



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

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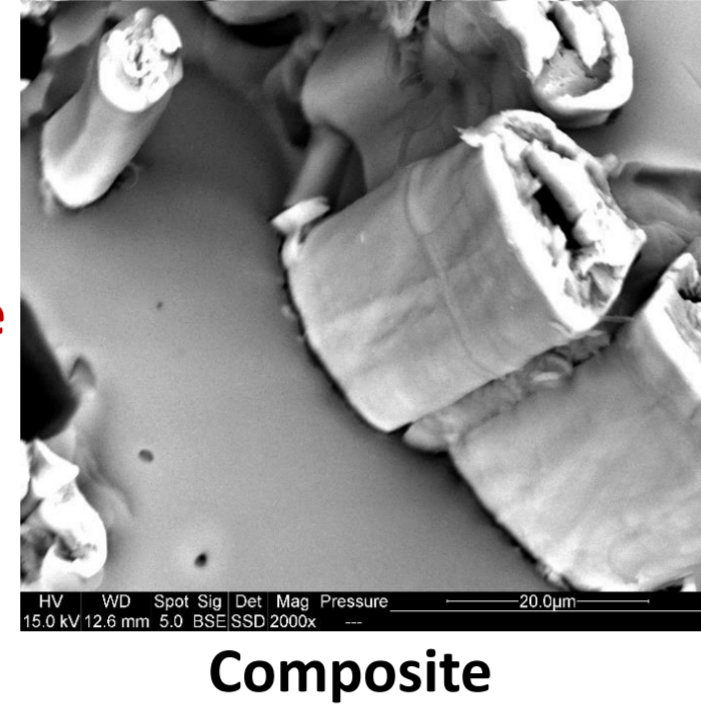
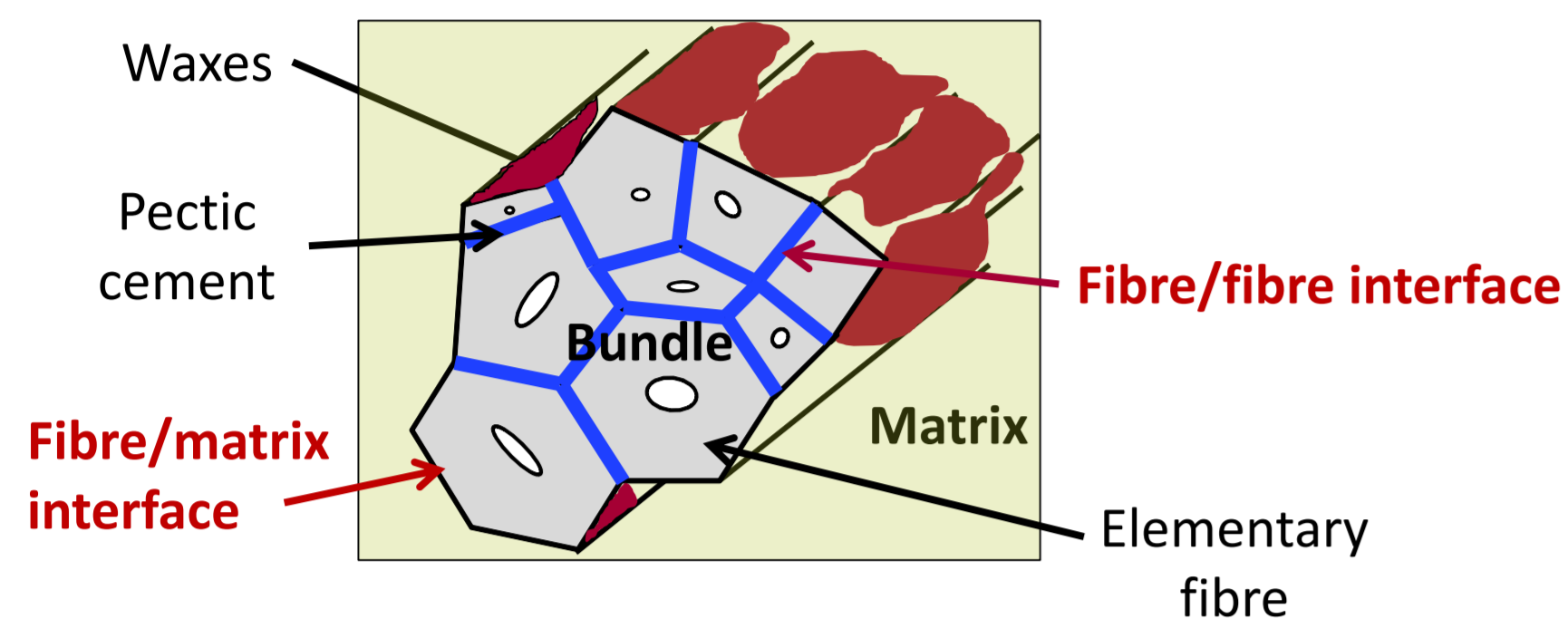
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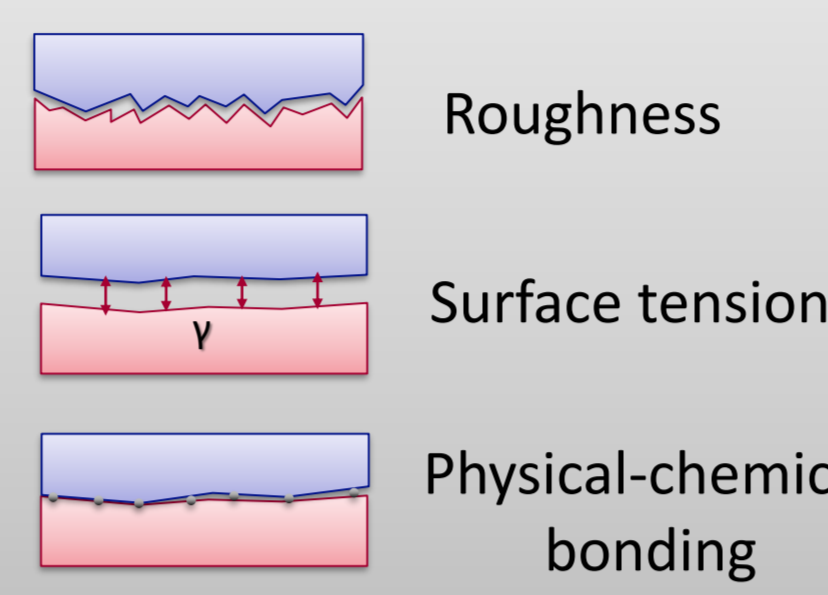
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## CONTEXT

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.

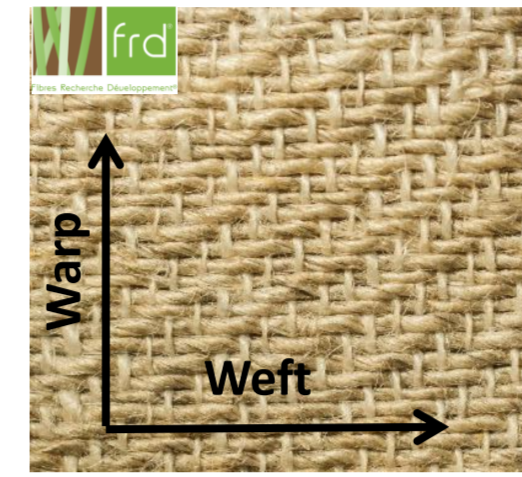


### Factors involved at the interface



## MATERIALS

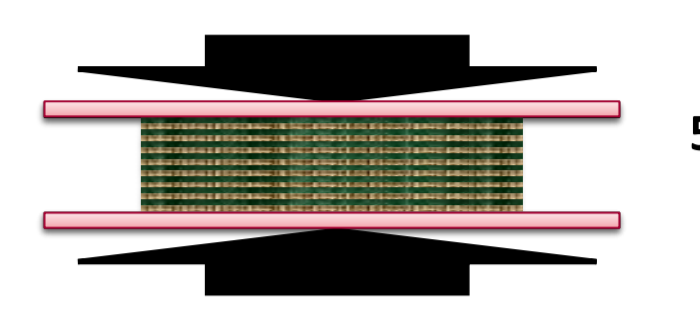
Quasi-unidirectional flax fibre fabric UD29, FRD, France



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



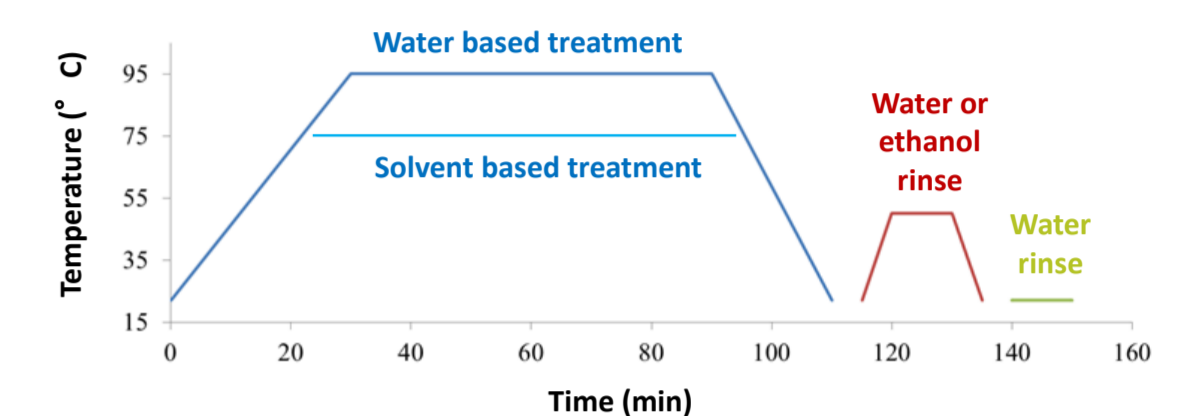
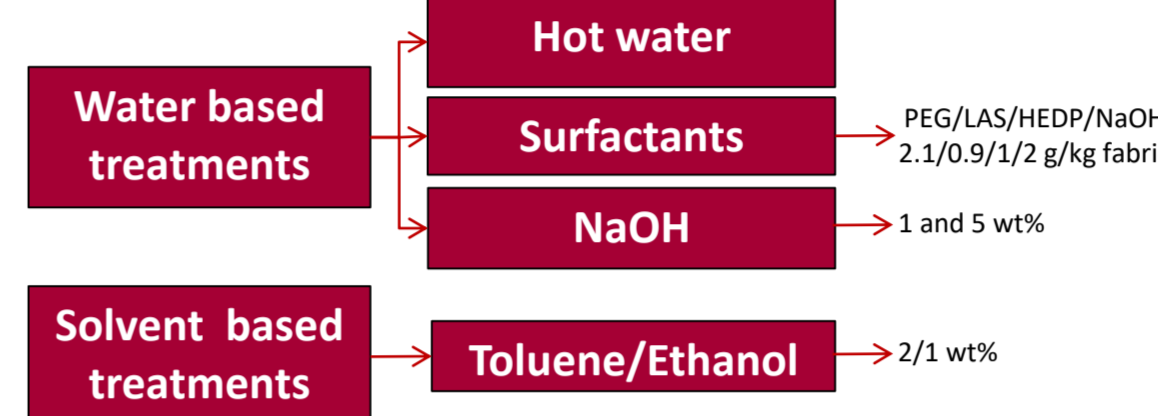
Composite processing : Thermo-compression  
 8 layers of UD29 impregnated with epoxy resin during 6h at 60°C for curing + 15h at 60°C of post-curing



50 bar

60°C

## WASHING TREATMENTS



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

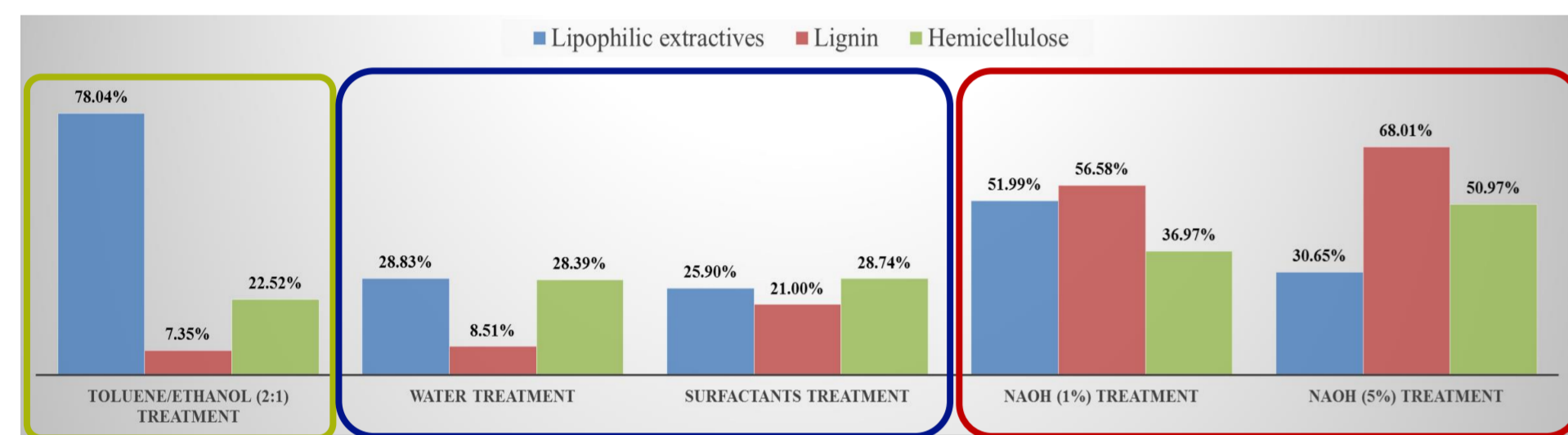
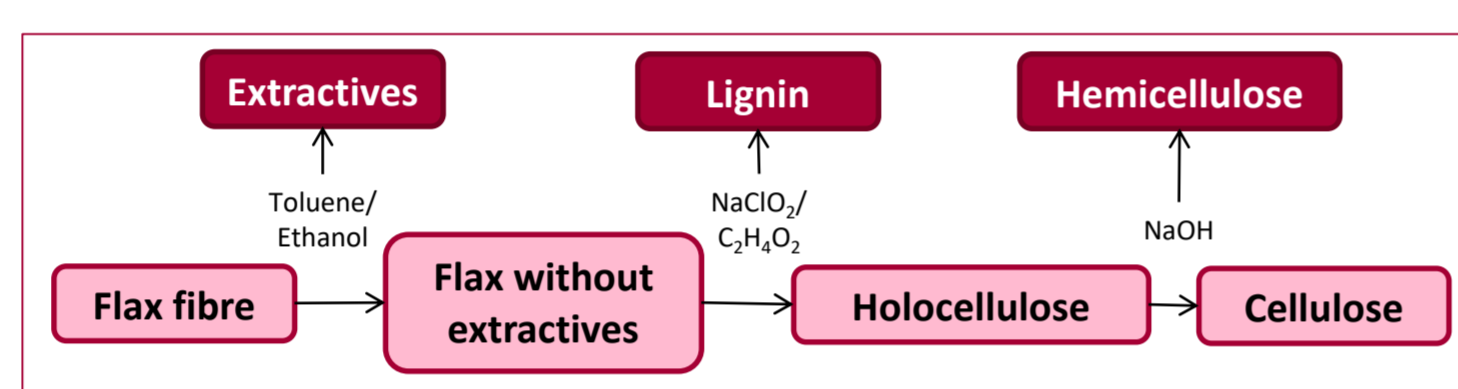
## OBJECTIVES

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

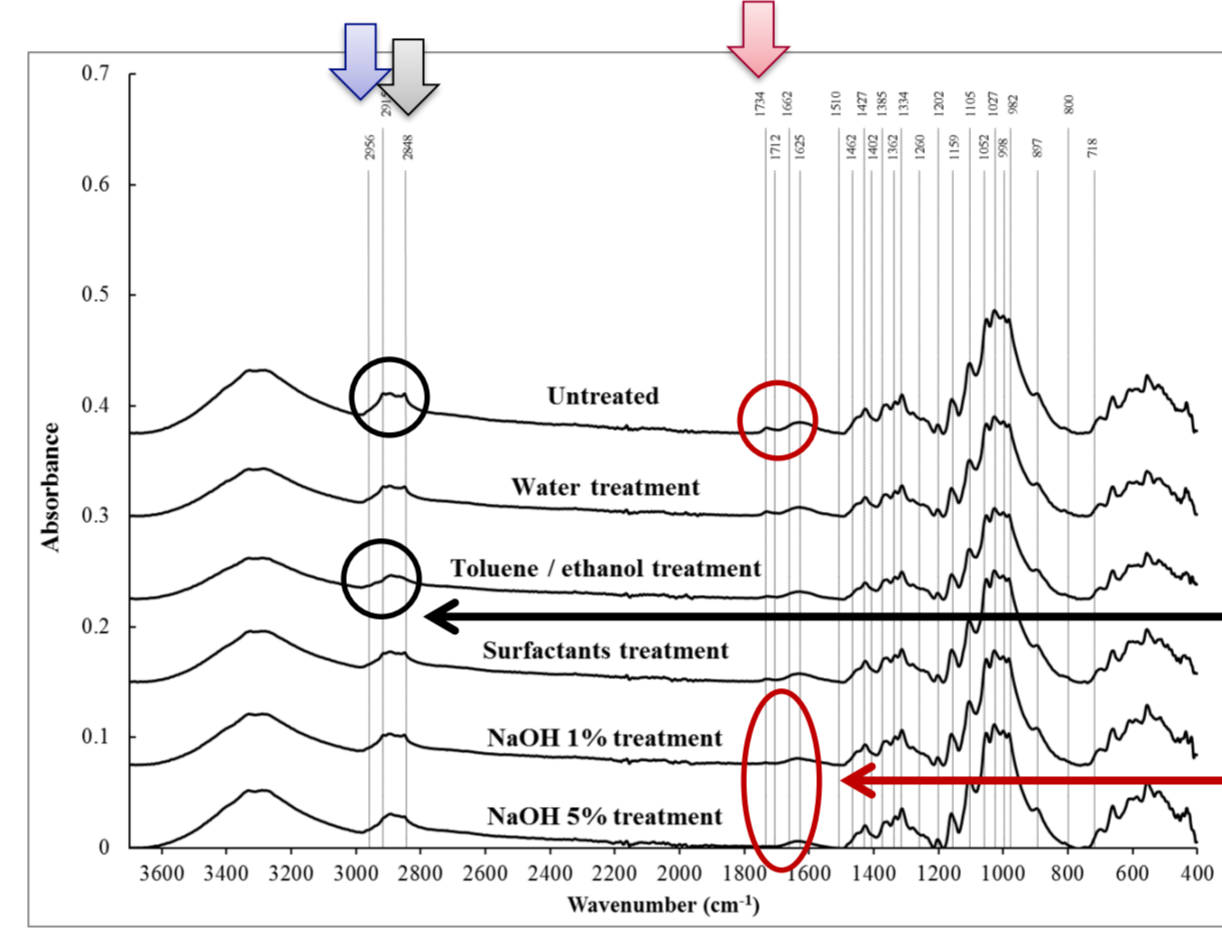
## FLAX FIBRE FABRICS PROPERTIES

### Chemical composition

- Successive extractions  
 TAPPI T-264 / ASTM D1104-56 / ASTM D1103-60 / ASTM D1102-84
- Ajustment of the values to the same amount of cellulose
- Weight 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



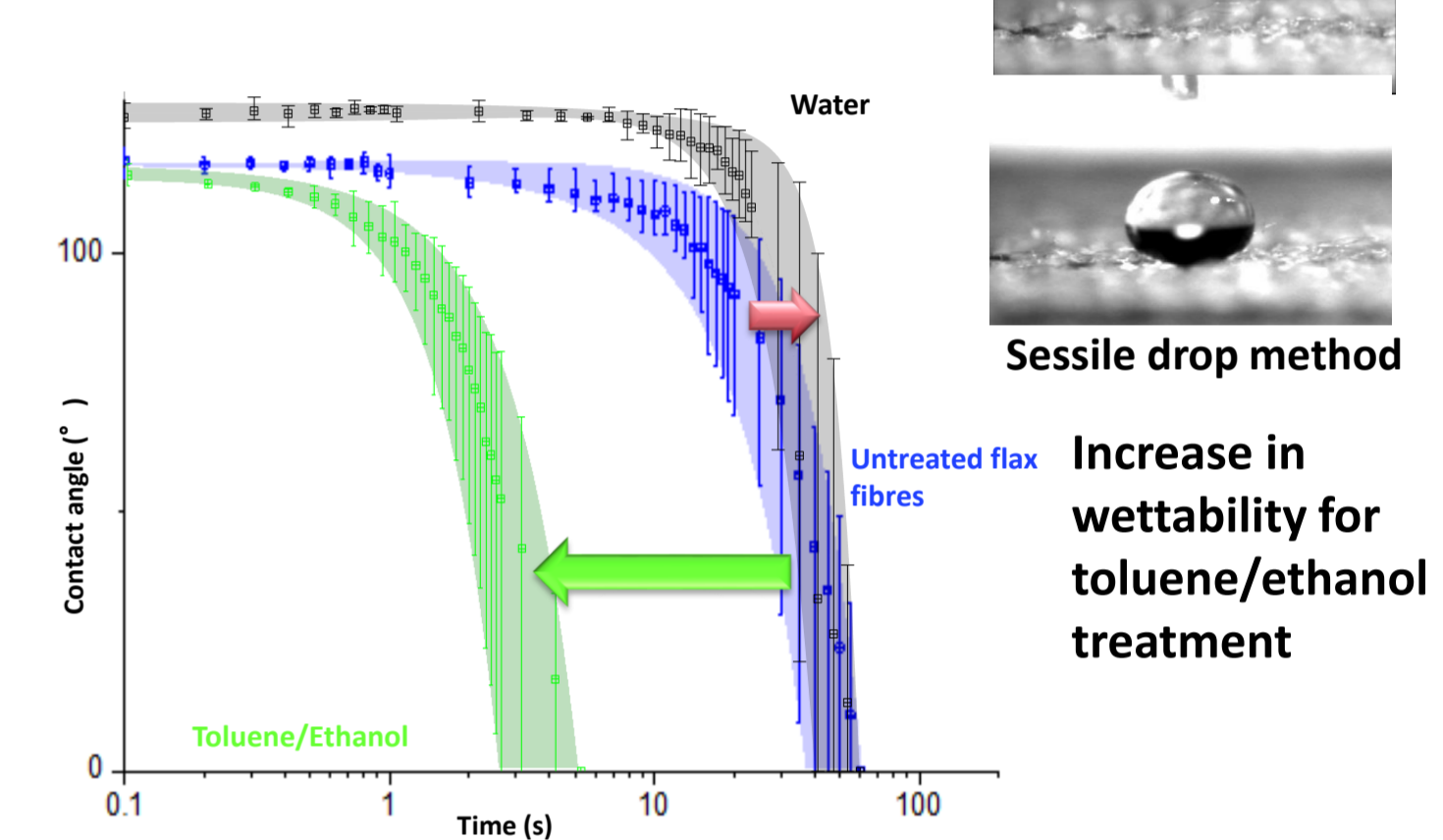
FTIR analysis (ATR)

Toluene/Ethanol treatment  
 Extraction of lipophilic components

NaOH treatments  
 Lignin extraction

### Surface properties

Water contact angle measurements



Sessile drop method

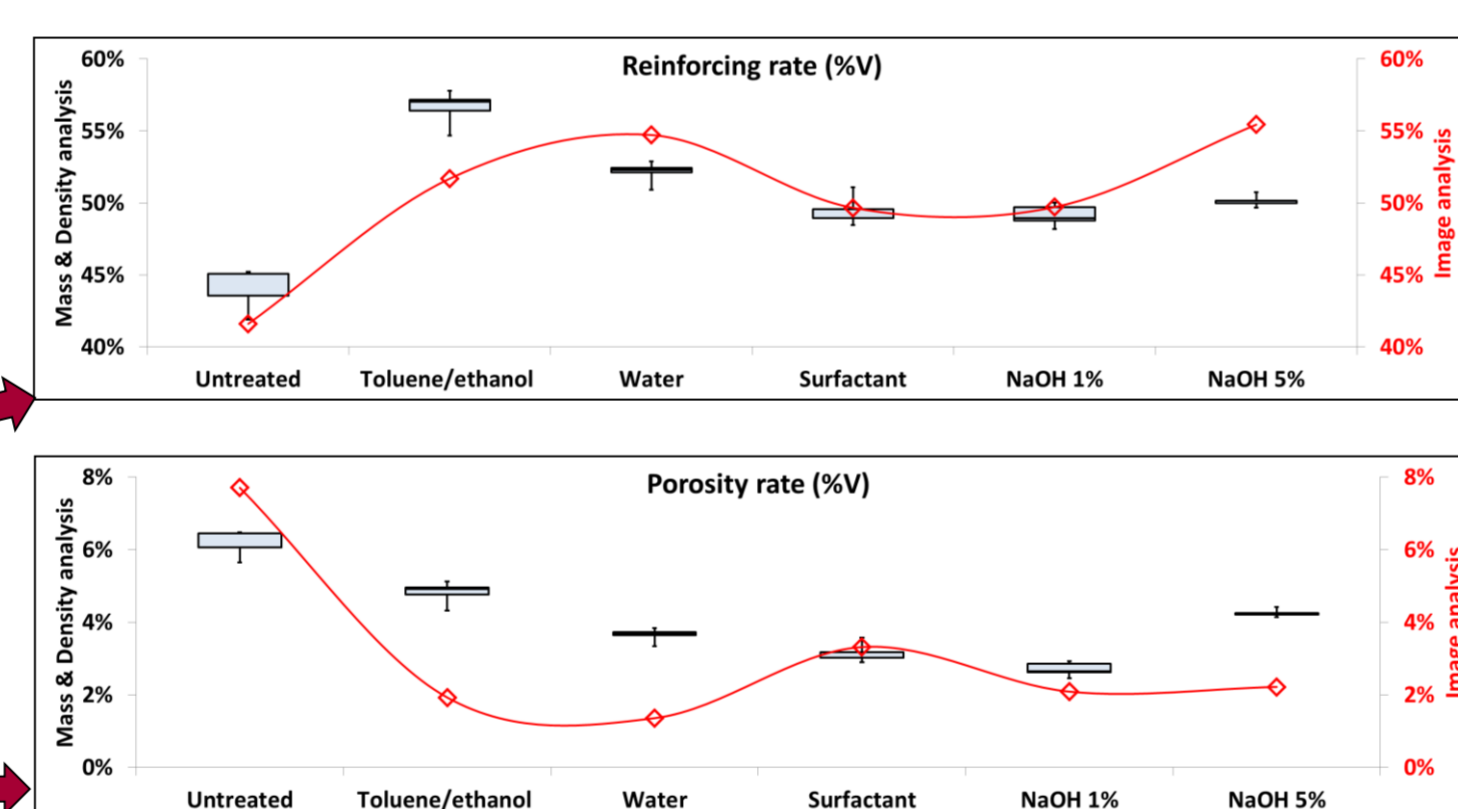
Increase in wettability for toluene/ethanol treatment

## FLAX / EPOXY COMPOSITE MICROSTRUCTURE

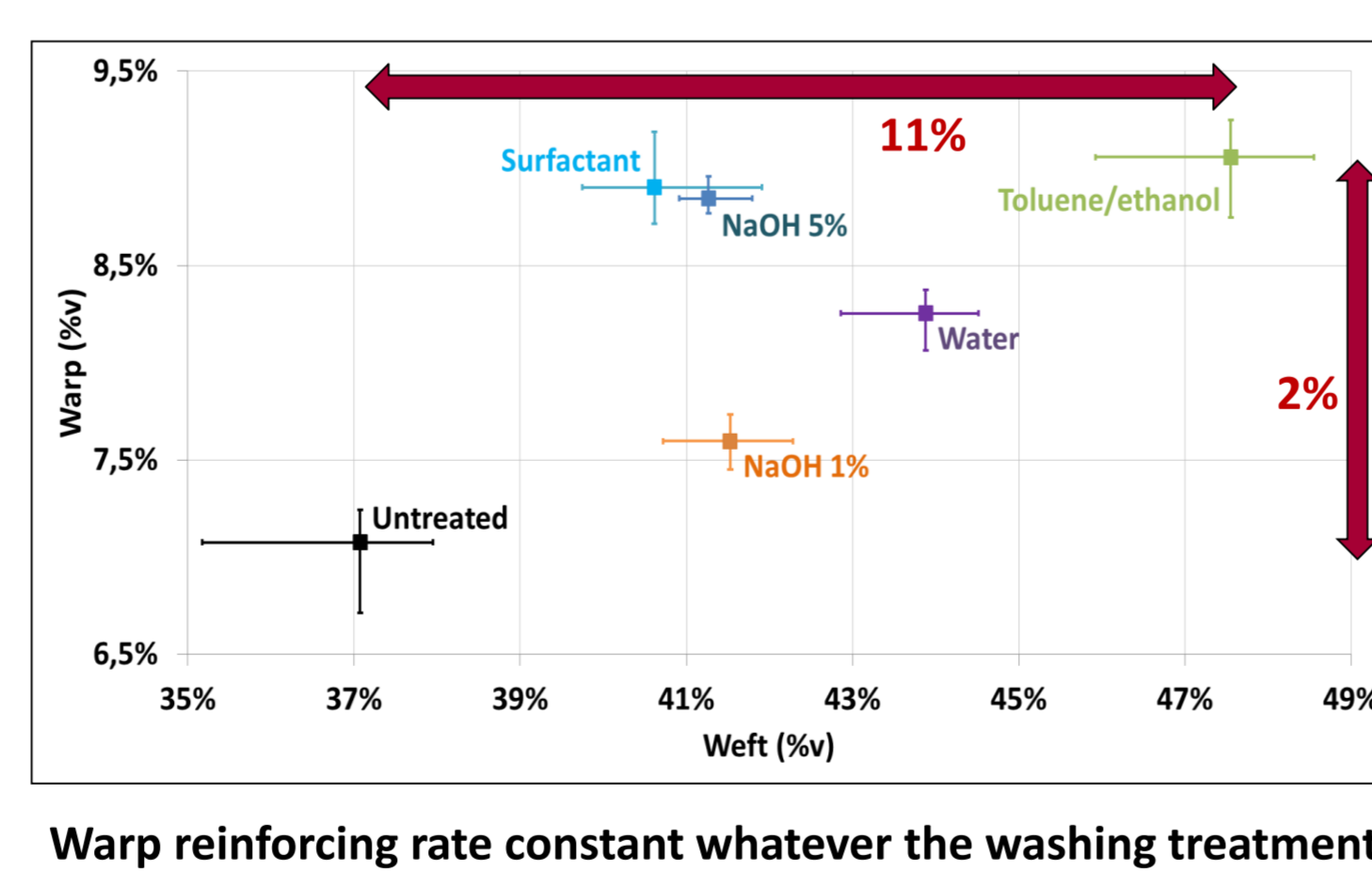
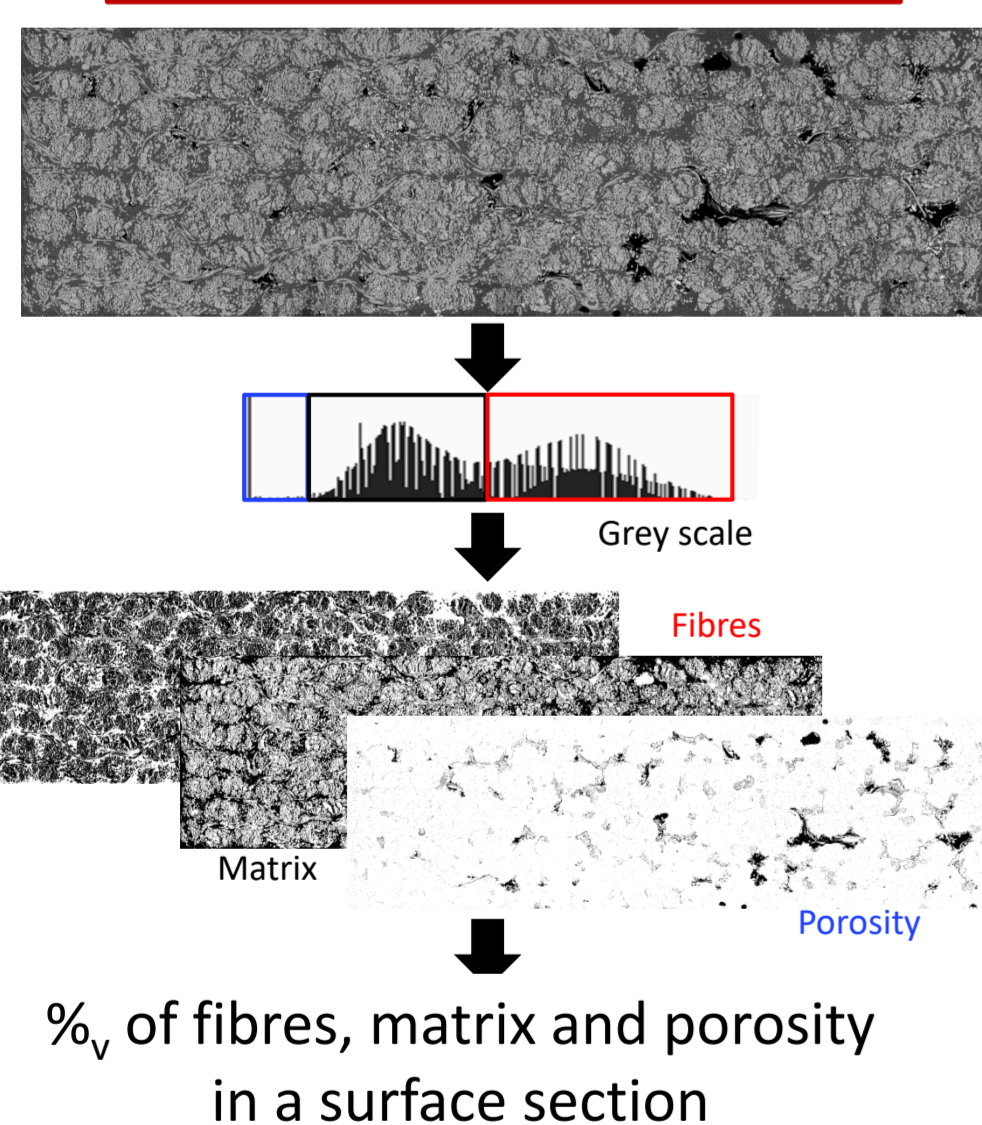
### POROSITY

#### 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 :  $\%_v(Reinf) = \%_w(Reinf) \cdot \frac{\rho_{Comp}}{\rho_{Reinf}}$   
 $\%_v(Matr) = \%_w(Matr) \cdot \frac{\rho_{Comp}}{\rho_{Matr}}$   
 $\%_v(Por) = 1 - (\%_v(Reinf) + \%_v(Matr))$

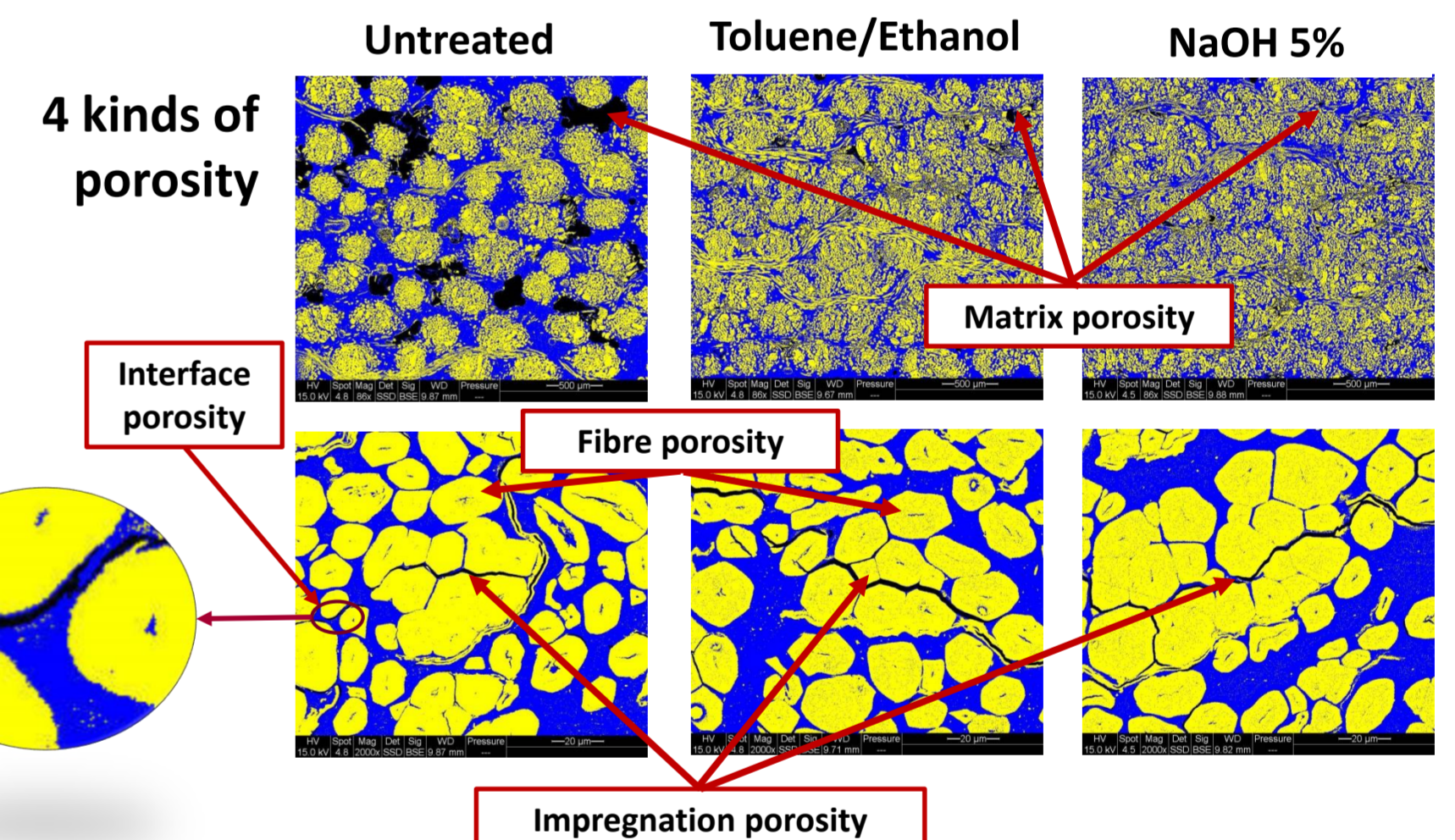


#### Method 2 : image analysis

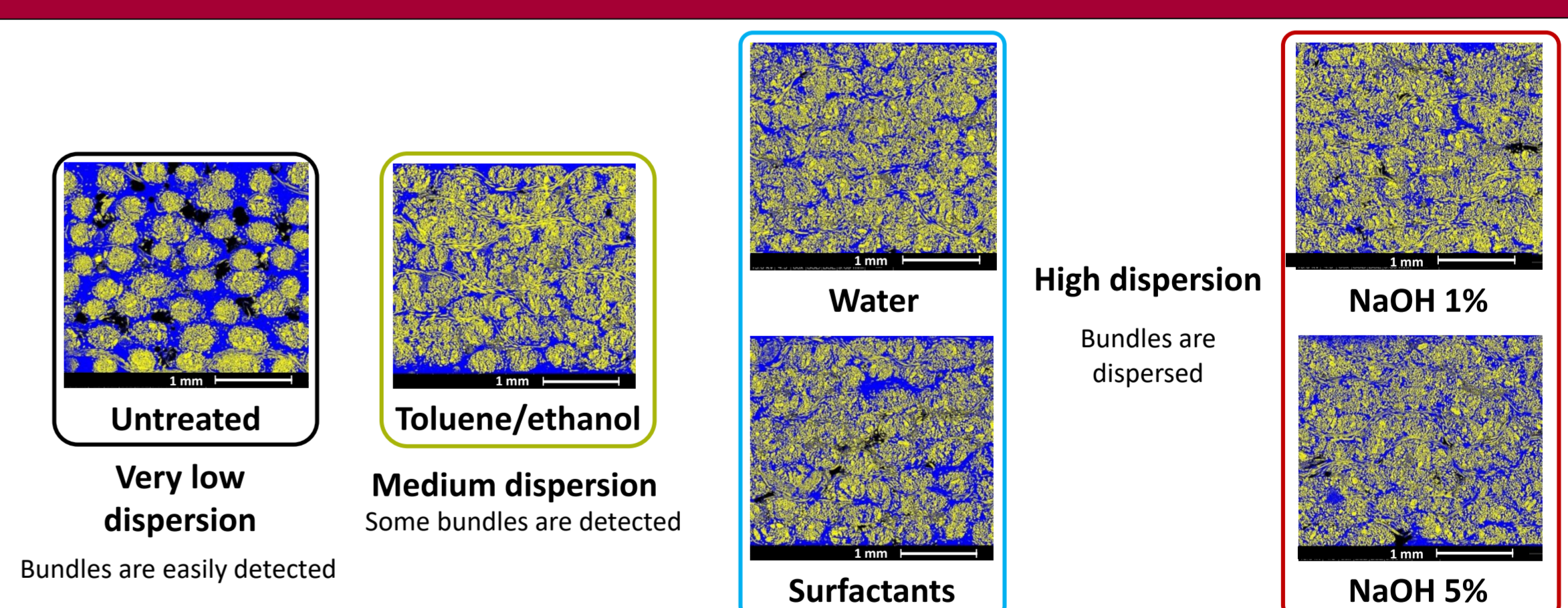


Warp reinforcing rate constant whatever the washing treatment

- 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 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

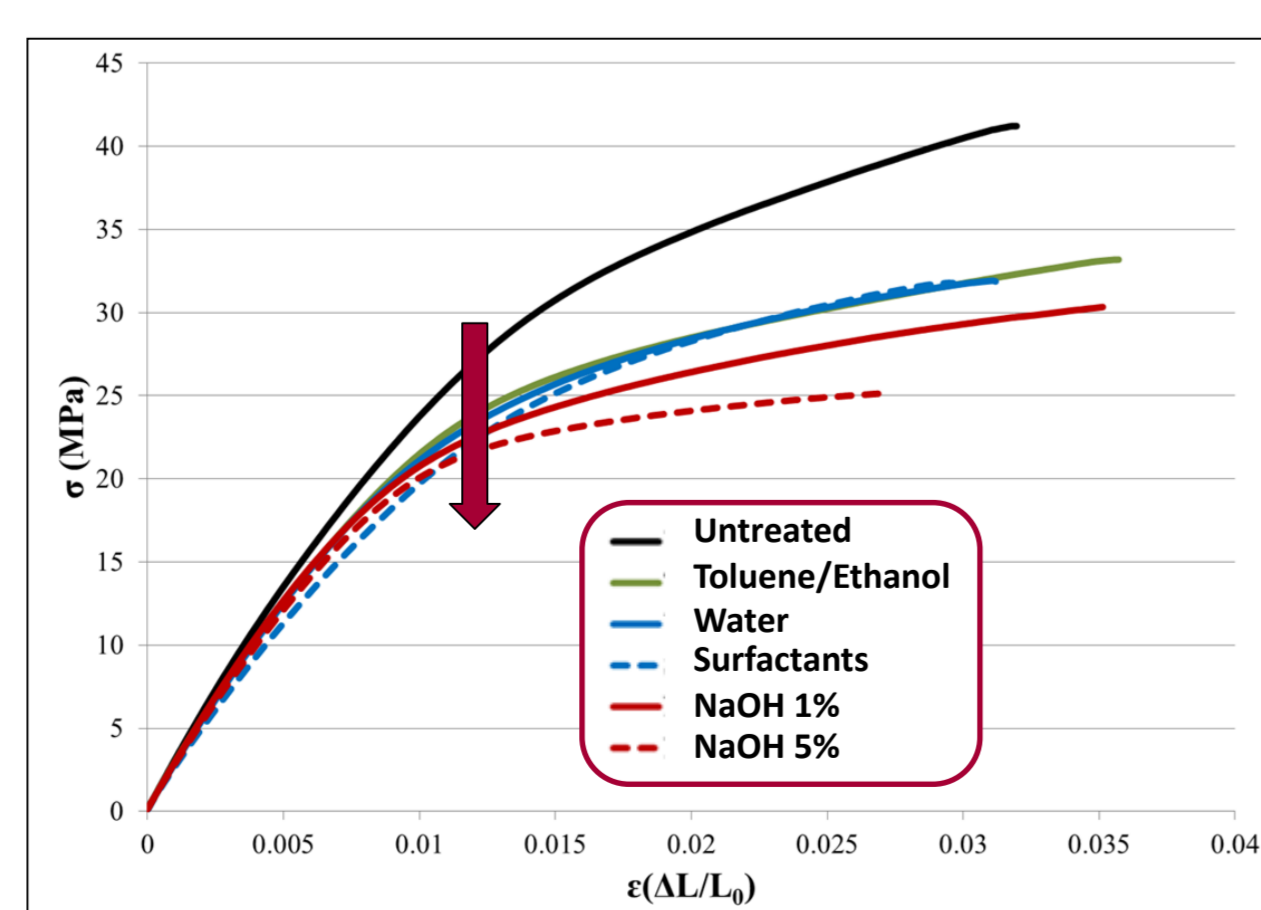
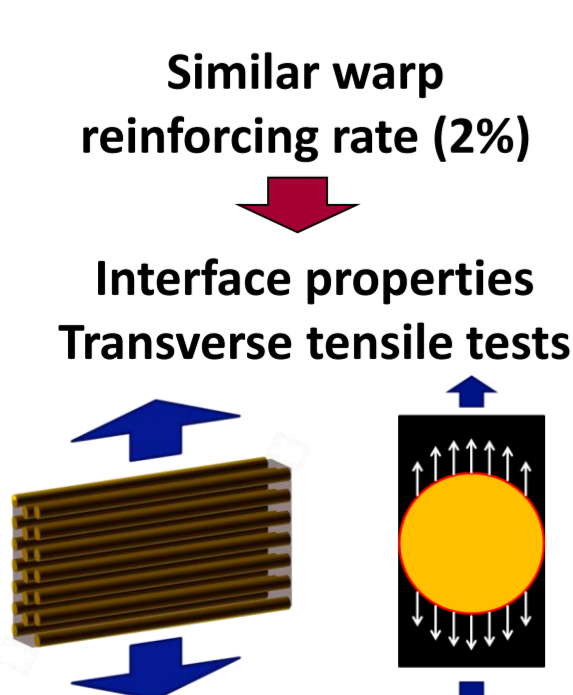
## CONCLUSIONS

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

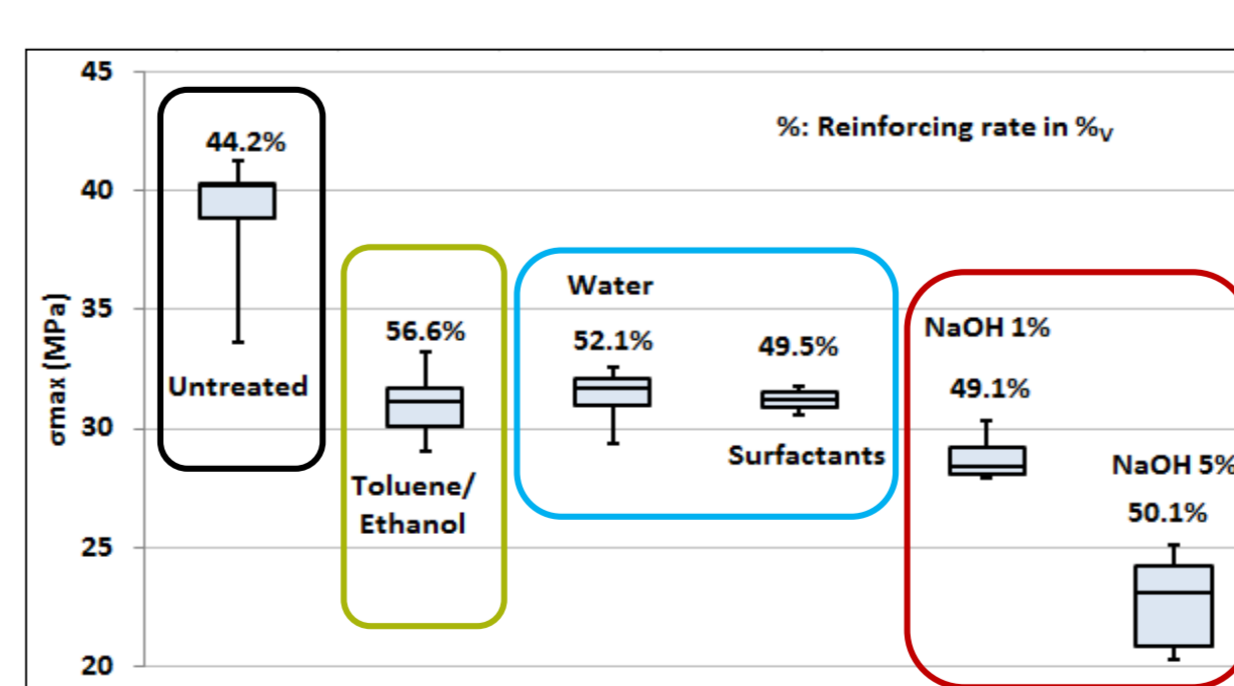
**Microstructure :**

- 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



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