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Effect of Reprocessing of Polyester/ Montmorillonite Nanocomposites

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25/01/2024

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Summary of literature review

-Polymeric materials, **especially polyesters**, are found in everything around us, their use extending from the most trivial consumer goods to the most advanced microelectronics packaging.

-There is an increasing need to create new materials that have unusual properties that cannot be found in traditional materials.

-Composite materials are used to achieve this.

-The most important of which is composite materials → they improve the properties of the polymer.

-Most commonly used nanofiller for polymer composites is Montmorillonite (MMT).

The problem to be solved

Unknown properties of recycled nanocomposites .

Aim of the research

- Study the **effect of recycling** on the morphology, mechanical and thermal properties of MMT-nanocomposites with different polyester matrices.

Practical part

Petroleum-based

Polybutylene Terephthalate (PBT)

- Low humidity absorption
- High strength and hardness
- Resistance
  - High temperature
  - Good wear
  - electricity
  - flame
  - motor oil, gasoline and brake fluids.

Polyethylene terephthalate (PET)

- Lightweight and Transparency
- High strength and hardness
- Good barrier to gases
- Chemical Resistance
- Temperature Resistance

Practical part

Bio-based

Polybutylene succinate (PBS)

- Biodegradability
- High strength and hardness
- Chemical Resistance
- Thermal Stability

Polylactic acid (PLA)

- Gloss and Transparency
- Biodegradability
- Easy to 3D printing.
- Mechanical properties

Practical part

Test samples

1- After drying I compounded the nanocomposites added 6 wt.% of MMT to each of PET, PBS, PBT and PLA using a twin screw extruder (1x extr.)

2- I repeated the extrusion for the reprocessed samples (2x extr.)

3- I dried all nanocomposite materials in an oven.

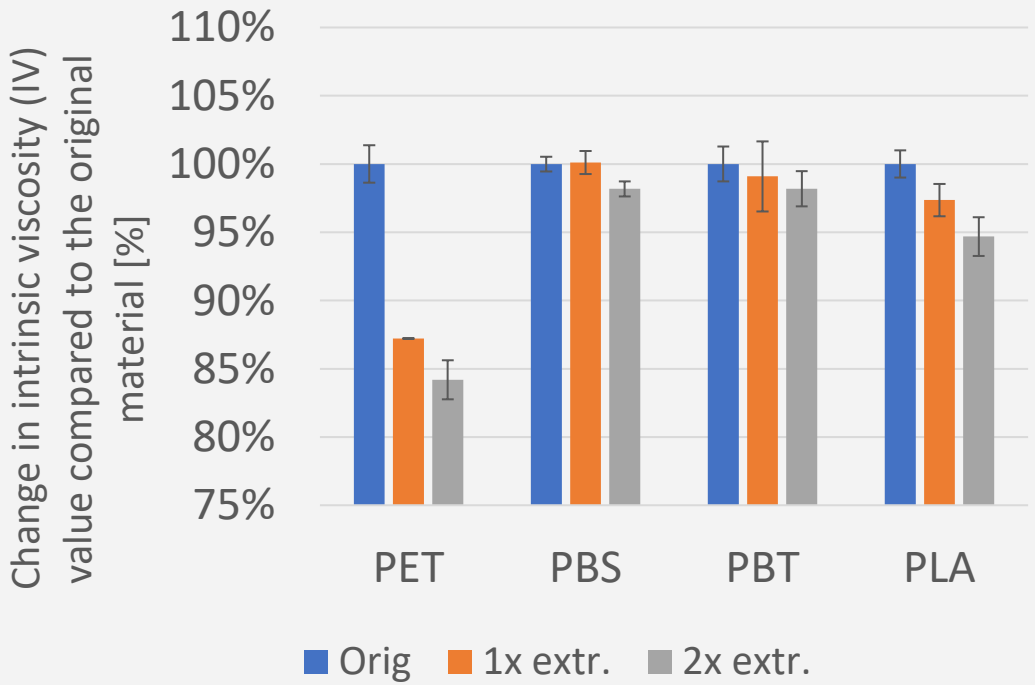
4- I used injection molding to make the test samples.

1

Practical part

Intrinsic viscosity (IV)

- Effect of recycling on the molecular weight of PET, PBS, PBT and PLA.



Mark-Houwink

$$[\eta] = K\,Ma$$

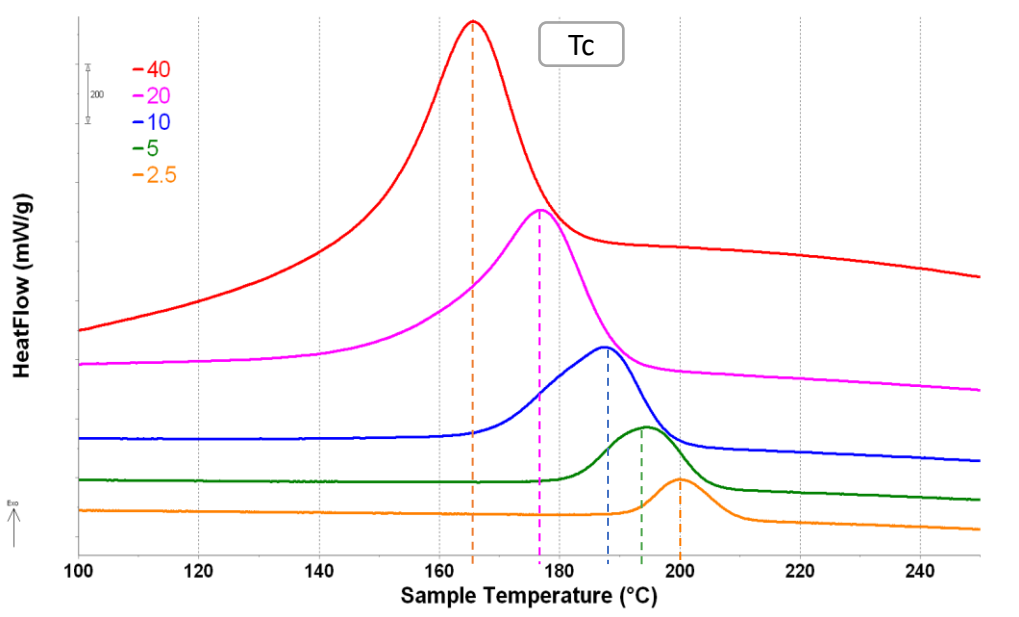
η: Intrinsic viscosity.
M: molecular weight.
K, a : constants.

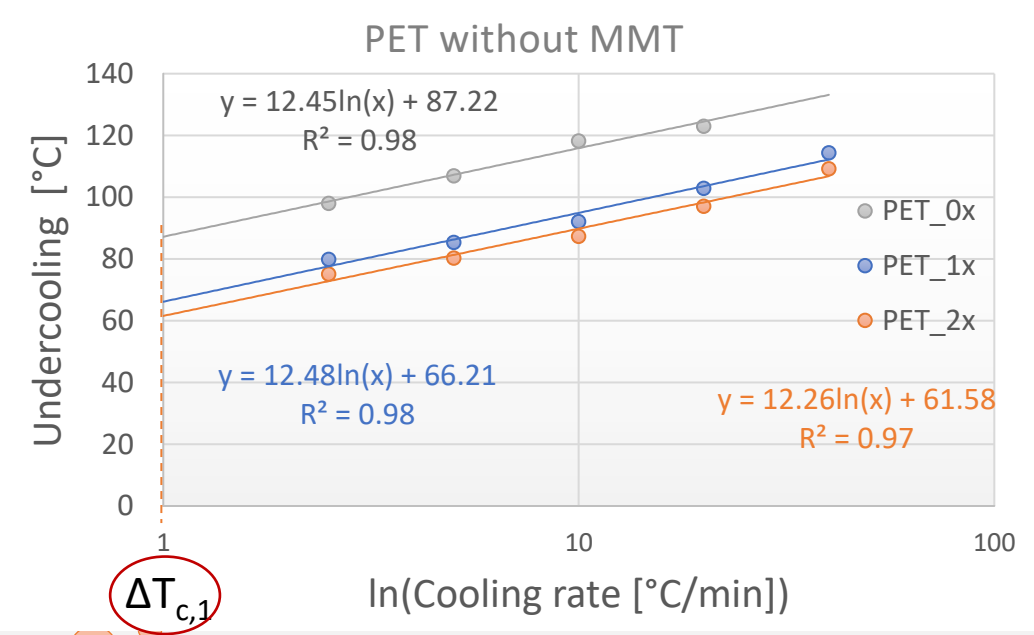
2

Practical part

Non-Isothermal crystallization of PET, PBS, PBT and PLA

I scanned them by using a DSC during the following cooling rates 2.5, 5, 10, 20, 40 °C/ min to determine the crystallization kinetics of the material in **non- isothermal** conditions.





$\Delta T_{c,1} = T_m^0 - T_{c,1}$

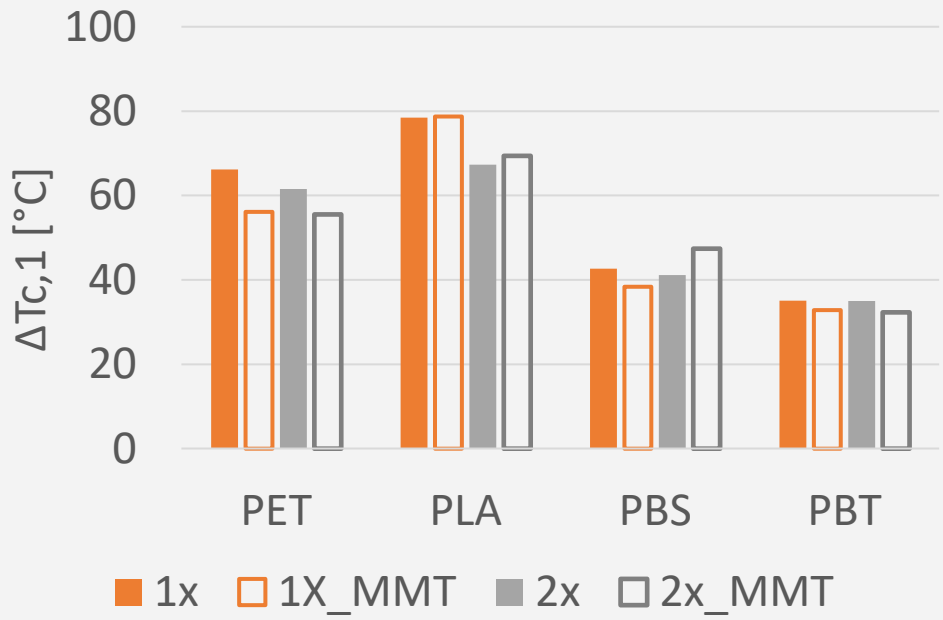
T_m^0: equilibrium melting temperature;

$T_{c,1}$: Crystallization temp. at the cooling rate: 1 °C/min

3

Practical part

Non-Isothermal crystallization of PET, PBS, PBT and PLA



3

$\Delta T_{c,1}$ is related to the thermodynamic driving force of the nucleation and its value depends mainly on the type of polyester: highest for PLA and lowest for PBT.

Practical part

Shrinkage of composites (PET, PBS, PBT, PLA / MMT)

The effect of adding MMT and recycling on the shrinkage of composite materials during 24 hours.

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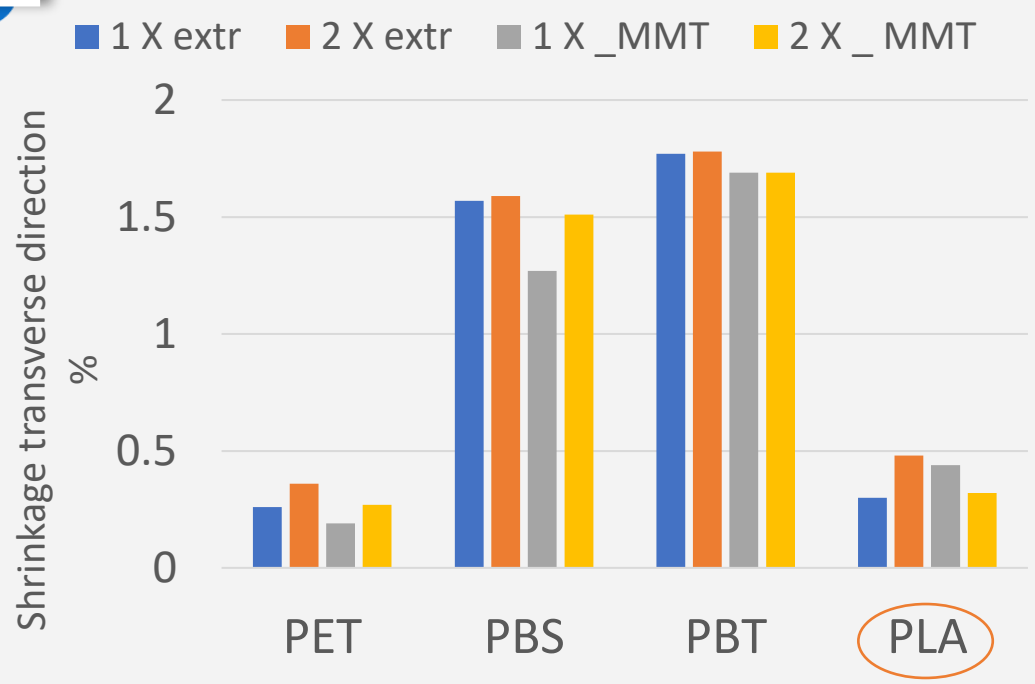
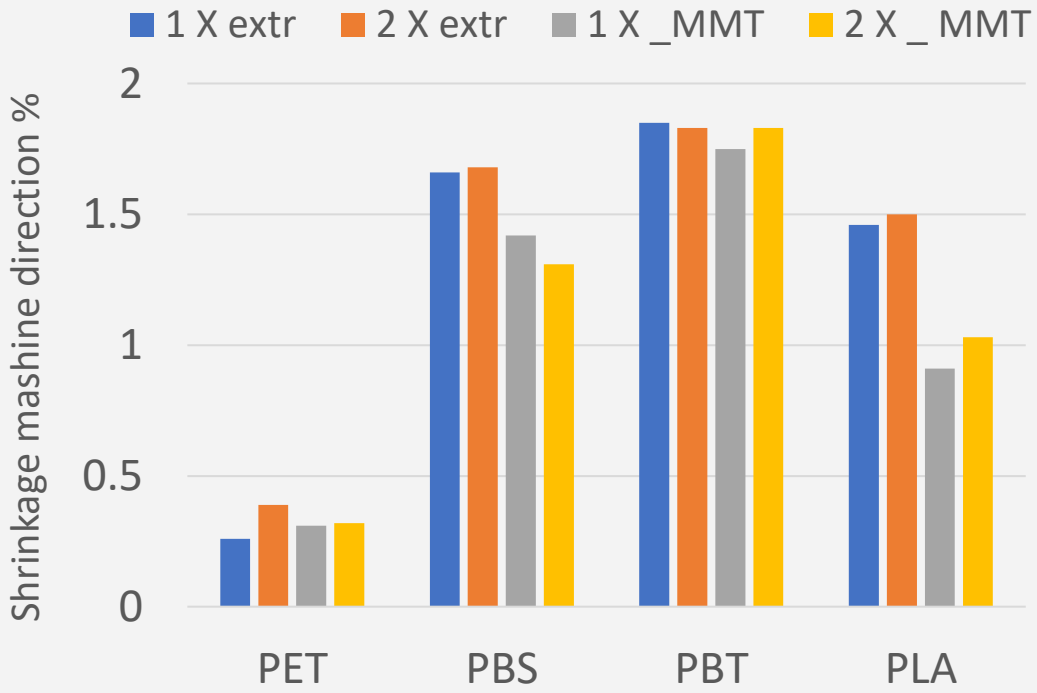


Transverse Direction



Machine Direction

Shrinkage increased with increasing number of cycles without adding MMT.

Practical part

Crystallinity of composites PET, PBS, PBT and PLA

We scanned them by using a DSC during the cooling rate 10 °C/ min to determine the Initial crystallinity percentage (CRF) of PBS, PBT, PET and PLA injection moulded samples (with/ without MMT).

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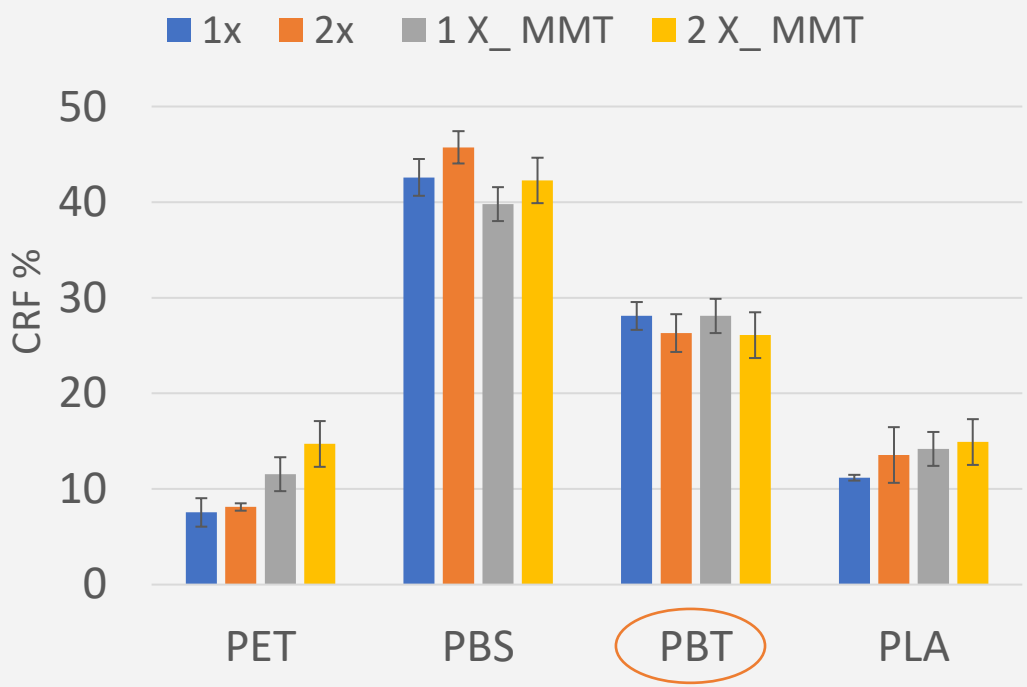
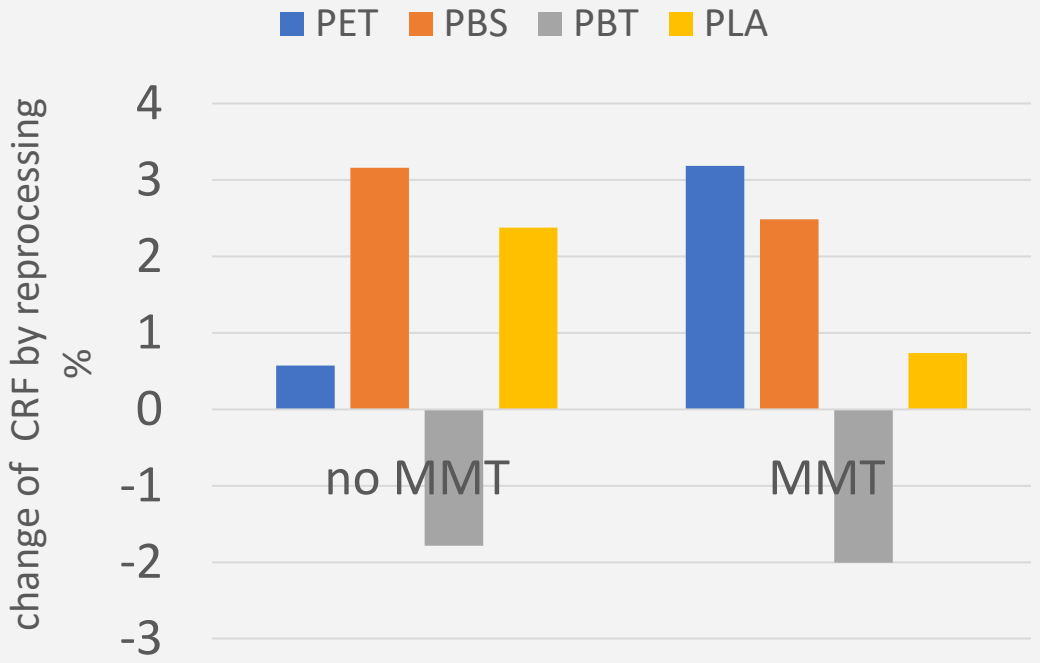


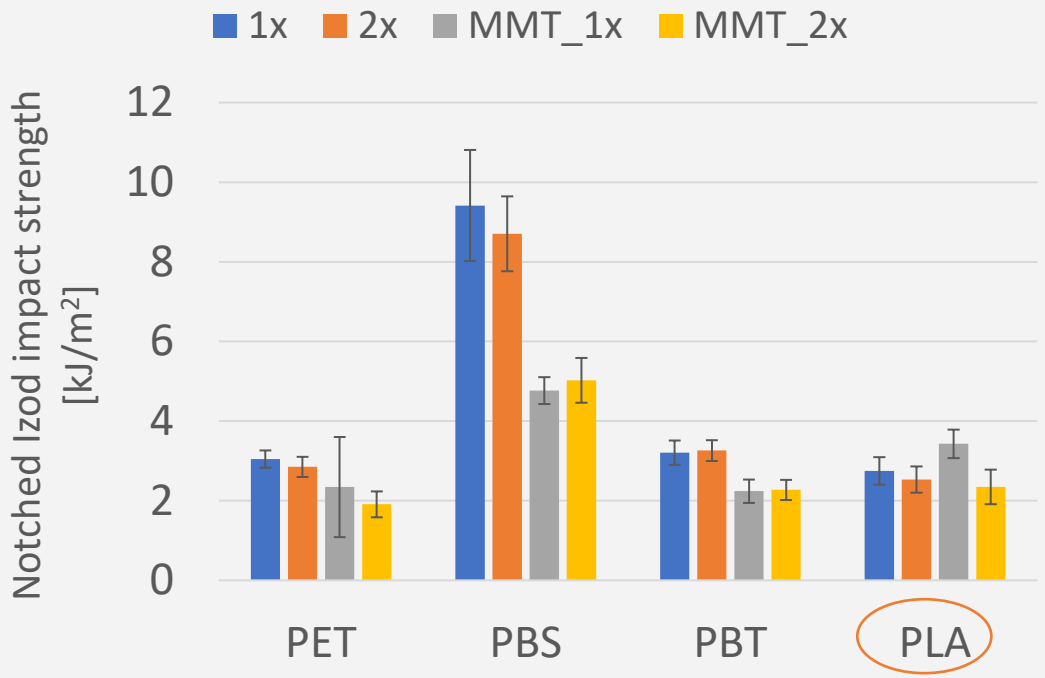


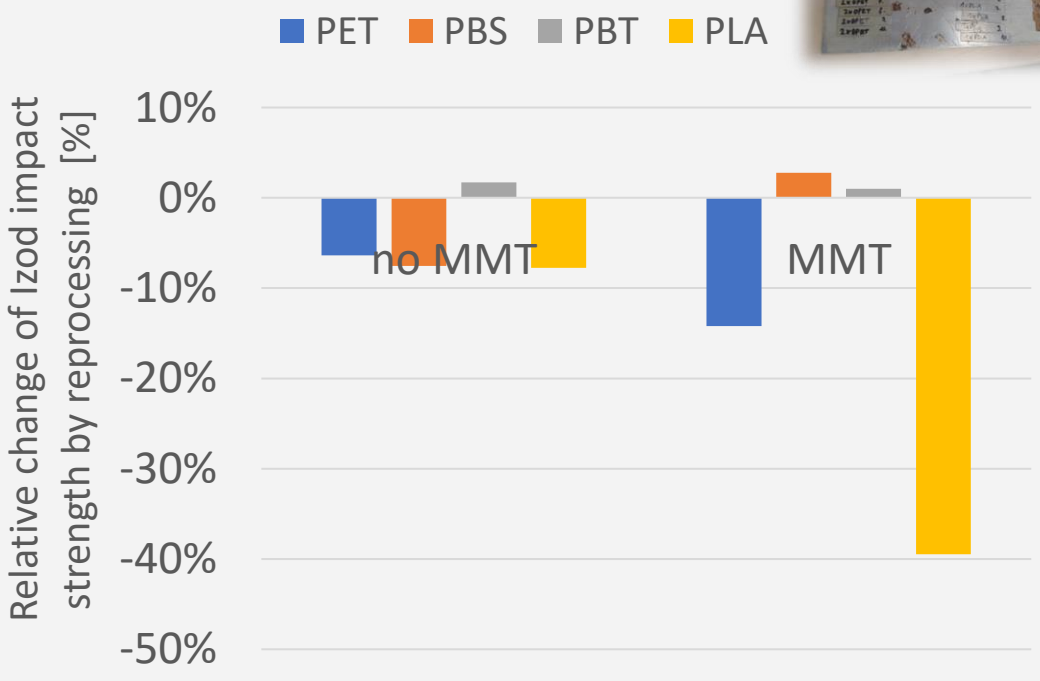
Increasing the number of recycling cycles led to an increase CRF for all types except **PBT**.

Practical part

Izod impact of composites (PET, PBS, PBT, PLA / MMT)

The effect of adding MMT and recycling on Izod impact strength of composite materials.





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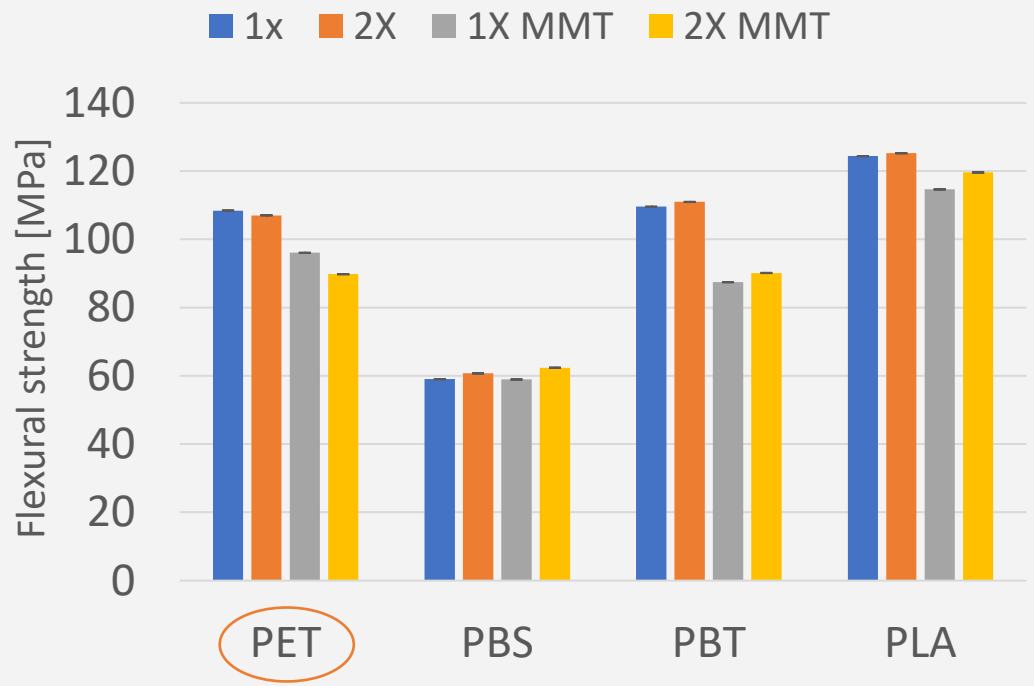
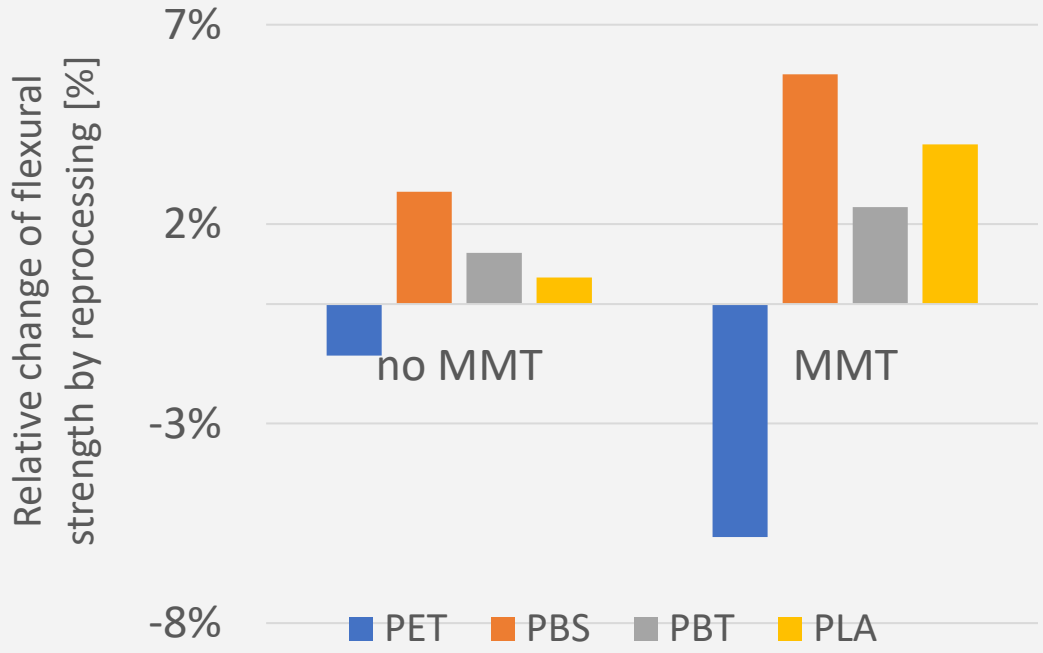
The number of recycling cycles did not have a noticeable effect on impact strength without MMT, but impact strength of **MMT-PLA** nanocomposite decreases significantly

Practical part

Flexural strength of composites (PET, PBS, PBT, PLA / MMT)

The effect of adding MMT and recycling on flexural strength of composite materials.





The number of recycling cycles did not have a noticeable effect on flexural strength without MMT, but flexural strength of **MMT-PET** nanocomposite decreases significantly.

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Practical part

Scanning Electron Microscope (SEM) - Energy Dispersive Spectroscopy (EDS) analysis of composites (PET, PBS, PBT, PLA / MMT)

We scanned the fracture surface of the samples after Izod impact test by using EDS.

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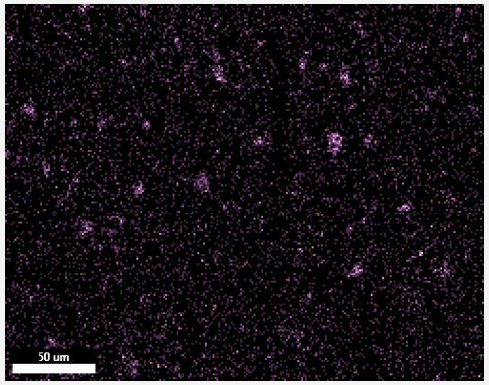
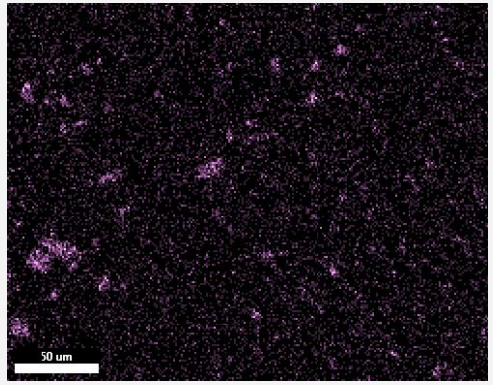
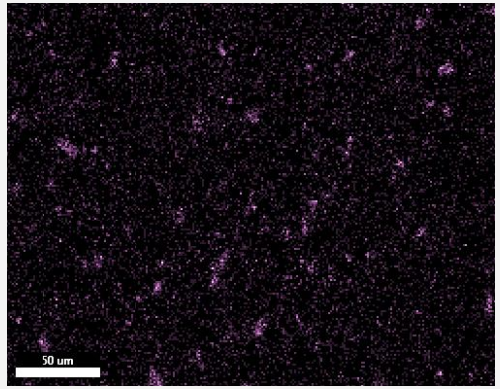
Si- MMT- 1X **Si- MMT- 2X** **Si- MMT- 1X** **Si- MMT- 2X**

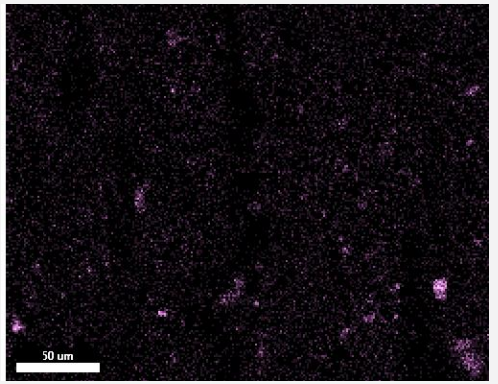
PET



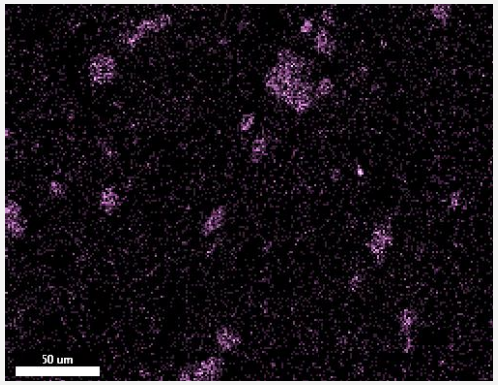


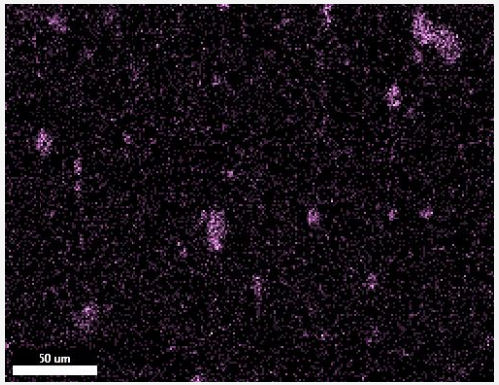
PBT



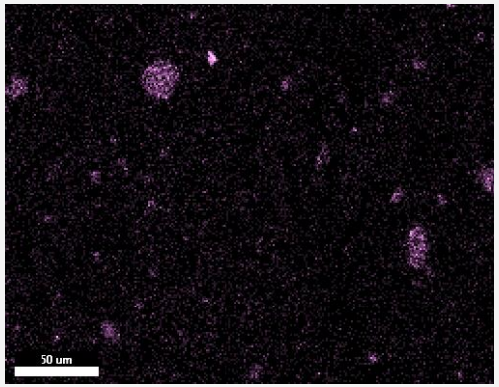


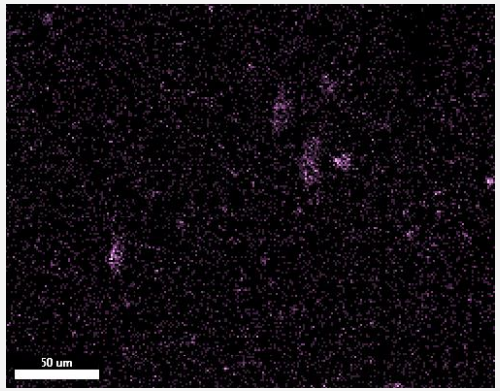
PBS





PLA





Conclusion:

The results

- The results indicate a change in the properties of polyesters as a result of **the following factors:**

  - Adding MMT and Recycling.

- Recycling had a noticeable effect on the intrinsic viscosity of **PET**.
- Recycling without adding MMT led to a decrease in the crystallization ability of both **PET** and **PBT**, while crystallization increased when adding MMT.
- Recycling resulted in a significant decrease in initial crystallinity percentage for **PET/MMT** and **PBT/MMT**.
- When adding MMT, recycling led to an increase in shrinkage in the transverse direction of **PET/MMT** and **PBS/MMT**, while **PLA/MMT** decreased .
- It led to an increase in shrinkage for **PBT/MMT** and **PLA/MMT** in the direction of the machine, while **PBS/MMT** decreased.
- The impact strength of **PLA** decreased with recycling in the presence of MMT.
- The flexural strength of all polyesters increased except for **PET**.
- Increasing the number of recycling cycles led to improved dispersion of MMT in the polymer matrix.

Plans for the future

We will do the following

- further analyses of new results.

- Scan the samples by using Dynamic Mechanical Analysis (DMA).

- Scan the samples by using Wide-angle X-ray scattering (WAXD).

- Studying the effect of recycling and adding MMT on the rheology of samples.

- Write two articles with IF:

  1- Connections between mechanical properties and morphology (flexural, impact properties / degradation, crystallinity, MMT dispersion, etc..)

  2- Time- and temperature-dependent properties of MMT/polyester nanocomposites (DMA, rheology, non-isothermal crystallization, WAXD, etc..)

List of publication

List of publication

- **First article :** *Zoubeida Taha Taha, Andrea Ádámné Major*, **A review on MWCNTs: The effect of its addition on the polymer matrix,** *Gradus*, https://gradus.kefo.hu/archive/2023-1/2023_1_ENG_012_Taha.pdf

- **Second article :** *Zoubeida Taha Taha, Andrea Ádámné Major*, **Investigating the effect of adding multiwalled carbon nanotubes on the morphological properties of polybutylene terephthalate,** (accepted).

- **Third article :** *Zoubeida Taha Taha, Andrea Ádámné Major, Ferenc Ronkay,* **Effect of Reprocessing on the Crystallization of Different Polyesters,** *Acta Technica Jaurinensis,* https://acta.sze.hu/index.php/acta/article/view/723/620 (accepted).

Semester Activities

Semester Activities

- I have participated in III. International Architectural Sciences and Applications Symposium (İksad Institute Conference).

- I have explored the literature review related to my research topic and wrote summaries of it.

THANK YOU for YOUR ATTENTION!