Influence of the flax fibre chemical composition on mechanical properties of epoxy biocomposite

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INFLUENCE OF THE FLAX FIBRE CHEMICAL COMPOSITION ON MECHANICAL PROPERTIES OF EPOXY BIOCOMPOSITE

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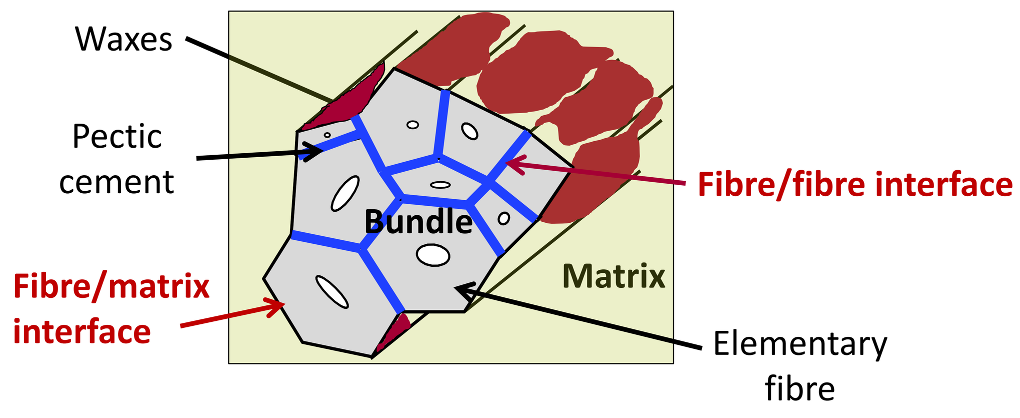
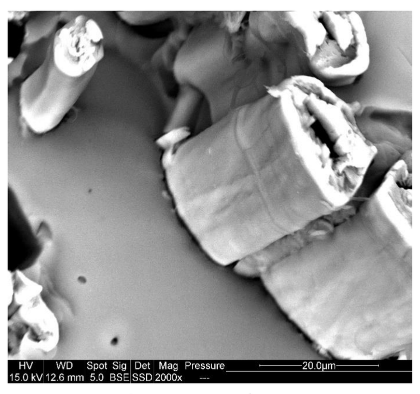
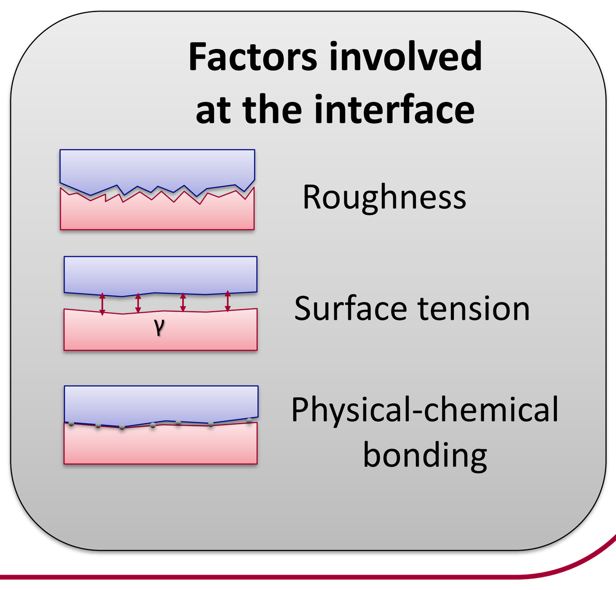
CONTEXT

Natural fibres based composites are increasingly used mainly because of their low density and positive life cycle assessment. Nevertheless an improvement of their mechanical properties is required. A better control of the fibre/matrix interface and of the intra-fibrillar interface within the fibre bundles has to be established.





Composite

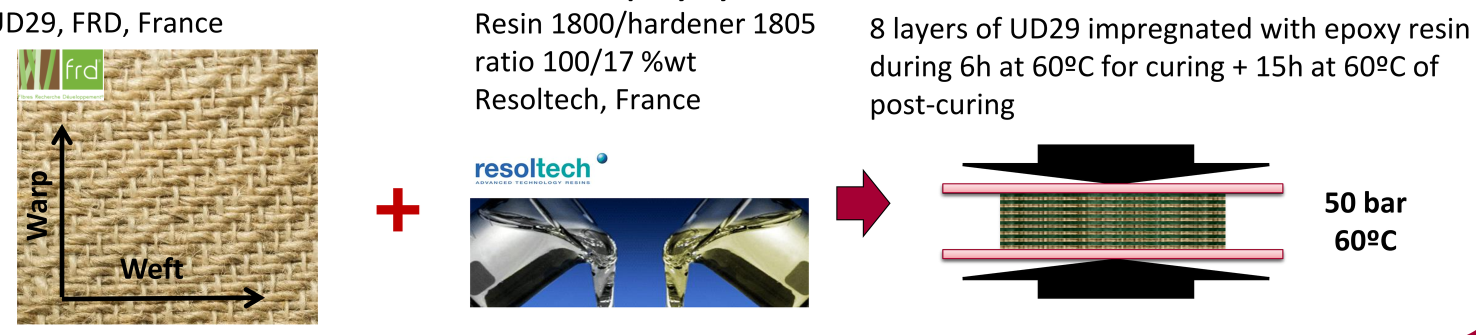


MATERIALS

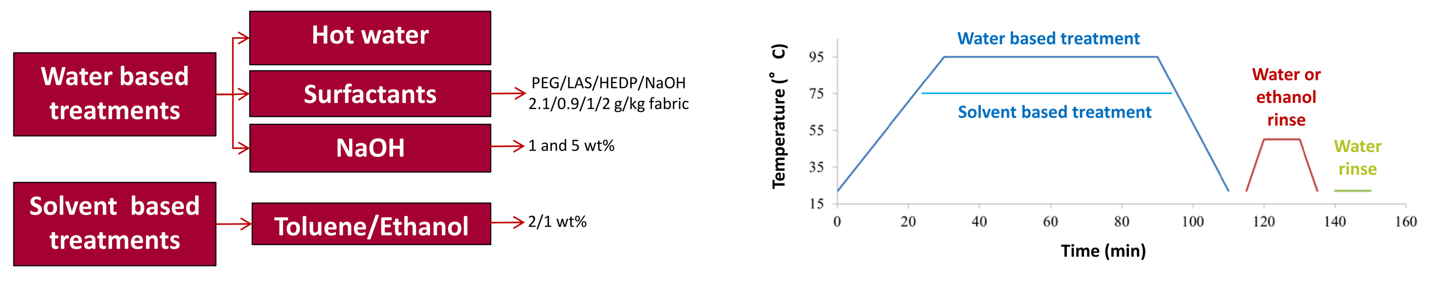
Quasi-unidirectional flax fibre fabric UD29, FRD, France

Structural epoxy system Resin 1800/hardener 1805 ratio 100/17 %wt Resoltech, France

Composite processing : Thermo-compression 8 layers of UD29 impregnated with epoxy resin during 6h at 60ºC for curing + 15h at 60ºC of post-curing



WASHING TREATMENTS



PEG : polyethylene glycol (non ionic) - LAS : alkyl benzene sulfonate (anionic) - HEPD : 1-hydroxyethane 1,1-diphosphonic acid (chelating agent)

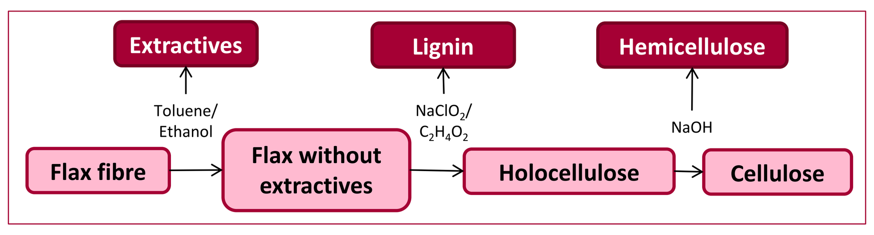
OBJECTIVES

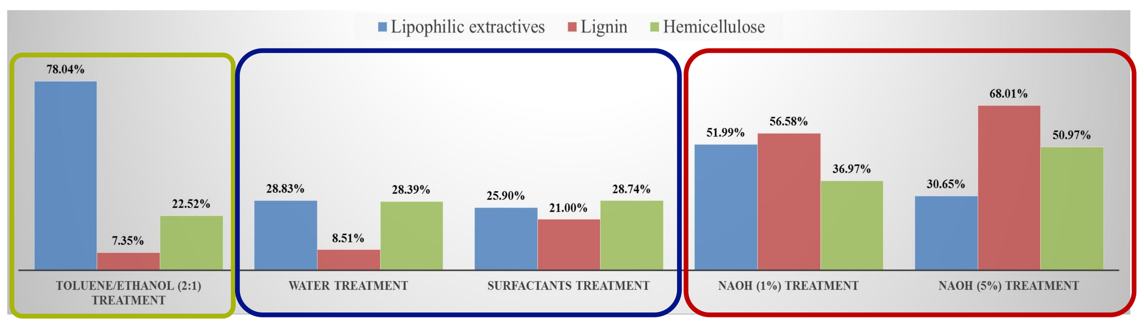
Study the influence of different washing treatments on the flax fibre fabrics properties and the flax/epoxy composite microstructure and mechanical properties

FLAX FIBRE FABRICS PROPERTIES

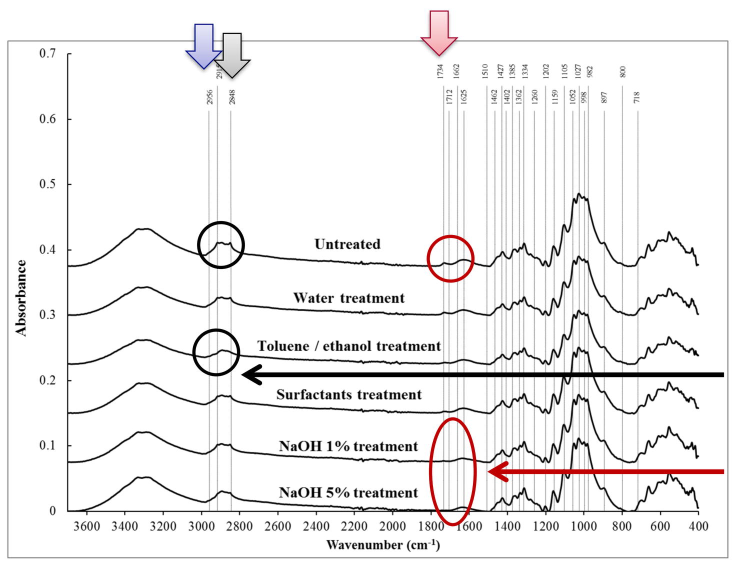
Chemical composition

1- Successive extractions
TAPPI T-264 / ASTM D1104-56 / ASTM D1103-60 / ASTM D1102-84
2- Ajustment of the values to the same amount of cellulose
3- Weigth loss (%) of each component vs. untreated fibre





3 evolutions according to the treatment nature :
- Toluene/Ethanol : removal of lipophilic extractives
- Water, surfactants : global weak extraction
- NaOH : strong extraction of lignin and hemicellulose



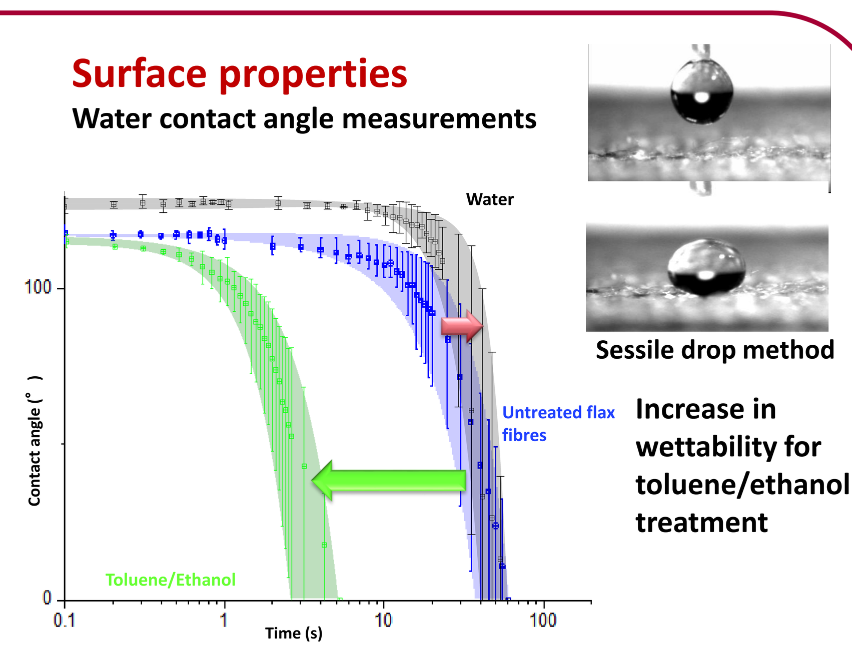
FTIR analysis (ATR)

Toluene/Ethanol treatment
Extraction of lipophilic components

NaOH treatments
Lignin extraction

Surface properties

Water contact angle measurements



Sessile drop method

Increase in wettability for toluene/ethanol treatment

FLAX / EPOXY COMPOSITE MICROSTRUCTURE

POROSITY

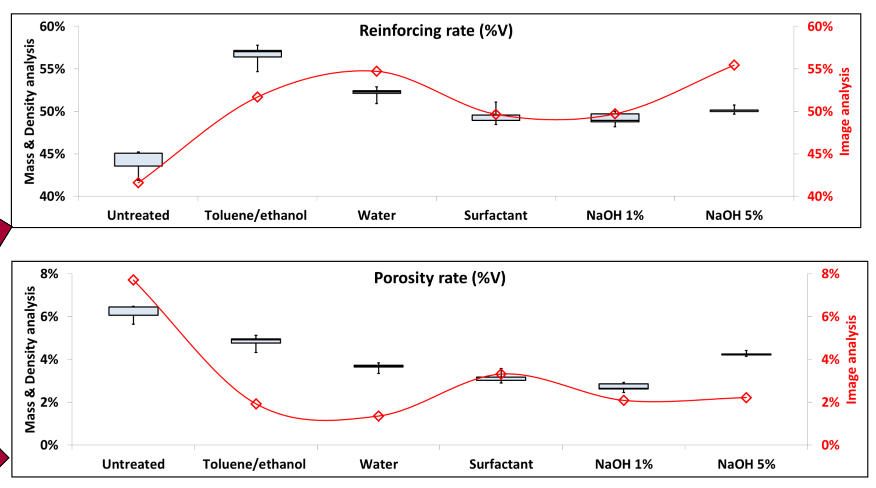
Method 1 : gravimetry and density analyses

- Mass reinforcing rate obtained from woven areal density
- Weight content of matrix obtained from difference between composite areal density and woven areal density
- Volume rates :

$$\%_{v\,(Reinf)} = \%_{w\,(Reinf)} \cdot \frac{\rho_{Comp}}{\rho_{Reinf}}$$

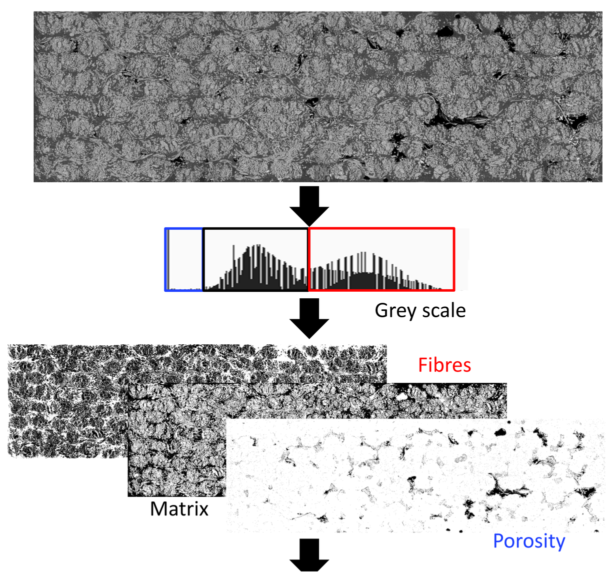
$$\%_{v\,(Matr)} = \%_{w\,(Matr)} \cdot \frac{\rho_{Comp}}{\rho_{Matr}}$$

$$\%_{v\,(Por)} = 1 - (\%_{v\,(Reinf)} + \%_{v\,(Matr)})$$

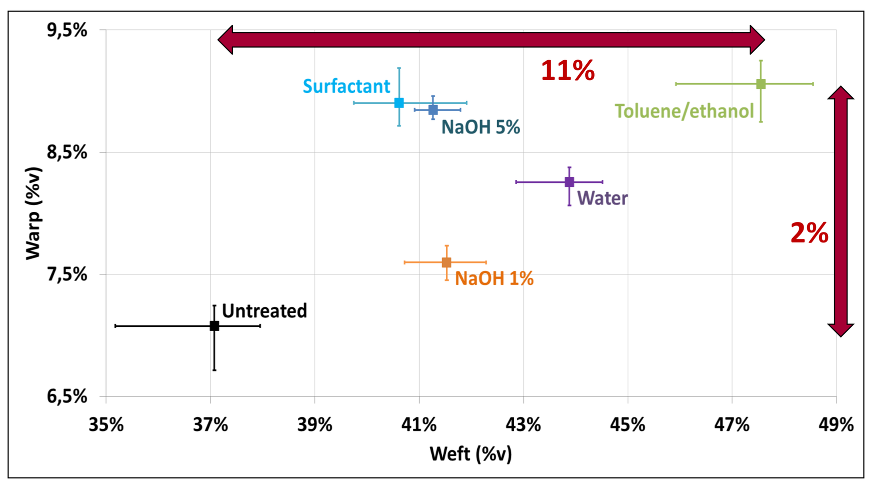


- **Small differences between both methods**
  → *Image analysis method is a more local method so that differences may occur for less homogeneous composite*
- **Decrease in the porosity rate whatever the washing treatment**

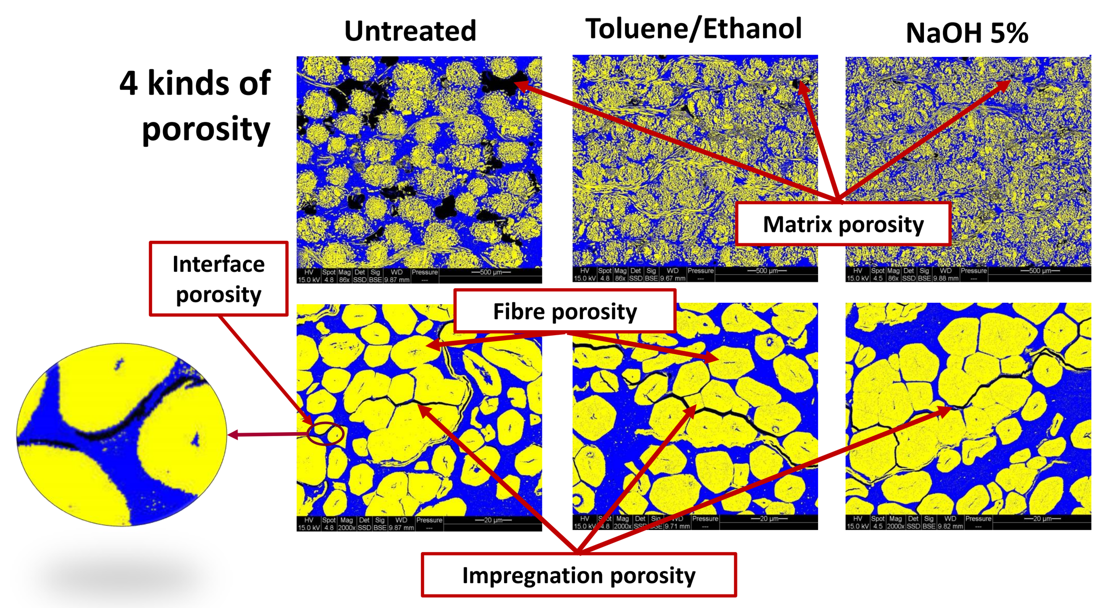
Method 2 : image analysis



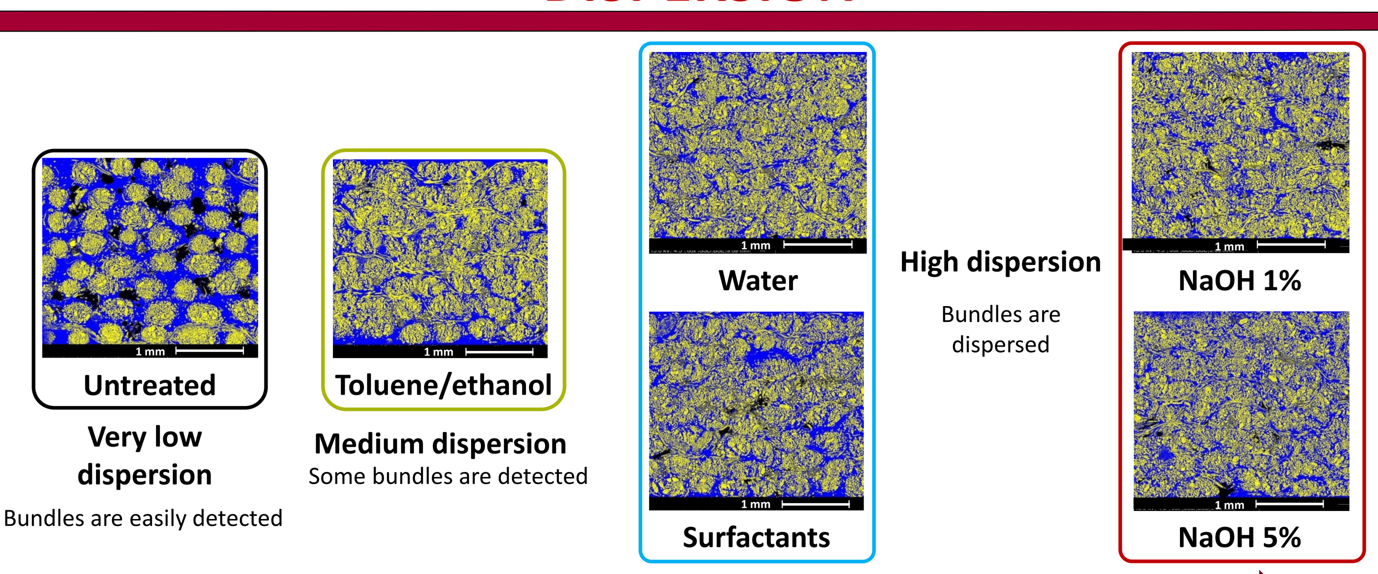
$\%_v$ of fibres, matrix and porosity in a surface section



Warp reinforcing rate constant whatever the washing treatment



DISPERSION



Very low dispersion
Bundles are easily detected

Medium dispersion
Some bundles are detected

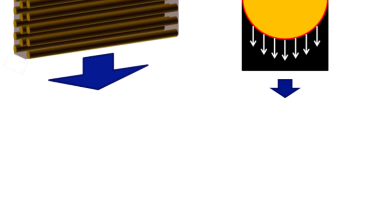
High dispersion
Bundles are dispersed

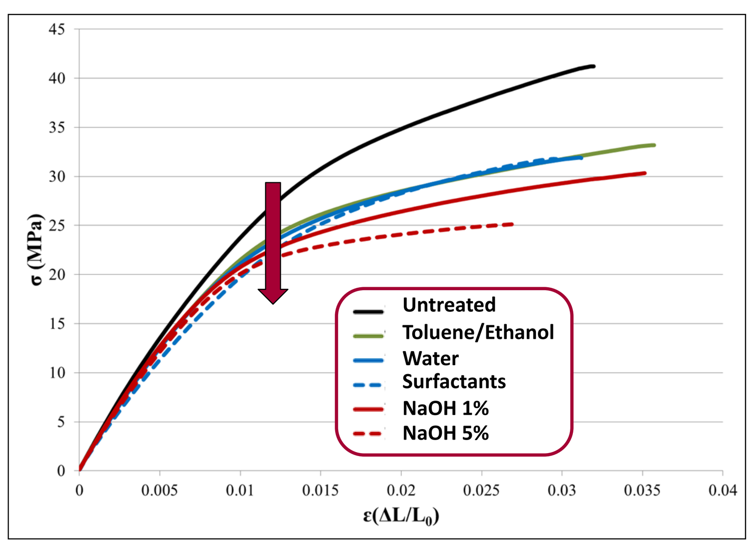
Improvement of the fibre dispersion within the composite

FLAX / EPOXY COMPOSITE MECHANICAL PROPERTIES

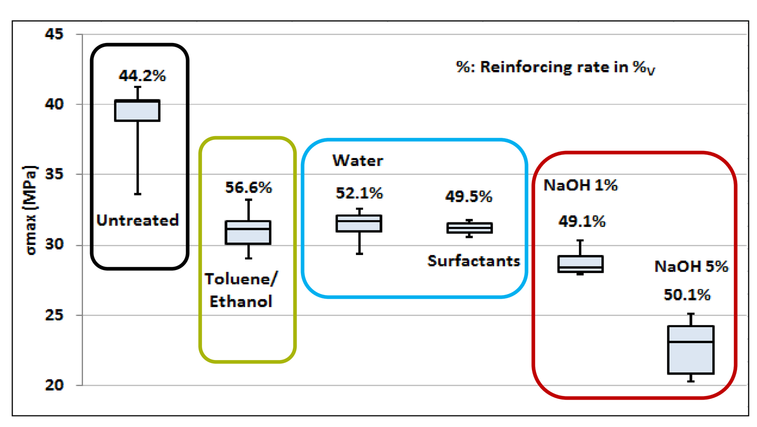
Similar warp reinforcing rate (2%)

Interface properties
Transverse tensile tests





Shift of the elastic-plastic transition to lower strength for more drastic extraction condition



Decrease in the maximum strength for each treatment even if the dispersion was improved

Two assumptions:
- **Bad elementary fibre / matrix interface**
- **Fibre components removal → variations in the stress accommodation within the composite**

CONCLUSIONS

Chemical composition : Toluene/Ethanol : extraction of lipophilic components
Water, surfactants : weak extraction
NaOH : strong extraction of lignin and hemicellulose

Microstructure :
- Decrease in the porosity rate, mainly matrix porosity, whatever the treatment
- Improvement of the fibre dispersion within the composite depending on the treatment

Mechanical properties : Decrease in the transverse mechanical properties due to either a bad elementary fibre / matrix interface, or variations in the stress accommodation within the composite

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