Yerba mate residue: an example of food waste utilization in the improvement of the properties of recycled plastics

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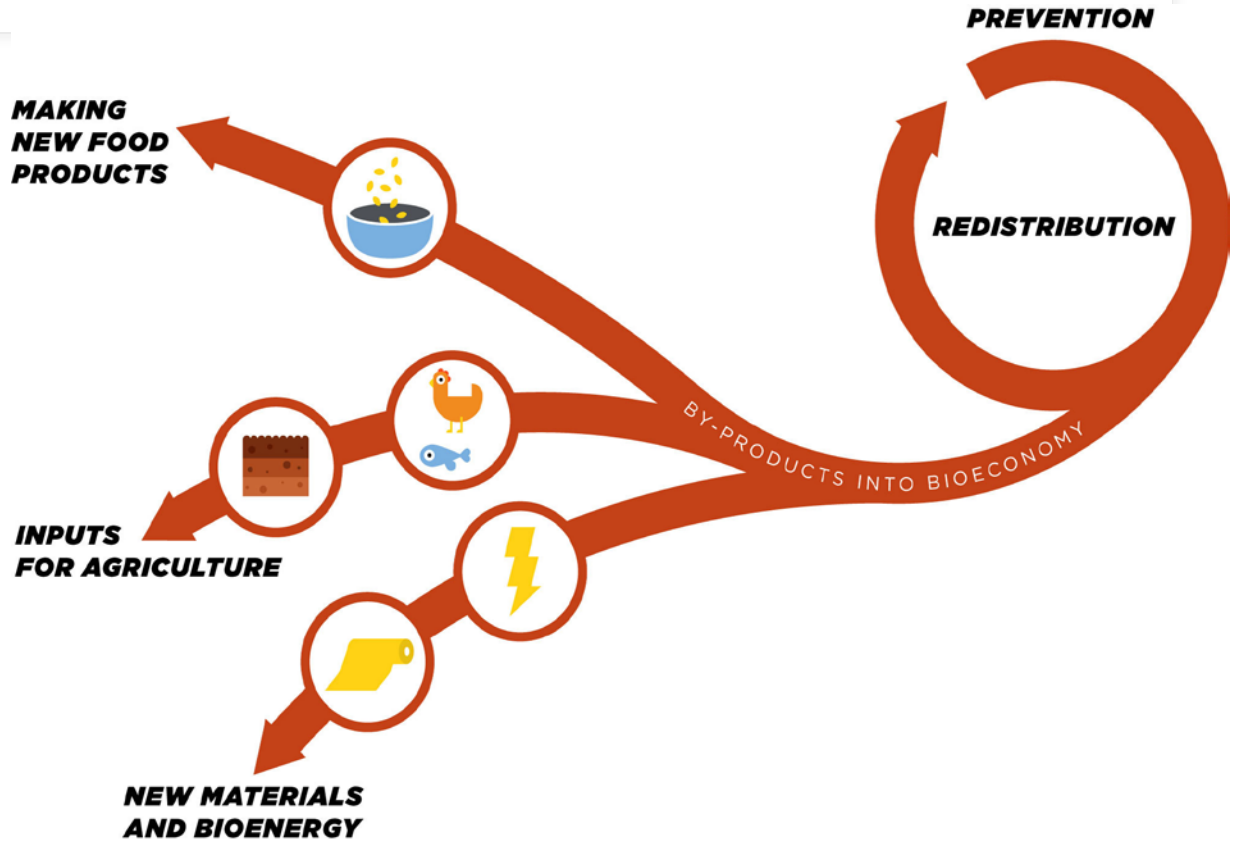
Food waste problem

Each year, tons of food residues are wasted around world.

These residues still have valuable chemical substances.

Their use in the improvement of properties of recycled plastics could be an interesting valorization method



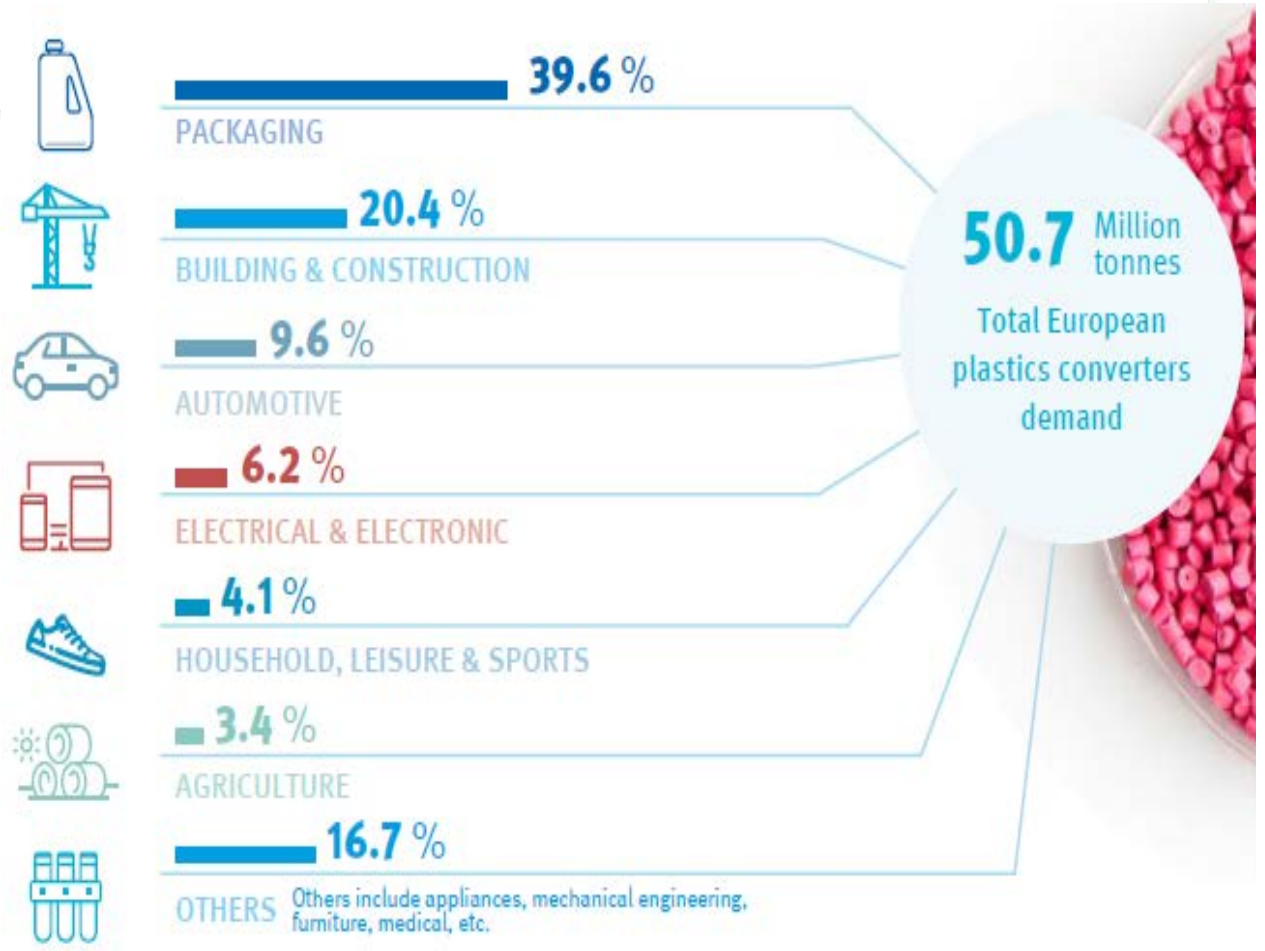
Plastics and bioplastics

Conventional plastics have excellent properties, are cheap but rely on non-renewable raw materials.

Most important application: **packaging**

Bioplastics **come from renewable resources** but **are expensive and have poorer properties**.

Some examples: **PLA**, PHBV, starch, **caseinates**...



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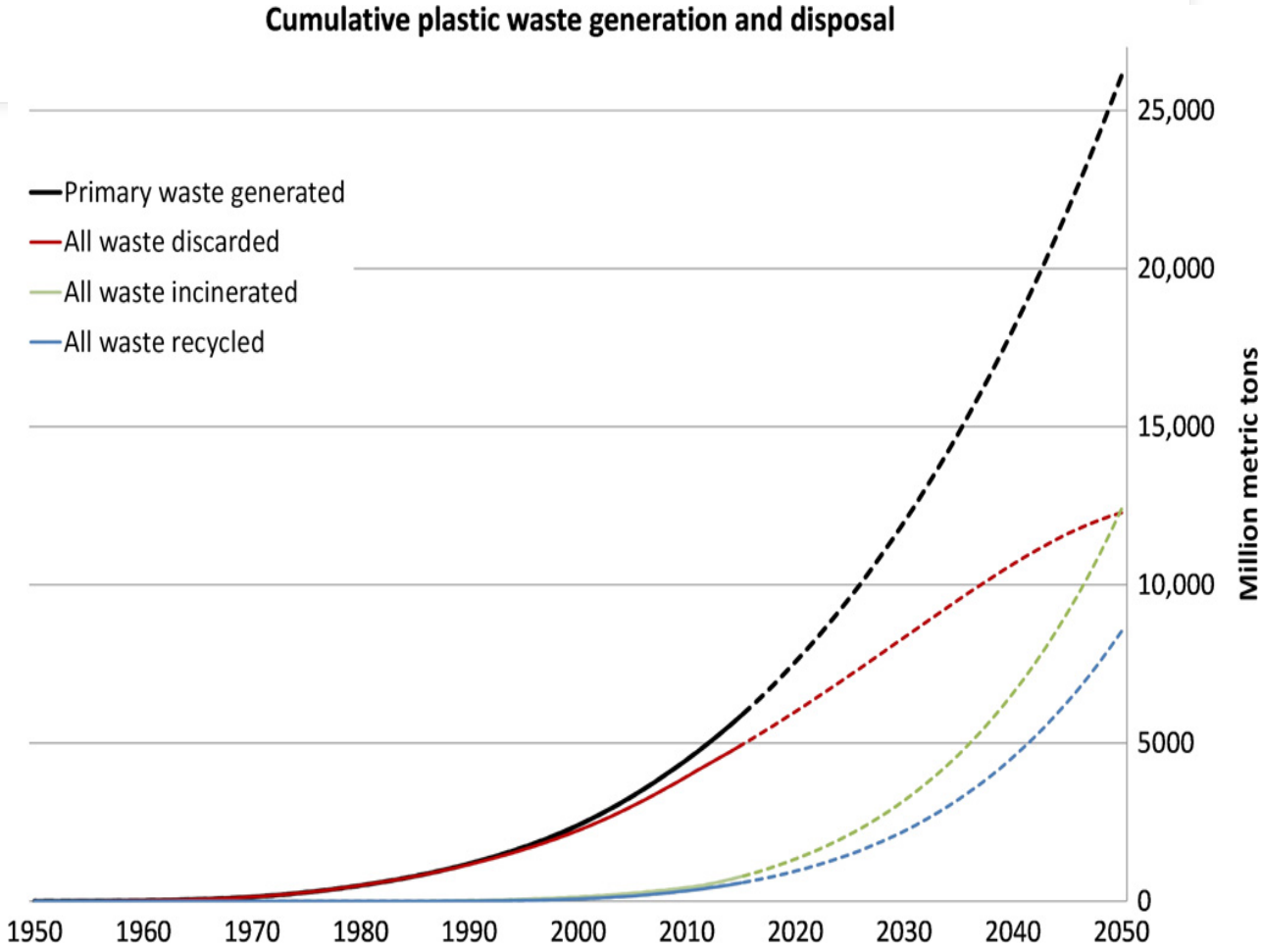
Recycling as valorization method

A considerable amount of plastic waste is mismanaged.

Bioplastics **do not escape** this problem.

Recycling, either chemical or **mechanical**, poses many advantages.

Mechanical recycling leads to a **decrease on the properties** of plastics and bioplastics.

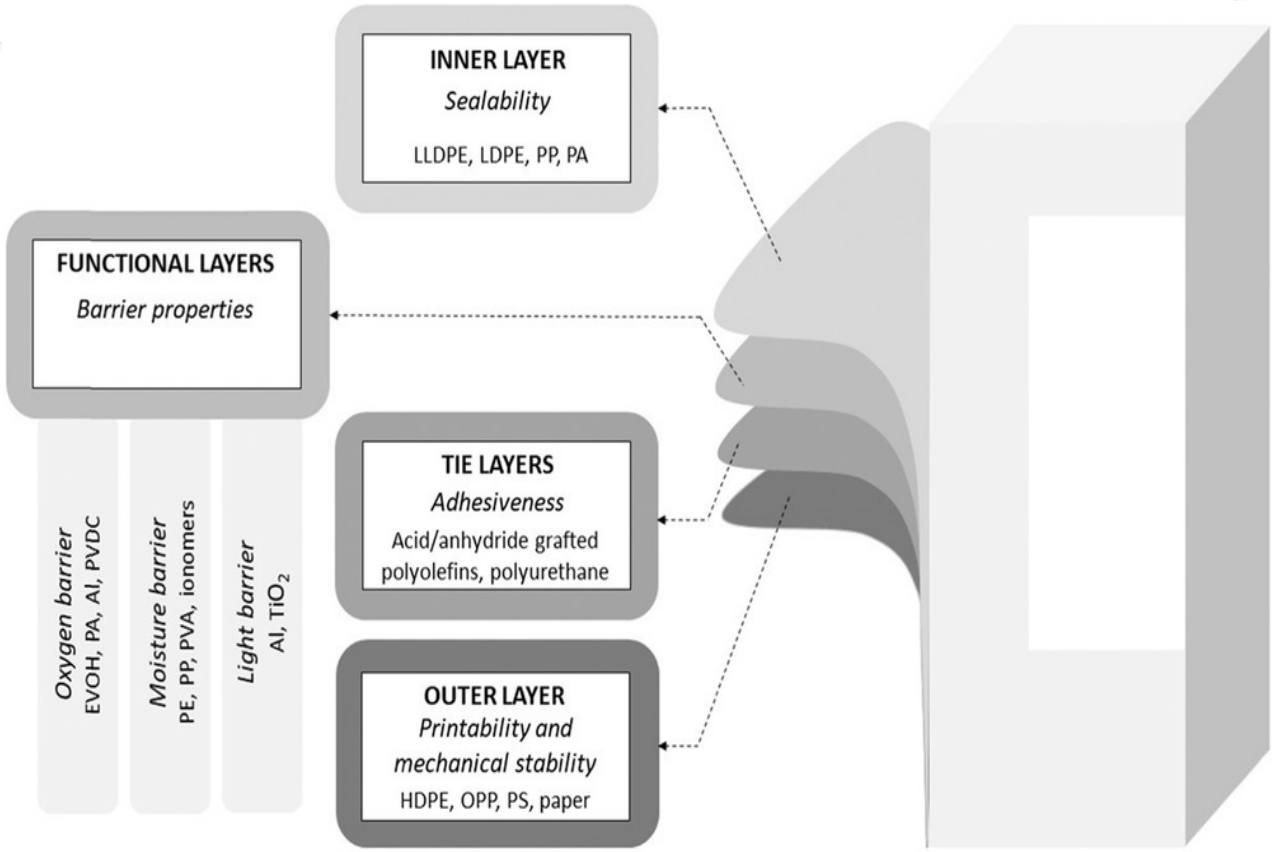


Geyer et al. (2017) DOI: https://doi.org/10.1126/sciadv.1700782

Improvement of the properties

Properties of recycled plastics and bioplastics can be improved by:

- ✓ Addition of fillers
- ✓ Development of multi-layer systems



Anukiruthika et al. (2020) https://doi.org/10.1111/1541-4337.12556

Main objective

Improve the properties of mechanically recycled PLA by:

- **Incorporating nanoparticles extracted from yerba mate residues.**

- **Developing a multi-layer system based on recycled PLA and sodium caseinate.**

Methodology

PLA pellets

Processing

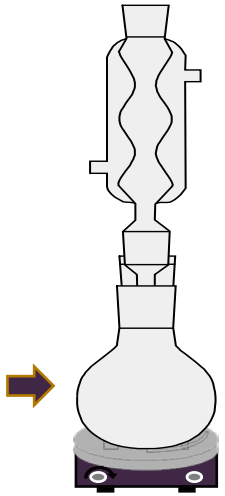
Accelerated ageing

Washing and shredding

Processing

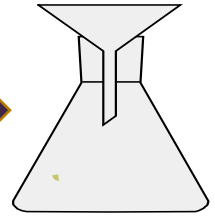
Recycled PLA (**RPLA**)

Yerba mate waste

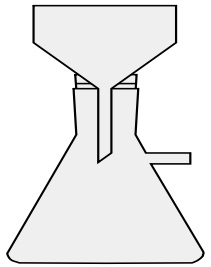


100 °C
1000 rpm – 60 min

Filtering



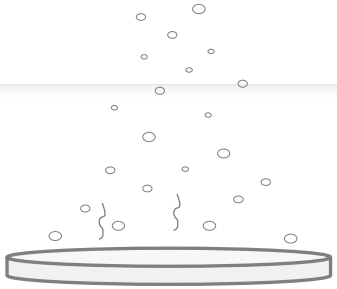
Freeze-drying



Yerba mate nanoparticles (**YMN**)

Methodology

Caseinate + Glycerol
(35 %wt.)
5 g in 100 mL H_2O

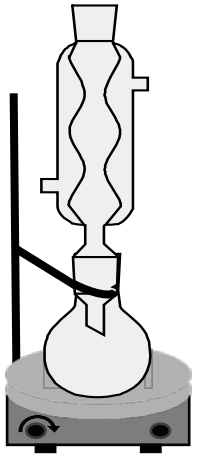


Solvent casting process

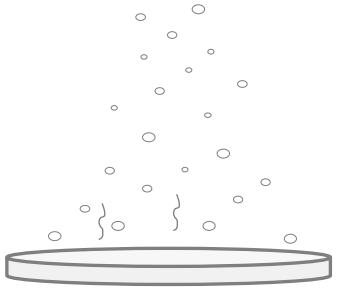
Caseinate film

Hot-plate pressing

Multi-layer films



RPLA + YMN (1 and 3 %wt.)
0.6 g in 60 mL $CHCl_3$ 40 °C



RPLA + YMN films

Results: Raman micro-spectroscopy

Three different zones can be appreciated.

No adhesion problems are noticed in the picture.

An authentic tri-layer system has been produced.

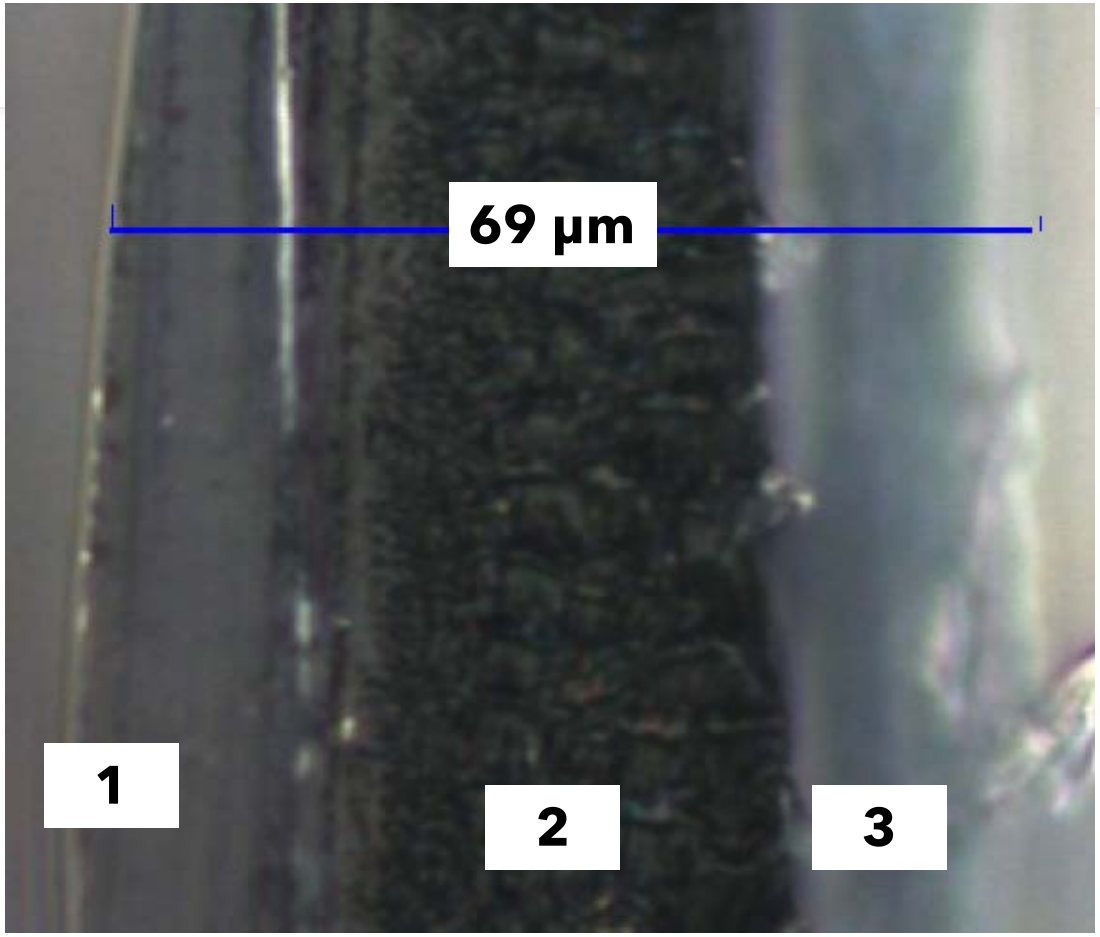


Fig. 1. Optical microscopy picture of the tri-layer system

Results: Raman micro-spectroscopy

Zones 1 and 3 are similar, showing characteristic absorption bands of PLA.

- ~1760 cm^{-1}: stretching C=O
- ~870 cm^{-1}: stretching C-COO

Zone 2 show some characteristic absorption bands of caseinate.

- ~1670 cm^{-1}: Amide I
- ~1450 cm^{-1}: Amide II

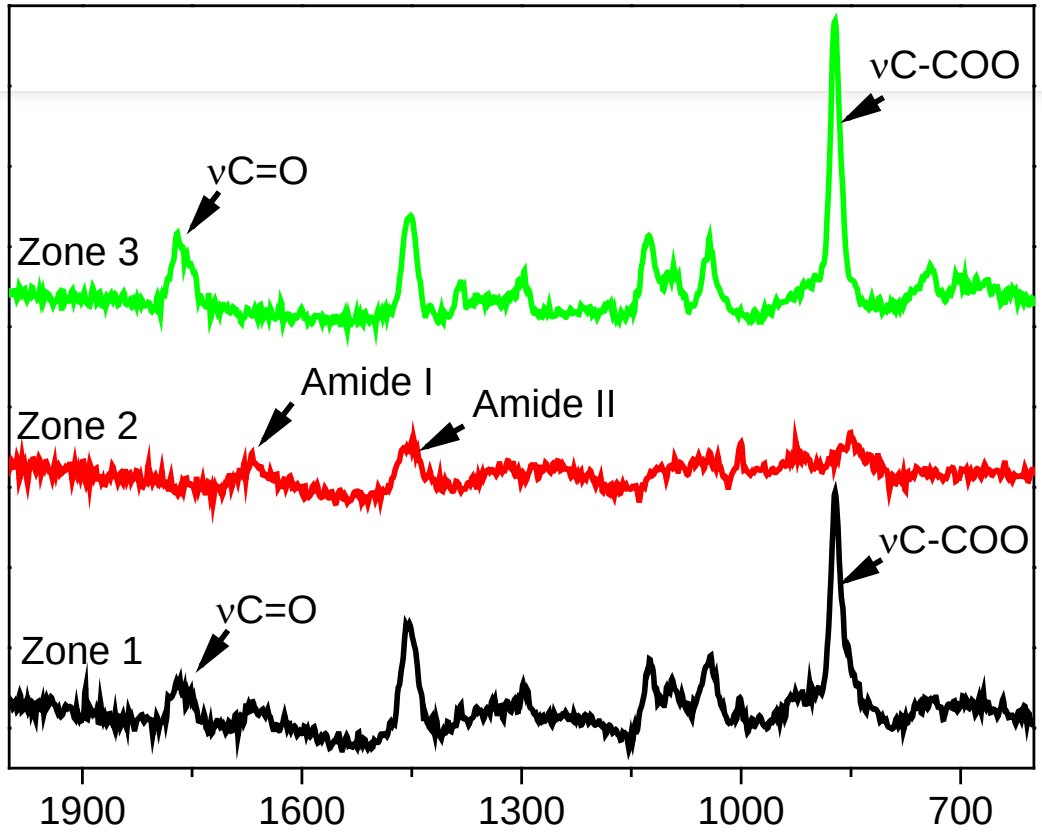


Fig. 2. Raman spectra of the different zones of the tri-layer

Results: UV-Visible spectroscopy

Absorption band around 270 nm indicates degradation of PLA.

The incorporation of the caseinate layer does not significantly affects the optical behavior.

YMNs show absorption in the UV region of the spectra, which could be useful for packaging applications.

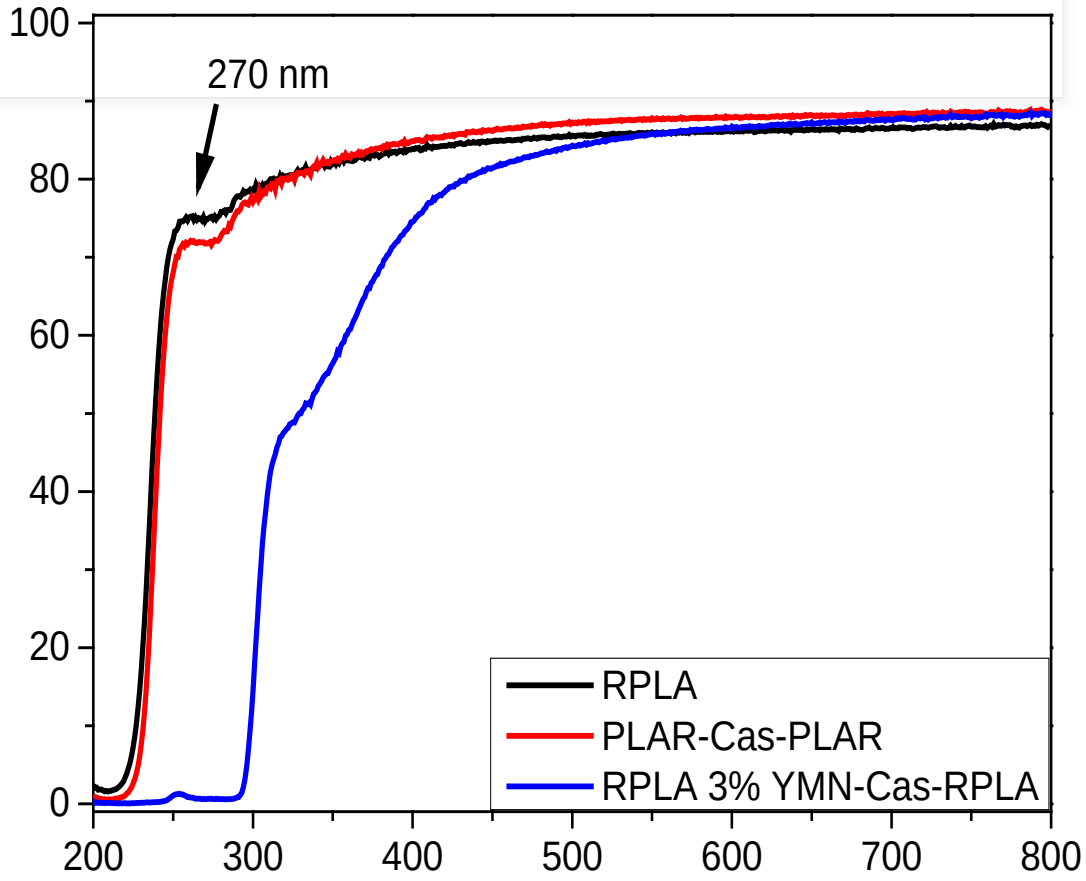


Fig. 3. UV-Vis spectra of the samples

Results: Thermogravimetric analysis

TGA curves of the tri-layer system show reduced thermal stability.

Due to decomposition of glycerol (< 240 °C) and caseinate proteins (> 300 °C).

The **addition of YMN protects** the caseinate layer against thermal decomposition.

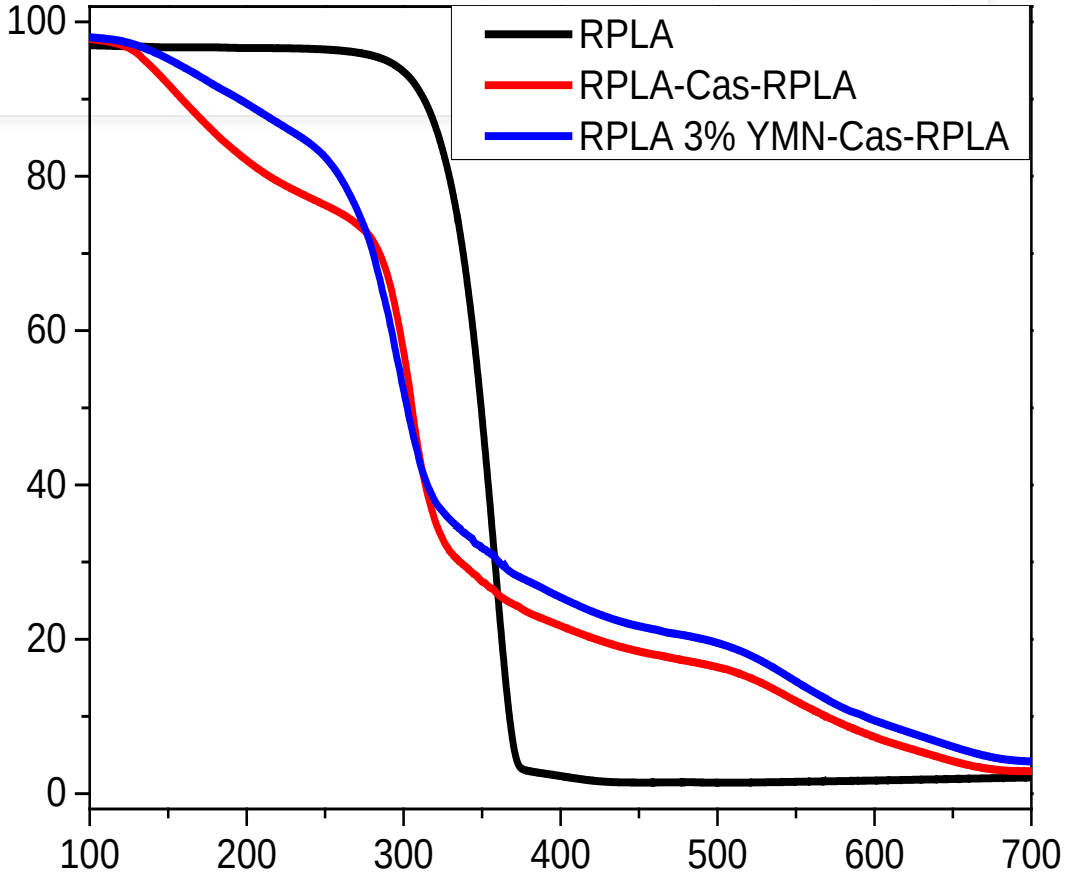


Fig. 4. TGA curves tri-layer systems

Results: Tensile tests

The tri-layer systems show significantly lower tensile strength that PLA.

This can be attributed to the poor mechanical properties of the caseinate layer.

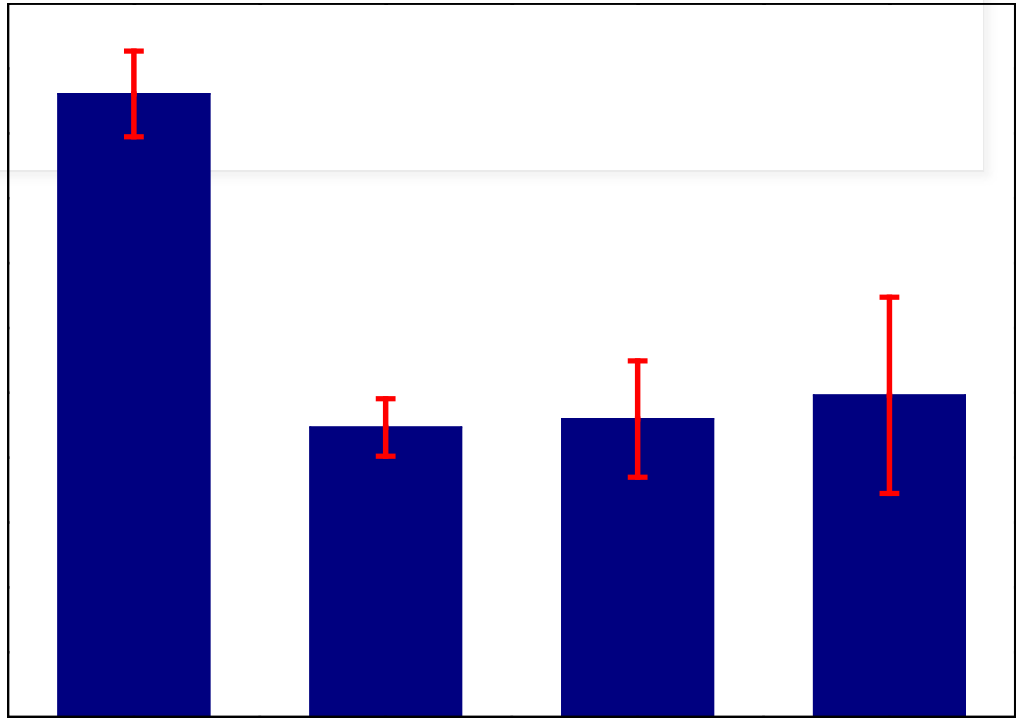


Fig. 5. Tensile strength of the samples

Results: Water vapor transmission rate

The addition of the **caseinate layer** **greatly improve the barrier properties** of the materials

The hydrophilic nature of YMN slightly increase the WVTR of the materials

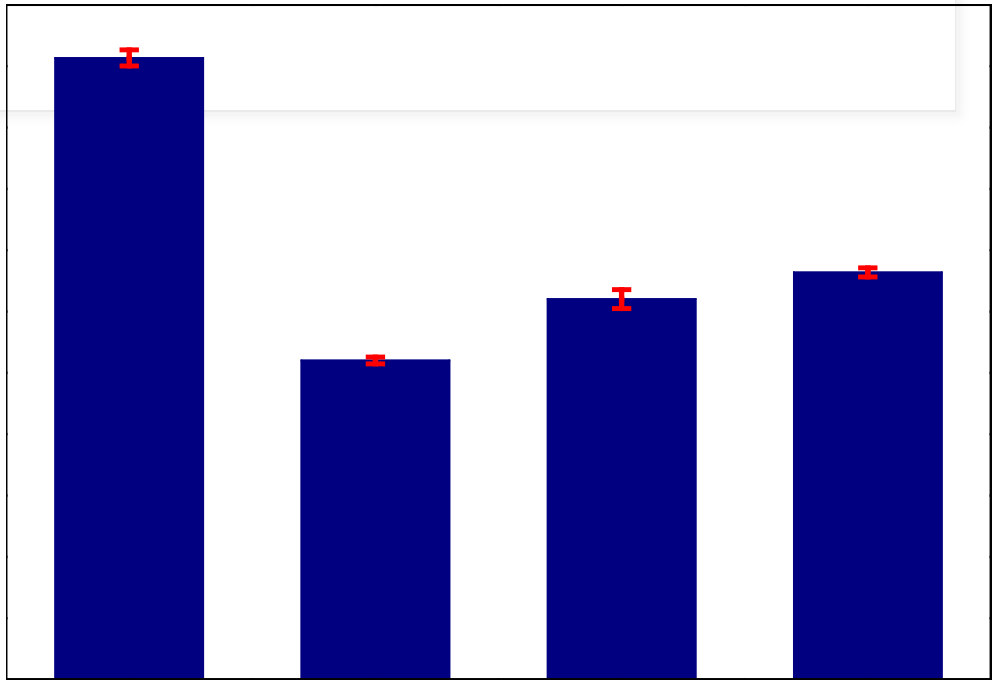


Fig. 6. WVTR values of the samples

Conclusions

Raman micro-spectroscopy shows that authentic RPLA-Caseinate-RPLA tri-layer was formed

YMN provide UV protection and increase thermal stability of the tri-layer system

The addition of the caseinate layer greatly improve the barrier properties of the system

Thank you for your attention

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