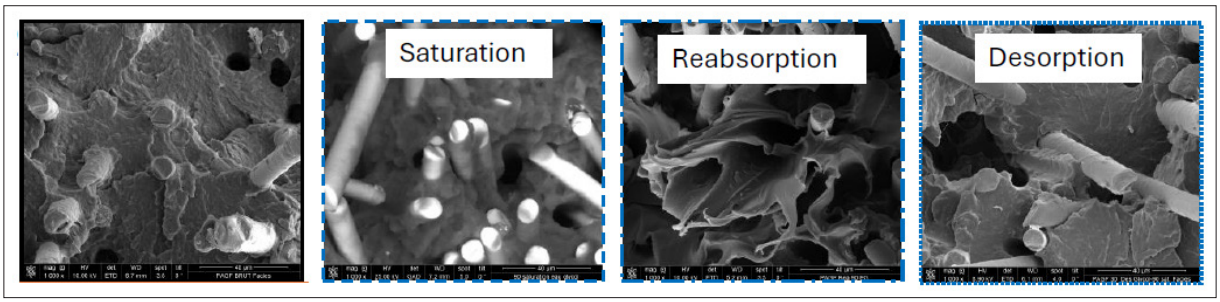
SEM Observations/90°C

PA6



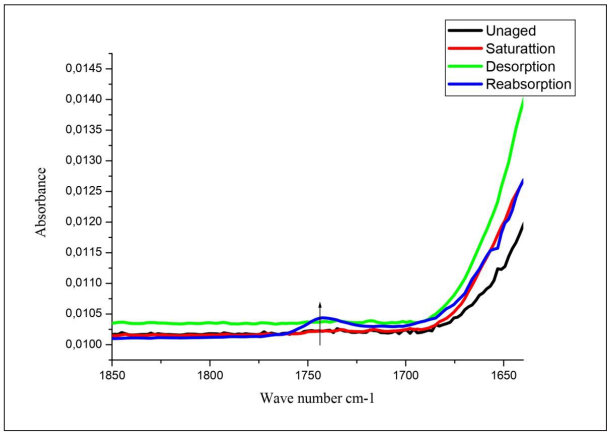
- After 1st and 2nd immersion), rough surface/ fibrils and/or sinusoidal folding are discernable plastic deformation (plasticization effect)
- After drying SEM observations are almost similar to those before ageing

PA6GF30



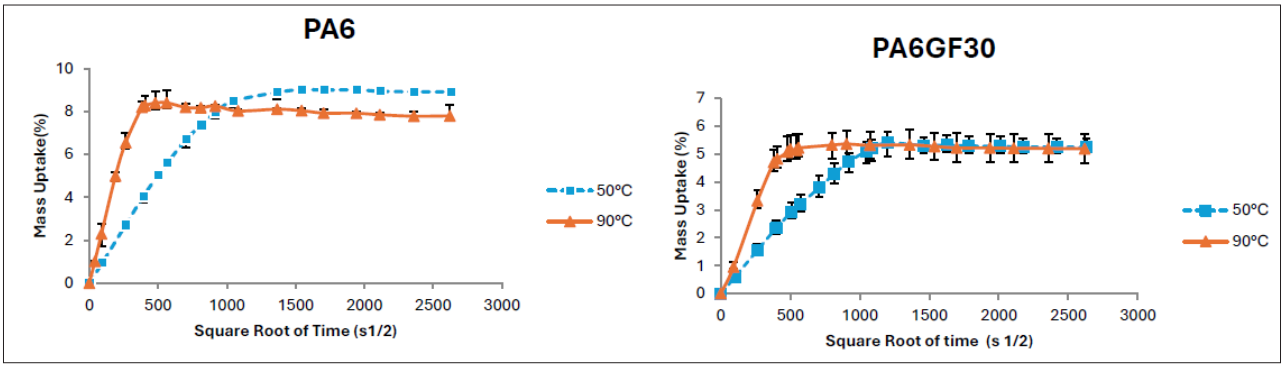
Reversibility of sorption process

IR Spectroscopy



- 1742 cm^{-1} = an imide detectable for PA6 samples aged at 90°C after second immersion (Reabsorption) →chemical degradation

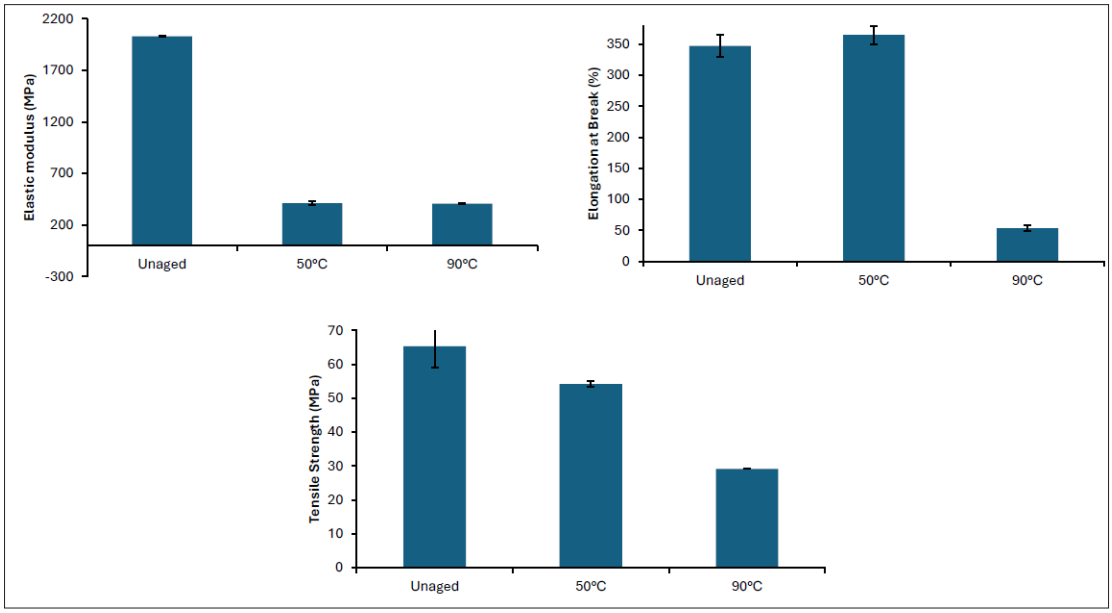
Effect of Long Term Ageing



- Decrease of mass uptake→hydrolysis of the macromolecular chains= leaching phenomenon
- This phenomenon remains visible for PA6 samples than for PA6GF30 at 90°C than at 50°C→ only the polymer is the only

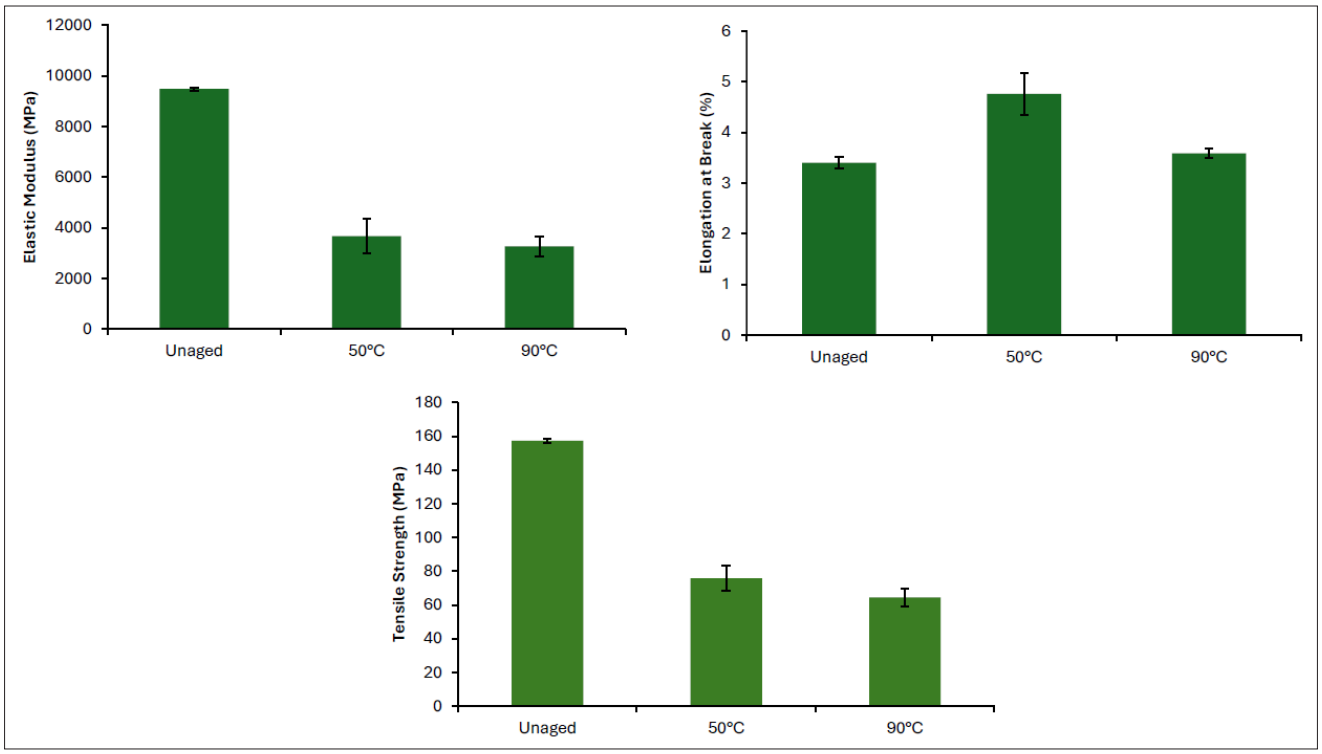
contributor on the ageing process which constitutes the hydrophilic portion (temperature effect)

Mechanical Characterization:PA6



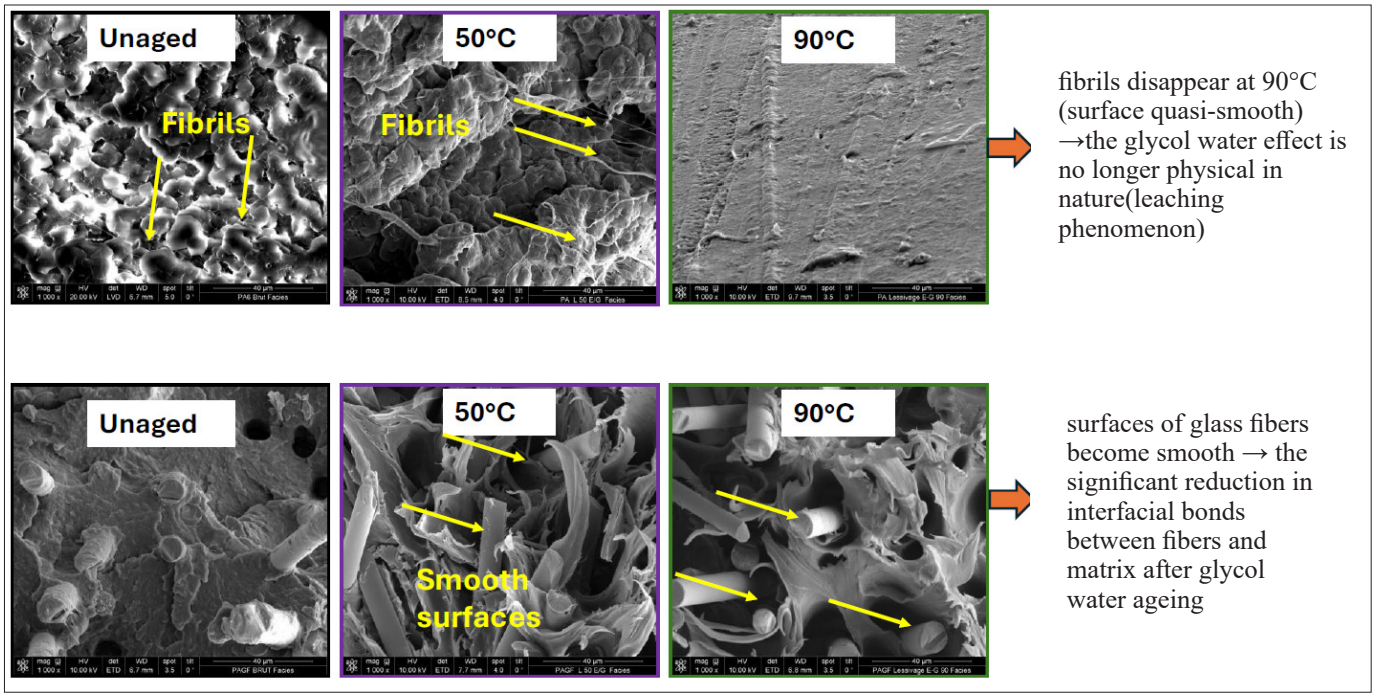
- Decrease of elastic modulus the same for all temperatures
- Tensile strength decreases progressively with ageing temperature
- Elongation at break, a catastrophic drop was measured for sample aged at 90°C estimated by 85% in comparison with unaged ones → the occurrence of irreversible damage (temperature impact)

Mechanical Characterization:PA6GF30

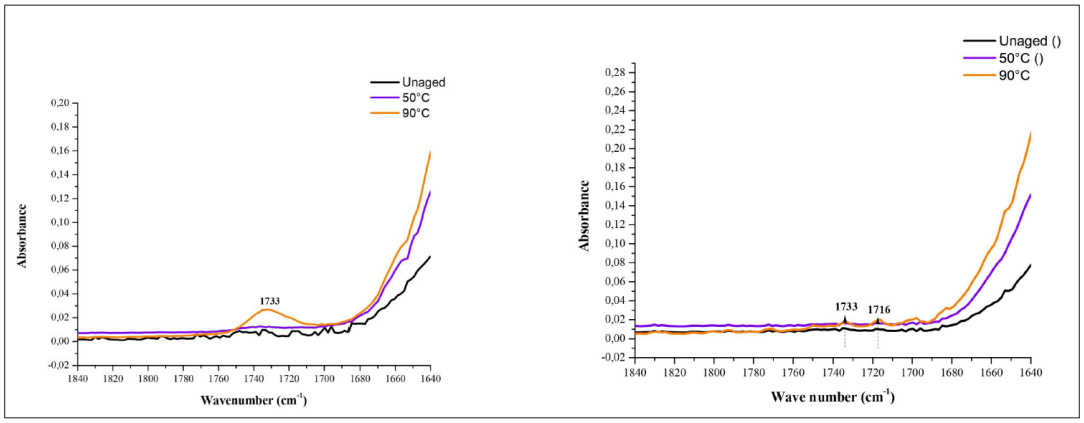


loss of both stiffness and strength →destruction of the interfacial zone between glass fibers and the matrix (the stability of this region is crucial for the effort transmission from the matrix to the fibers)

SEM Observations



IR Spectroscopy



- 1733 cm^{-1} = an ester more detectable for PA6 samples aged at 90°C than other samples
- 1716 cm^{-1} = attributed to the formation of diametric acids or ketones as reported →species, known as oxidation products, suggest that studied material undergoes thermodegradation with its extent depends on both parameters' temperature and time

Conclusion

At short ageing, sorption is reversible (at 90°C) for PA6 samples

• Damage of the interfacial adhesion between fibers and matrix is irreversible

• After long term ageing, hydrolysis of the macromolecular chains in the polymeric matrix → leaching phenomenon (remains pronounced for PA6 samples than for PA6GF30 ones)

→ Occurrence of mechanical changes (pointed out by IR spectroscopy results)