Cellulose Valley

BY FONDATION GRENOBLE INP

REINVENTING PACKAGING

POSTERS POC 2023

Barrier properties on 3D cellulose objects via dip-coating

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Grenoble INP Pagora

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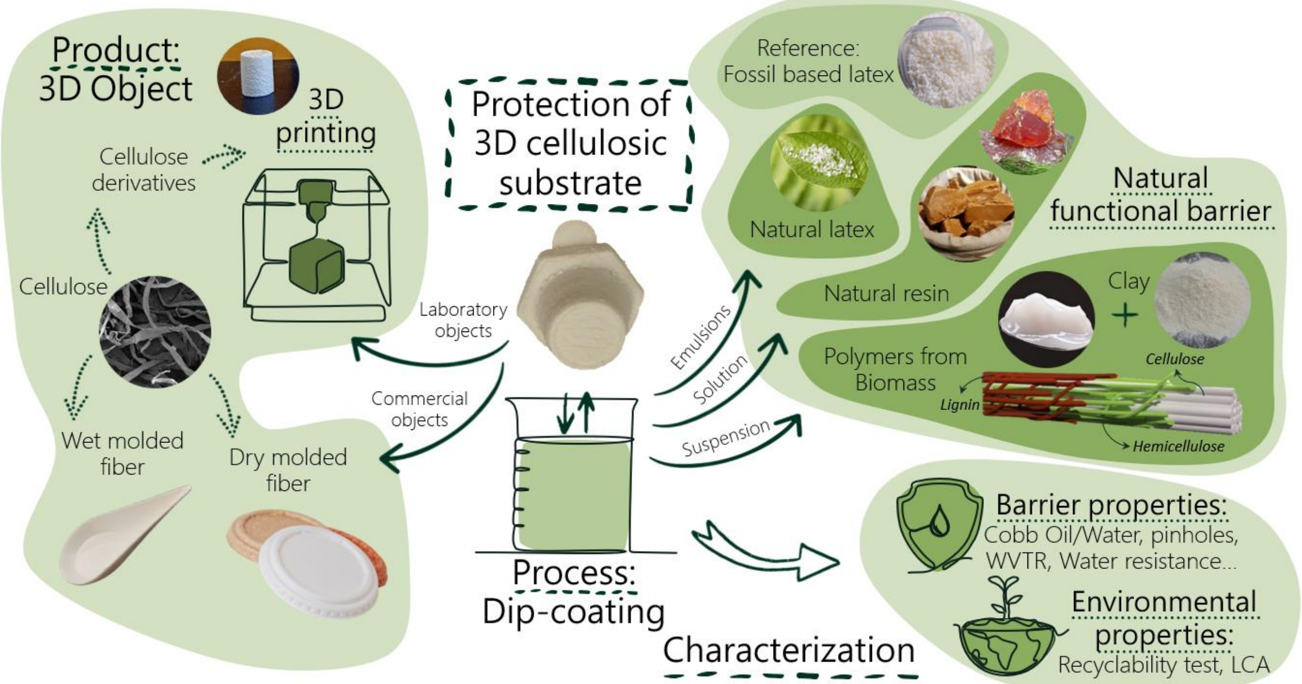
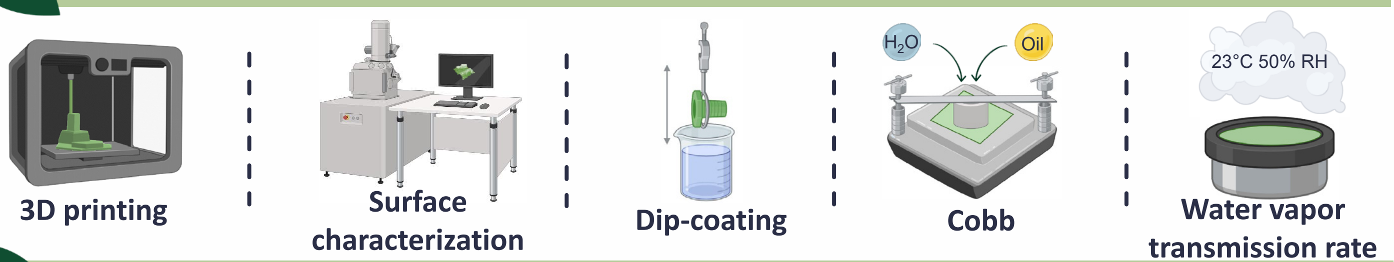
Context

New laws are being voted by the European union and the French government to promote reduction of single-use plastic production and consumption. 3D plastic objects such as bottle caps or disposable cutlery are rarely recycled and commonly found in nature. New sources are being studied to provide bio-based, recyclable and biodegradable 3D objects among which bottle caps. The main challenge of this project is to provide grease, water and gas **barrier properties to cellulose 3D objects via dip-coating**.



Material & method



Conclusion and perspectives

Best result: Natural Latex

+

- Good oil and water vapor barrier properties
- Medium water barrier properties

−

- Low water resistance
- Viscous coating→ accumulation in complex shapes
- Not recyclable (issue with the substrate)

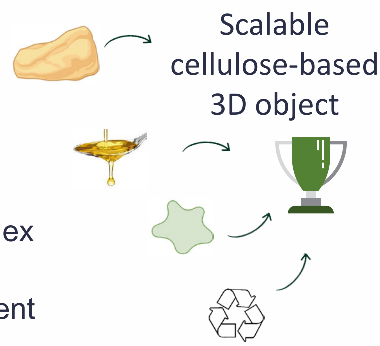
Next:

More tests with natural resin

Analysis on coating viscosity

Optical analysis of complex shapes

Recycling test with different substrates



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Development of new coated paper with high barrier and mechanical performance

Nicolas COURTOIS - 2nd year engineering school
University of Technology of Troyes (UTT)

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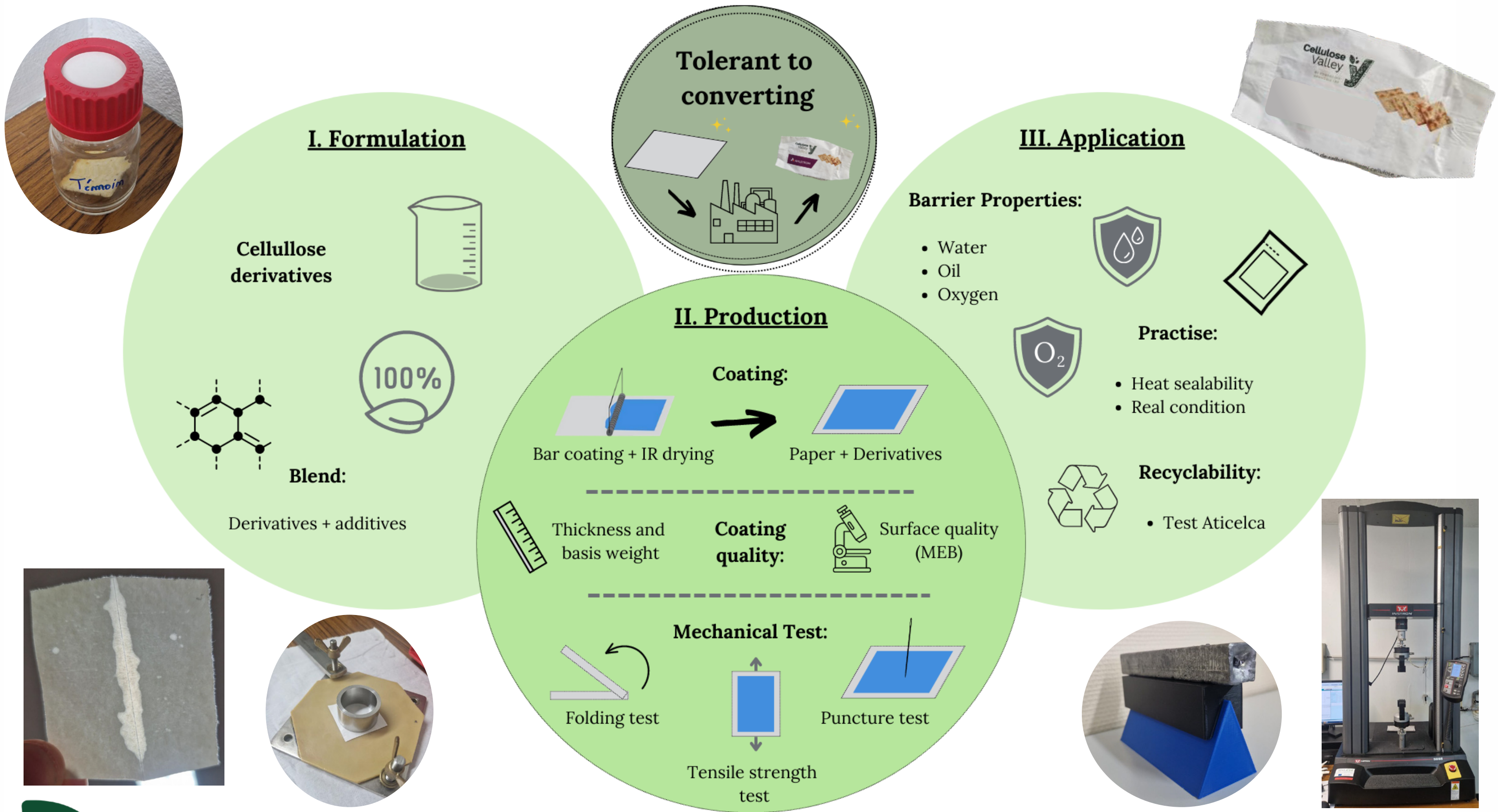
Context

The European SUP directive and the French AGEC law regulate the use of single-use plastic. As a result, manufacturers need to find alternatives to plastic. The use of paper with a biosourced, recyclable coating to improve these properties could be a possible solution, particularly in food packaging. Will this coated paper be able to withstand all the mechanical stresses present in industry without losing quality? This is the question I'd like to answer by carrying out fold, friction and tensile tests to mimic industrial constraints and find the best coating formulation.

Materials & Methods



Conclusion & perpectives

- Mechanical properties don't change significatively with 5g/m² of cellulose derivatives coating
- Increase of stiffness except for one cellulose derivative
- Increase fold resistance with add of plasticizers in small quantity
- Correlation between stiffness and fold resistance
- Good thermo sealability in 1s at 190°C

- Recyclability test (Aticelca standard)
- Live cycle assessment
- modification of barriere propeties with elongation of the paper

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New packaging solution for humidity protection

Fiona Di Luzio - Master 2 internship

Université Grenoble Alpes, UFR Chimie & Biologie, Master 2 PTA

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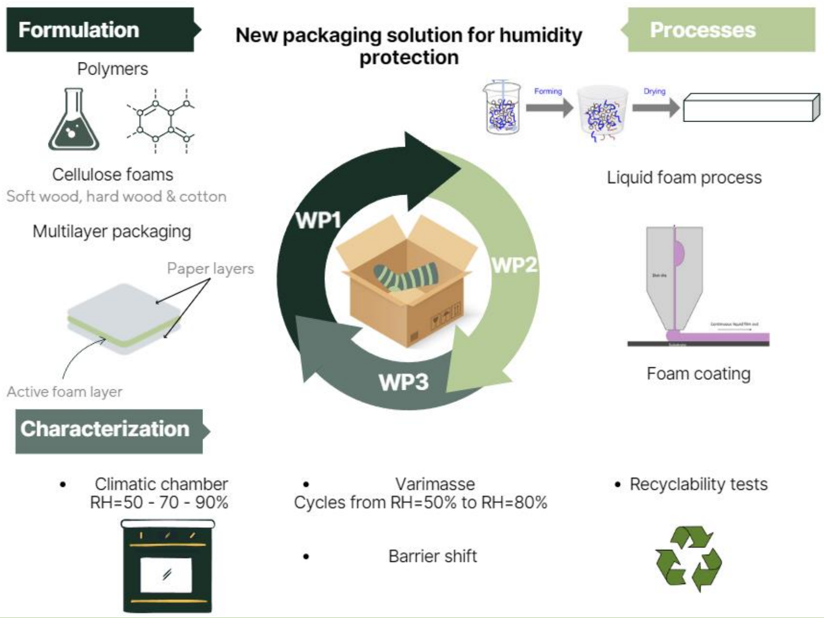
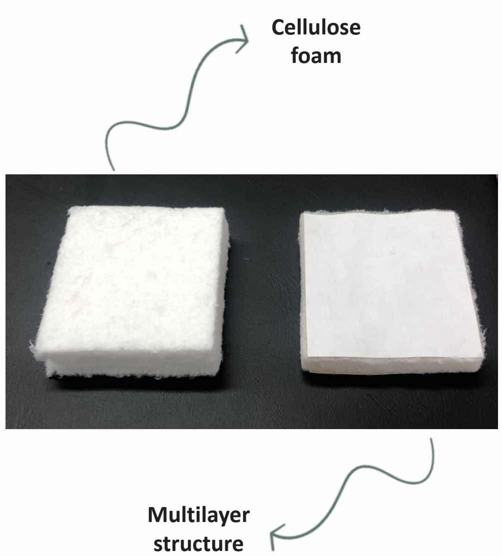
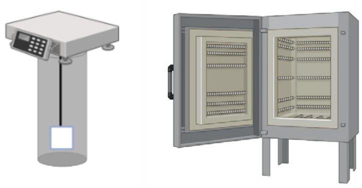
Context

Packaging accounts for 40% of plastic waste. In view of the current ecological situation, this field is therefore arousing great interest. New legislations such as AGEC (anti-waste for a circular economy) and SUP (Single use plastic) laws are motivating companies to find solutions, which must be more respectful of the environment. The aim is to develop a **recyclable** packaging with **high humidity protection** properties.

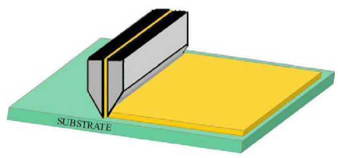




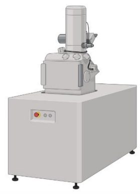
Material & Methods



Water vapor absorption



Coating process



Scanning electron microscopy

Conclusion & perpectives

- Increase of polymers's and foam's moisture uptake over time at different relative humidities
- Slower kinetic observed during barrier shift tests

- Recyclability tests
- Improve foam coating homogeneity
- Improve parameters found

High barrier recyclable flexible cellulosic paper for wet and greased cooking dough packaging

HEDHILI Emna - End of study project

INSA Tunis (Tunisie)

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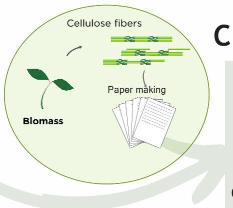
Context

Replacing plastic packaging with cellulose based paper

The law of February 10, 2020 on the **fight against waste** and the circular economy (**AGEC law**) provides for the banning of single-use plastics for 2040.



Cellulose paper

Made of

- Abundant,
- Renewable,
- Biodegradable

cellulose fibers.

Sustainable /Cheap

Environmentally friendly material

Low weight,

Degradable/Recyclable

≠

Porous structure

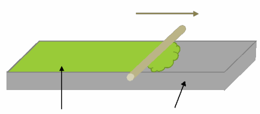
Hydrophilic nature,

Cellulose paper as a material can hardly compete with conventional plastics in some key properties; **waterproof, wet strength, durability, and gas (water vapor and oxygen) barrier capability.**

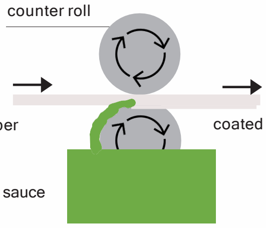
Materials and methods

Possible processes

Bar coating



Size press coating



Coating the paper with sauces to enhance the packaging proprieties

Requirements

PAPER

- **paper 1**

  Coating base
  High-strength Natural white
  (no OBA)

- **paper 2**

  Coating base
  High smoothness
  Lower basis weight Facilitates the sealing process
  Optimum rigidity

Coating sauces

Innovative

- **Cellulose derivatives**
- **Cellulose derivatives +polymers**

Commercial

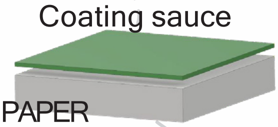
- **Latex1**
  Recyclability
  Oil and grease barrier
  Low water vapor transmission
  Heat seal
- **Latex 2**
  Heat seal capability
  Moisture barrier
  Oil and grease resistance
  Water resistance
- **Silicone**
  Moisture resistance
  Oil barrier
  Water barrier
- **PLA**

Application

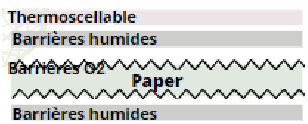
Innovative packaging solution with **high barrier proprieties** for cooking dough

Methodology

1.One layer only



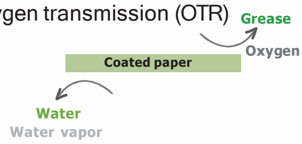
2. Multilayers (max 6)



Investigated proprieties

Barrier properties

- Absorption (Cobb oil and water)
- Permeation and Air permeability (Bensten and Mariotte's flask)
- Contact angle (with water).
- Rugosity
- Water vapor transmission (WVTR)
- Oxygen transmission (OTR)



Other tests:

- Recyclability
- Biodegradability
- Mechanical resistance(traction tests)

Perspectives

- **Good barrier to oil and water.**
- **Low air and gas permeability.**
- **Flexible**
- **Heat sealable**

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Barrier corrugated cardboard 3D tray packaging using bioadhesives and ultrasound welding

Mathis LAGIER - Material Science and Engineering

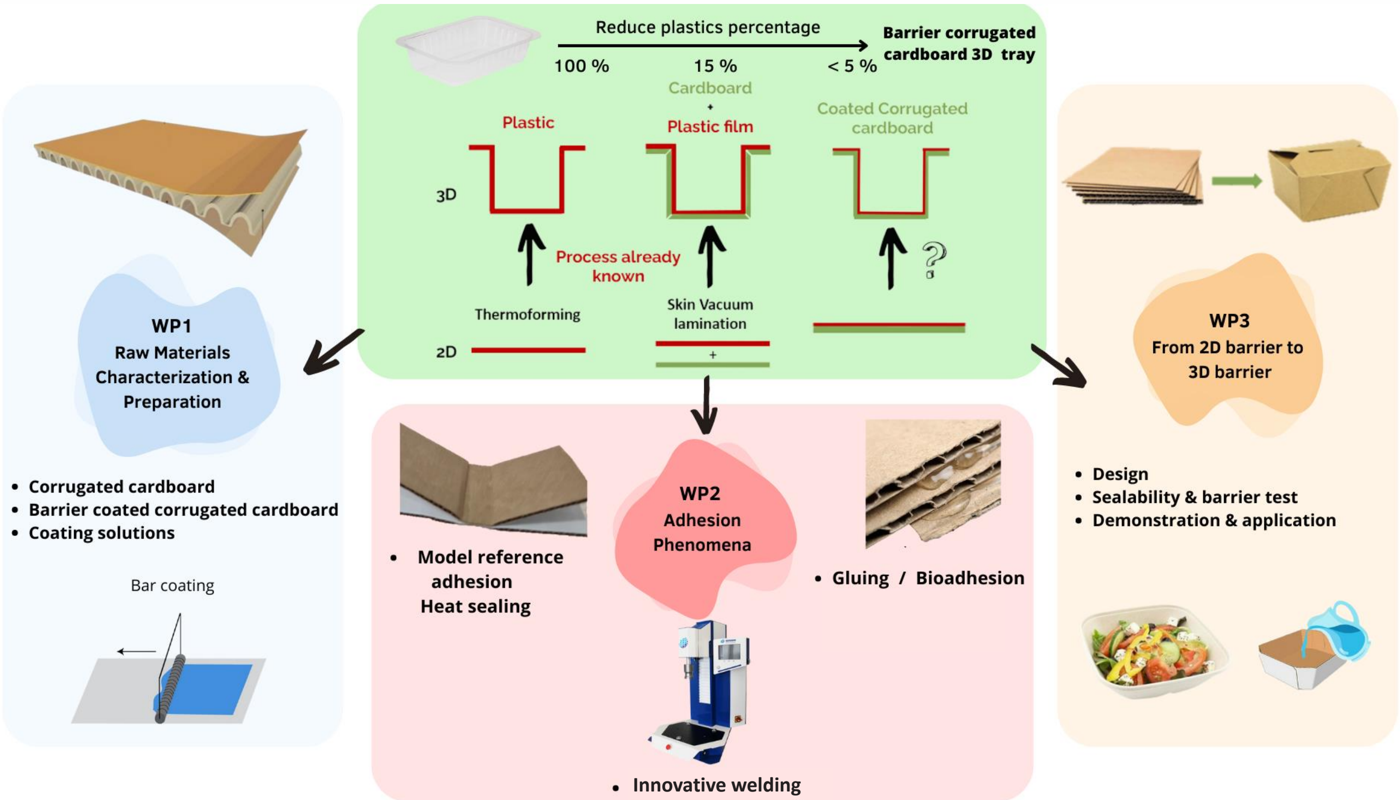
Grenoble-INP Phelma (FRANCE)

Cellulose Valley

BY FONDATION GRENOBLE INP

Context

To provide food packaging **plastic trays** made by thermoforming have been widely used, but with current legislations on **Single Use Plastic** (SUP directive) and **anti-waste law (AGEC)**, alternative solution need to be found. Cellulose based packages are a solution and new materials such as **barrier coated corrugated cardboard** could be used. However, the process to make the tray from this new material is not established and **innovative welding** or **bioadhesives** are solutions that we have investigated.



Demonstrator only 1,5% of plastic

- With bioadhesives

- Innovative Welding

Recyclable with paper
Food contact
Good barrier properties

Conclusion and perpectives

Main results :

- Adhesiveness level of industrial glues reached with bioadhesives
- Equivalent adhesion level reached with innovative welding and Heat sealing
- Innovative welding reduce welding time and electric consumption
- Design of a 3D barrier coated corrugated cardboard tray

Perspectives :

- Welding test with other coating solution
- Application tests with water, oil and food

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New high gas barrier cellulose 3D container for cosmetic cream packaging

Aziza MNALLAH - Master 2 Internship

INSA Tunis (Tunisie)

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Context

This project aims to meet the requirements of the **anti-waste law** and the European directive on single-use plastics (AGEC, law SUP) by offering an alternative solution to reduce the production of plastic waste. The objective of this project is to develop an alternative with **high gas barrier properties**, biodegradable and of biological origin for the packaging of cosmetic products. Barrier properties are developed through **innovative** coating techniques.

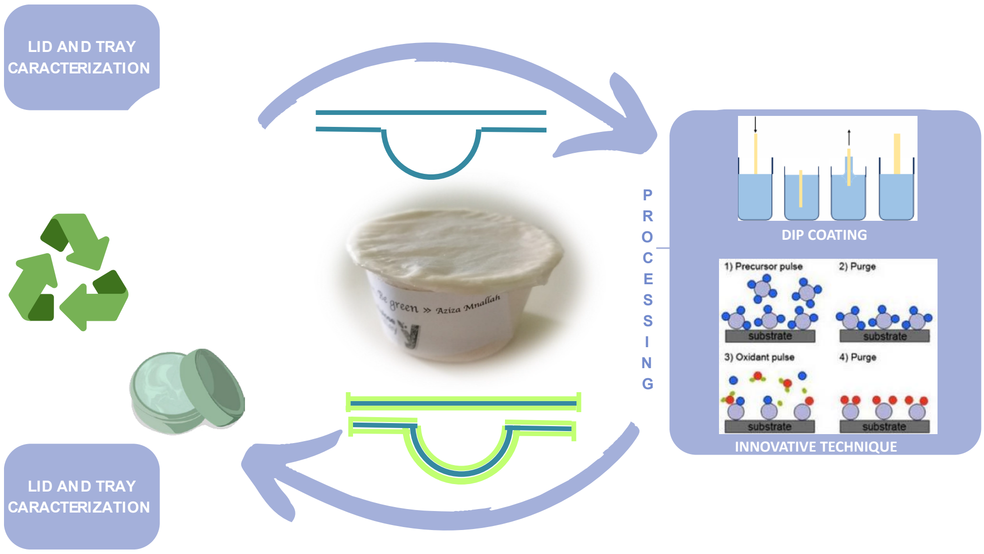
Raw Material

Wet and Dry Molded Cellulose (WMF and DMF)

Paper

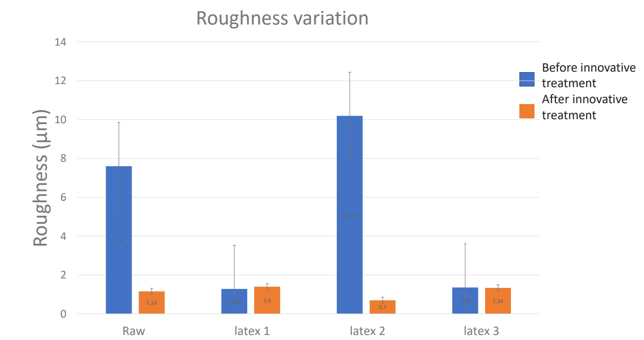
Barrier proprieties for:

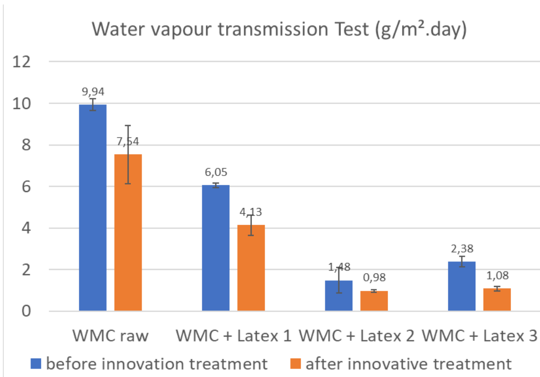
- Gas: air permeation
- Water vapour: WVTR
- Oygen: OTR
- Water: Cobb water
- Grease: Cobb oil



Dip coating :

- 4 polymer Latex
- Different time of dipping
- Monolayer approach





Conclusion and perpectives

- New treatment increases water vapour barrier of molded cellulose
- Good resistance to water and grease

- Choosing the best coating Latex
- Recycling test following Aticelca norm
- Aging Test

Surface technologies to implies barrier onto rigid 3D structure and influence of surface preparation : spray deposition

Suzy Ruano

Grenoble-INP Pagora

Cellulose Valley

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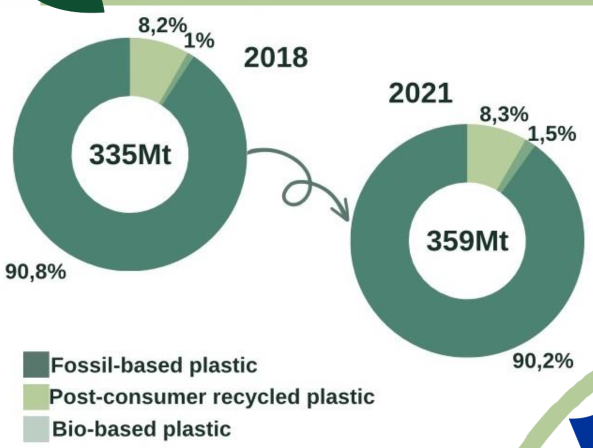
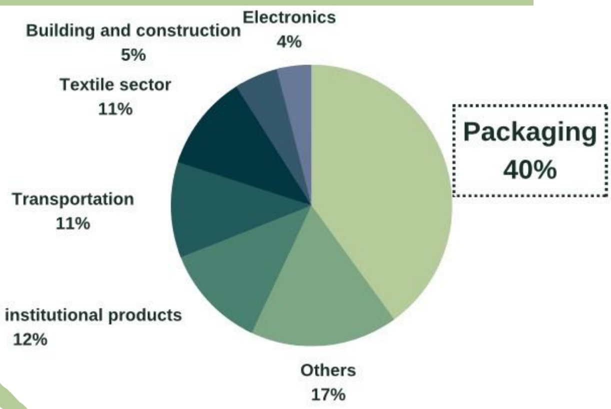
Context



World plastics production

Source: Conversio Market & Strategy GmbH and nova-Institute

Only 9% of plastic waste was recycled properly in 2019



Origin of plastic waste in 2019

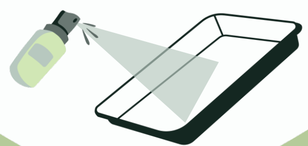
OECD Environment Statistics, "Global Plastics Outlook : Plastic waste in 2019." May 28, 2022. Accessed: May 25, 2022.

SUP directive

AGEC law

Spray application process

BARRIER SPRAY COATING



WP1 Formulation

WP2 Process

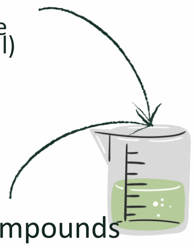
WP3 Characterization

Properties studied

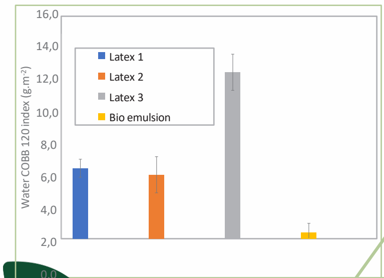
Intrinsic properties

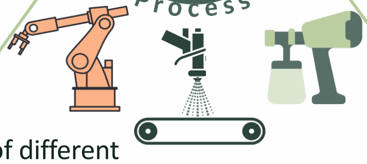
Rheology

MFC (cellulose microfibril)



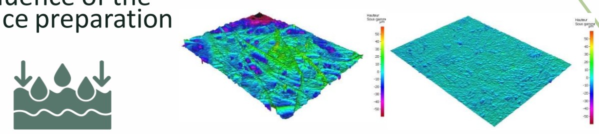
Other Biobased compounds



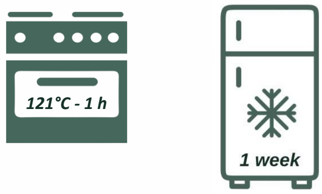


Use of different sprays

Influence of the surface preparation

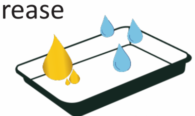


Recyclable in paper/board stream



Real conditions study

Barrier properties



Demonstrator and conclusions

- Spray coating is a complex application technique which takes into account many parameters : viscosity, type of nozzles, type of fluids, surface of the subtrate, …
- For an optimum spraying, the surface must be closed
- Measurements in real-life conditions need to be carried out with the chosen commercial solution

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Secondary packaging active to protect chocolate-madeleine (aroma barrier) and repulse insects

Thaís TAVEIRA - Exchange Program

Grenoble-INP Pagora - Univ. Federal de Lavras UFLA

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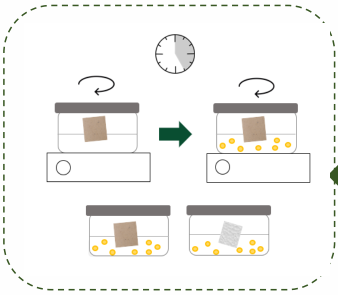
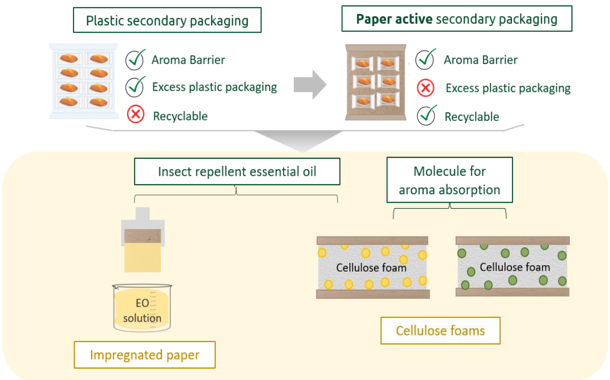
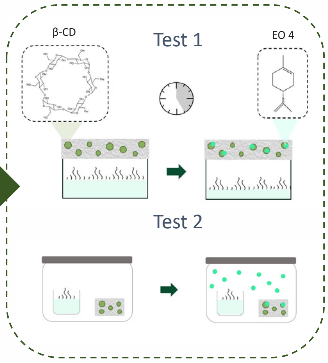
Scope of the Project

Faced with the issue of excess plastic packaging, contamination of packaging by insects and the use of synthetic insecticides, the objective of this work was to develop a secondary active packaging based on cellulosic materials with the incorporation of essential oils (EO) (release system) and cyclodextrin (CD) (absorption system).







From these tests and the techniques used in the project (UV-Vis, DLS, SEM, FTIR and TGA), the behavior of each material in relation to the release or absorption of actives was studied.

Results and Discussion

Release System

Impregnated paper

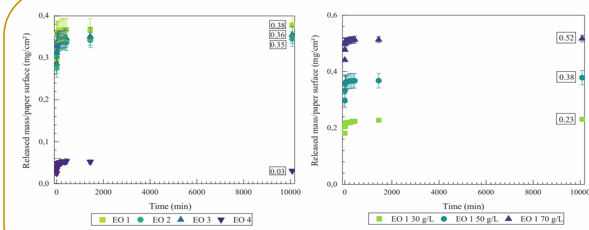


Figure 2. Release test of paper impregnated with EO 1 at different concentrations

- The release of EO occurred quickly, probably due to the easy mobility of EO in the structure.
- All EOs released a final mass close to 0.3 mg/cm², except EO 4 (0.03 mg/cm²), this is due to its high volatility.
- The amount of EO present in the paper, after the impregnation process, was proportional to the concentration of the solution used.

Cellulose foams

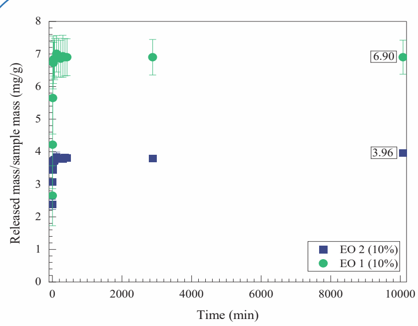


Figure 5. Release test of cellulose foams

- Fast release kinetics and similar behavior for both EOs.

Table 1. Densities of cellulose foams with EO

Sample	Density (kg/m³)
Reference	40 ± 3
EO 1 10%	60 ± 4
EO 2 10%	35 ± 2

- It is believed that the foam with EO 1 was able to retain a greater amount of EO due to poor bubble formation during processing, which also influenced the difference in foam density.

Absorption System

- Overlapping peaks and increasing intensity as the amount of CD increases: change in foam structure.

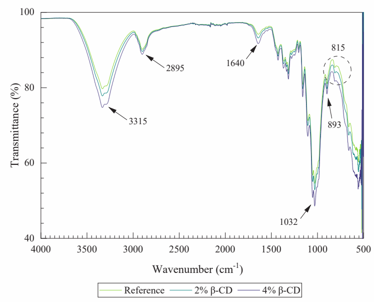


Figure 6. FTIR of cellulose foam with β-CD in the proportions of 2% and 4%.

- For the absorption peak at 815 cm-1, characteristic of the α-type glycosidic bonds of CD, only an increase in peak intensity was observed: the presence of CD in the foam was not as significant.

Table 2. Absorption test results

	Test 1 (g/m².day)	Test 2 (%)
Reference	58 ± 2	0.1 ± 0.03
4% β-CD	52 ± 1	- 4.1 ± 0.5

- In Test 1, the 4% CD sample absorbed a small amount of EO 4 molecules relative to the reference.
- In Test 2, the 4% CD sample experienced a 4% mass loss: moisture loss from the foam and due to water loss in processing.

Conclusions and Perspectives

- **EO delivery systems**: numerous variables influence the release kinetics and the amount of EO released, mainly due to the interaction of each material with the EO and processing.
- **Absorption systems:** CD was probably lost during foam processing, but there was still a small amount of EO 4 absorbed by the sample at 4%.
- Potential and versatility of using cellulosic materials as active food packaging for potential insect repellency and aroma absorption.
- Validate the repellent potential of each material against insects through a biological test using the analyzed EO. The must be done for the absorption system with β-CD.
- Testing ways to better control EO release in paper, while for foam, testing ways to prevent EO and CD loss during processing.

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