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S. MIGUEL AZORES PORTUGAL

# End of life of PLA and flax fiber reinforced PLA biocomposite

## Effect of hygrothermal ageing

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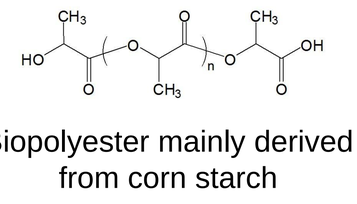
## CONTEXT

**PLA**
Polylactic acid



Biopolyester mainly derived from corn starch

**Flax fibers**

Vegetal bast fibers for composite reinforcement




Food packaging



Cosmetic packaging



Automotive interior

**Recyclable**
**Compostable**
**Incinerable**

PLA is very sensitive to hydrolysis
Flax is hygroscopic

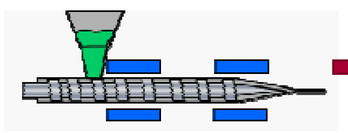
**Degradation in humid conditions and high temperatures**

**What is the influence of hygrothermal ageing on the end of life of PLA and PLA/flax biocomposite?**

## MATERIALS & METHODS

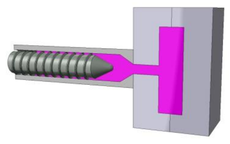
80%w/w PLA granules
7000D NatureWorks

20%w/w flax fibers
FRD - Mean length = 6 mm

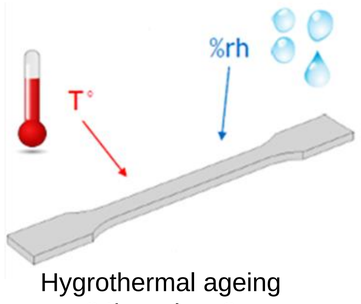


Compounding by twin-screw extrusion
T = 180° C

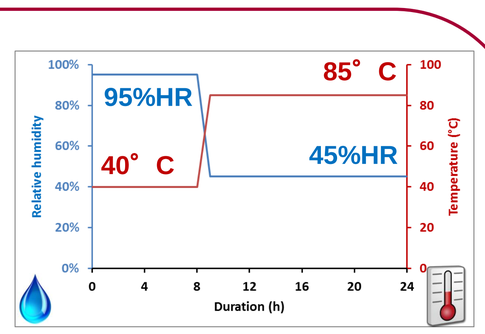
Injection molding of ISO 1A « dog bone » samples



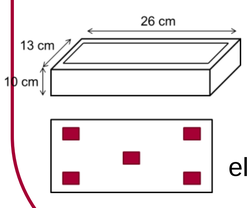
Compound pellets are dried at 50° C overnight




Hygrothermal ageing
24h cycle x 3

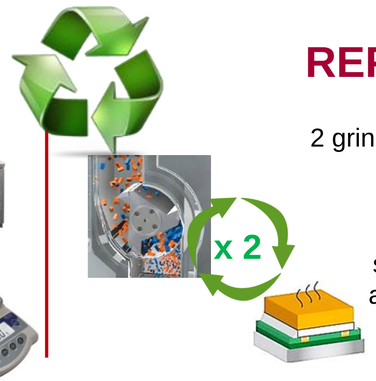



### COMPOSTING




Lab scale composting test
ISO 20 200
10 weeks at 58° C

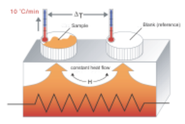
Characterization of **surface morphology** by scanning electron microscopy (SEM) and **mass loss** measurements



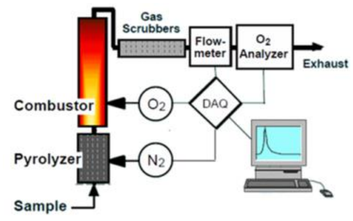

### REPROCESSING

2 grinding/compression cycles

Characterization of **PLA crystallinity** by differential scanning calorimetry (DSC) and **mechanical properties** by flexural tests



### INCINERATION



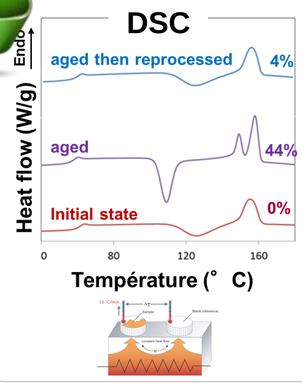

Measurement of the **Total Heat Release THR (J/g)** by pyrolysis combustion flow calorimeter (PCFC)

THR = Lower Heating Value (LHV)

## RESULTS

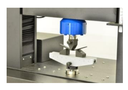
### REPROCESSING

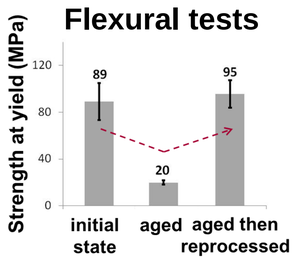
#### Virgin PLA



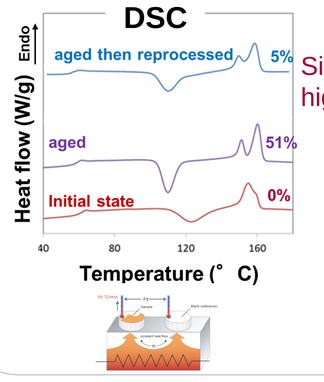

Amorphous polymer at the initial state
Higher crystallinity after ageing because of a chain scission degradation

Recovery of the degraded mechanical properties after reprocessing



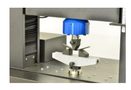


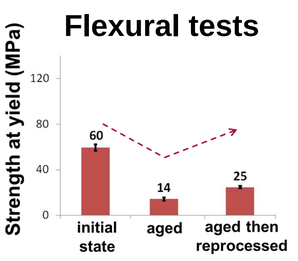

#### PLA/flax



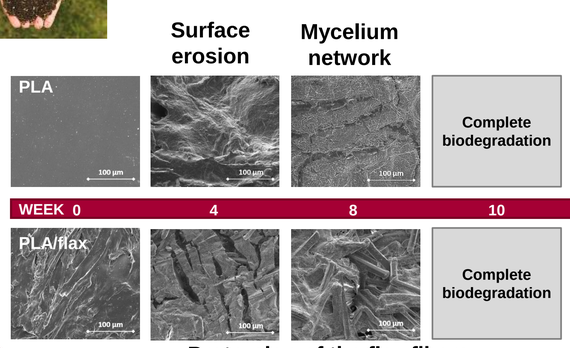

Similar tendencies with flax fibers: higher crystallinity after ageing

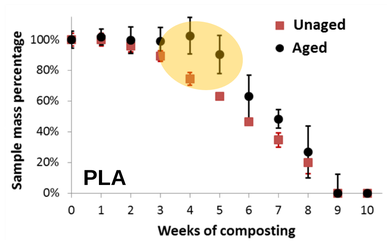
Less significant recovery of the degraded mechanical properties after reprocessing with flax fibers



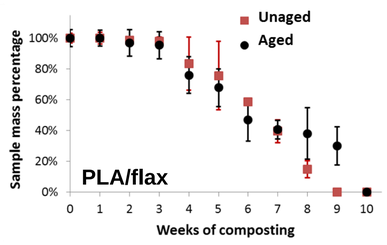



### COMPOSTING



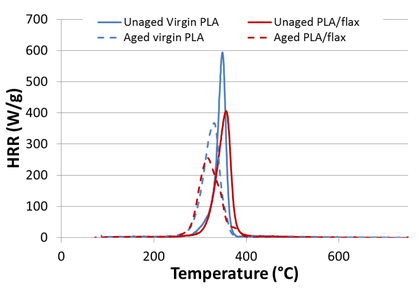




Lag-time of 2-3 w for unaged PLA and 3-4 w for aged PLA
Complete biodegradation at week 9 for both




Lag-time of 3-4 w for both unaged and aged PLA/flax
Complete biodegradation at week 9 or 10 for both

Similar surface degradation progression by SEM for unaged and aged samples




### INCINERATION

Decrease of the thermal stability after ageing but preservation of the recoverable energy by incineration (THR)

| | PLA unaged | | PLA/flax unaged | | PLA aged | | PLA/flax aged | |
|---|---|---|---|---|---|---|---|---|
| pHRR (W/g) | 587 | ± 11 | 425 | ± 27 | 361 | ± 6 | 275 | ± 26 |
| THR (kJ/g) | 14,1 | ± 1,3 | 14,9 | ± 0,5 | 15,7 | ± 0,2 | 14,6 | ± 0,4 |
| T°C | 348,5 | ± 6,4 | 356,0 | ± 0,0 | 328,0 | ± 1,0 | 320,0 | ± 4,4 |

## CONCLUSION

**Recovery of the mechanical properties by reprocessing of the aged PLA**
**Less recovery for PLA/flax biocomposite**

**No major effect of hygrothermal ageing on the composting biodegradation despite a microstructure alteration**

**Preservation of the recoverable energy by incineration (THR=LHV)**

## OUTLOOK

- Transfer to the pilot / industrial scale ?
- Life Cycle Assessment (LCA) for a comparison of composting, reprocessing and incineration scenarios
- What about the presence of impurities and other pollutants in the waste flow ?

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**Images :**
http://goo.gl/4D8f59, http://goo.gl/x3szde, http://goo.gl/b1LVCU, http://goo.gl/bcMuSu, http://goo.gl/5eNxNb, http://goo.gl/407HFV, http://goo.gl/PZr1Gp.

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