ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

John von Neumann University

Preparation and investigation of nanocomposites with polymer matrix

Supervisors
Dr. Andrea Ádámné Major
Prof. Dr. Ferenc Ronkay

PhD Student
Kashif Ullah Khan

Doctoral School of Materials Sciences and Technologies
2024-25

23/01/2025

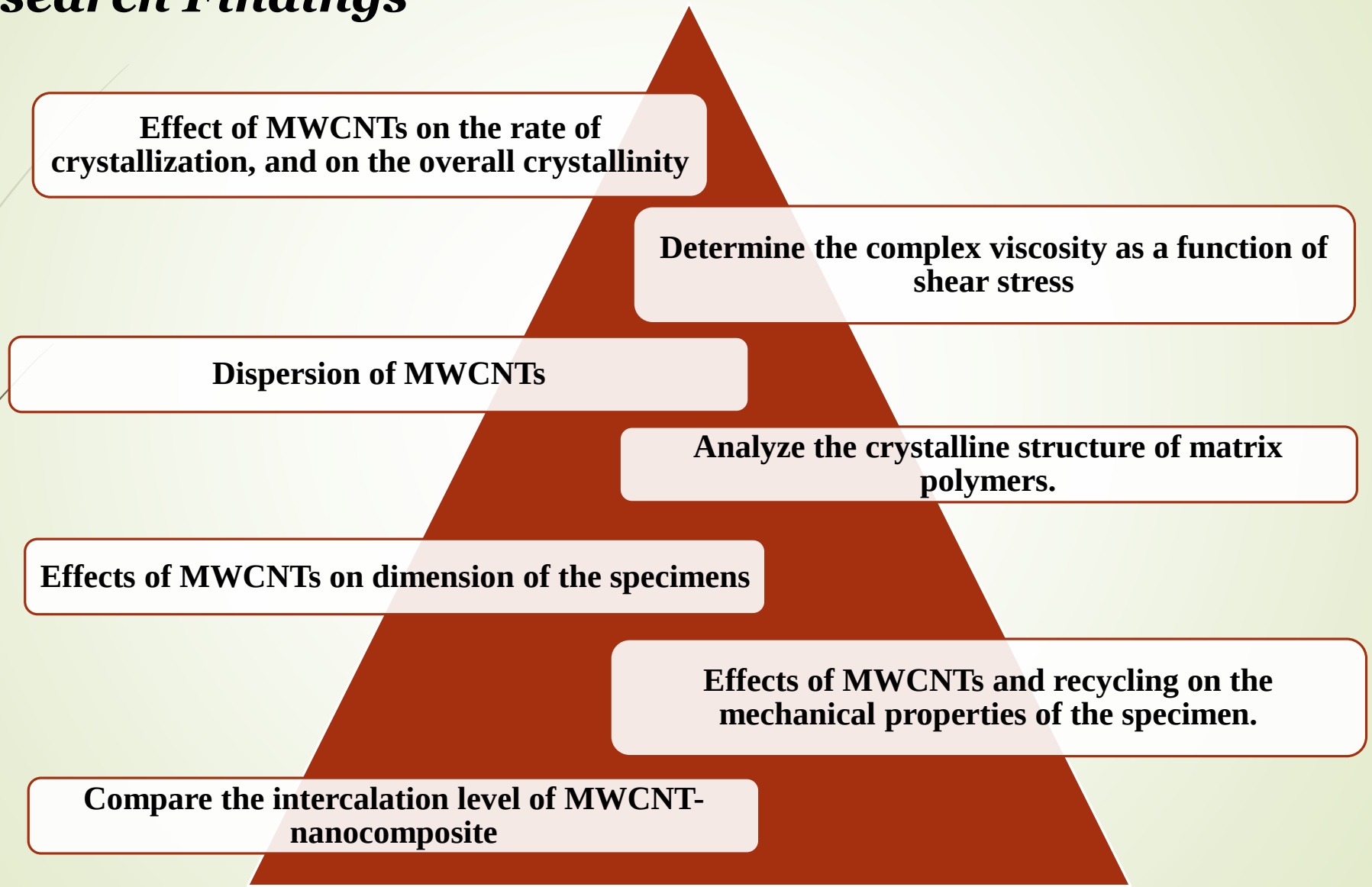
TABLE OF CONTENT

1. Aim of research
2. Research findings
3. Materials and Experiment
4. Results
5. Work plan
6. Activities

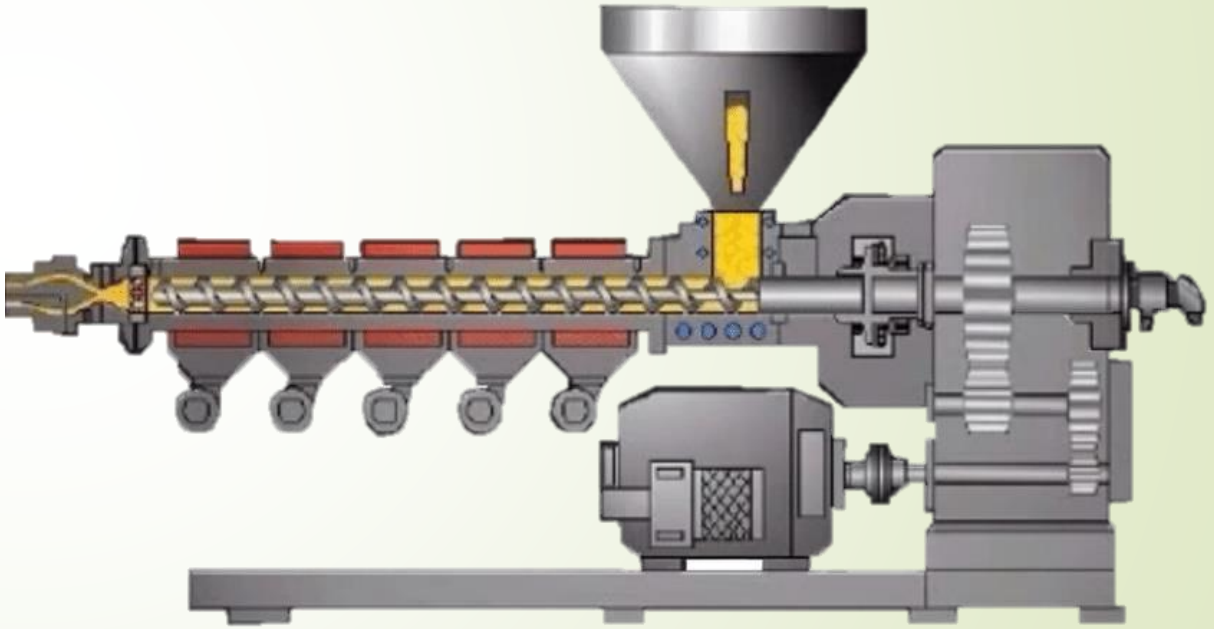
Aim of research

"Preparation and Investigation of Polymer Matrix Nanocomposites"

4 *Research Findings*



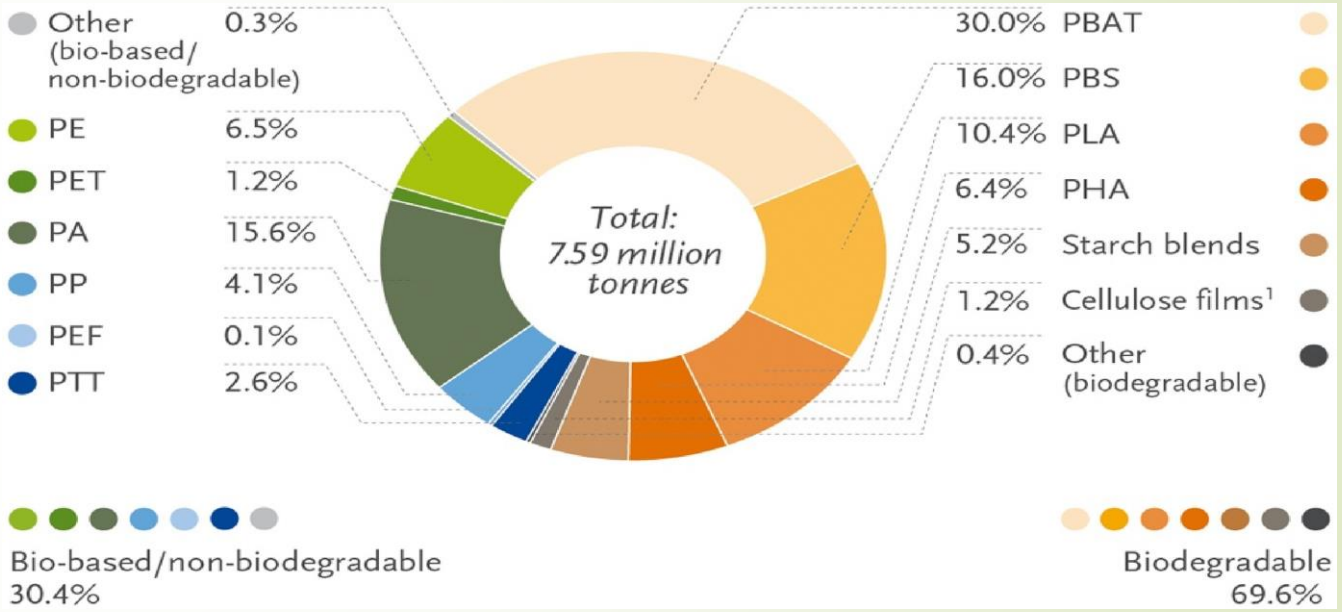
Materials and Experiment



Materials

a

- **Polyesters**
  - **Non-biodegradable**
    - **PET**
    - **PBT**
  - **Biodegradable**
    - **PLA**
    - **PBS**



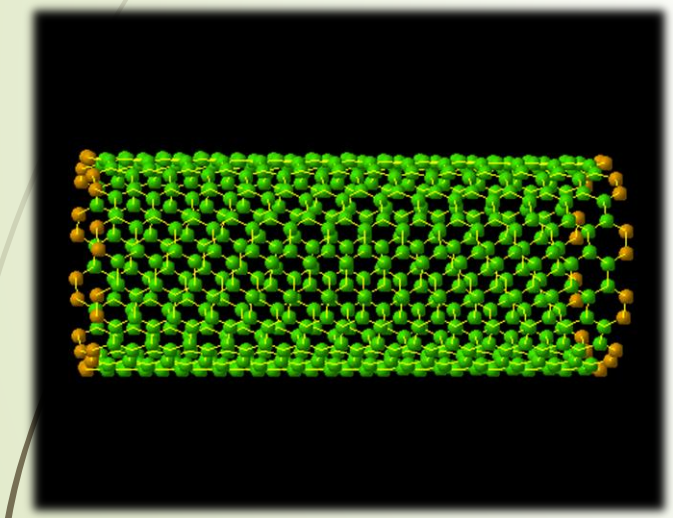
Worldwide production capacities of bioplastics 2026.*

*H. Ramezani Dana, F. Ebrahimi, Polym. Eng. Sci. 2023, 63(1), 22. https://doi.org/10.1002/pen.26193

Materials

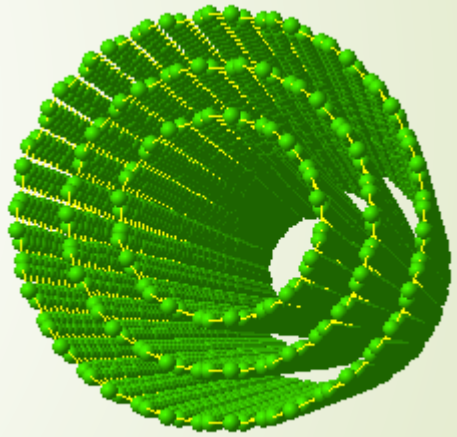
CNTs

SWCNTs



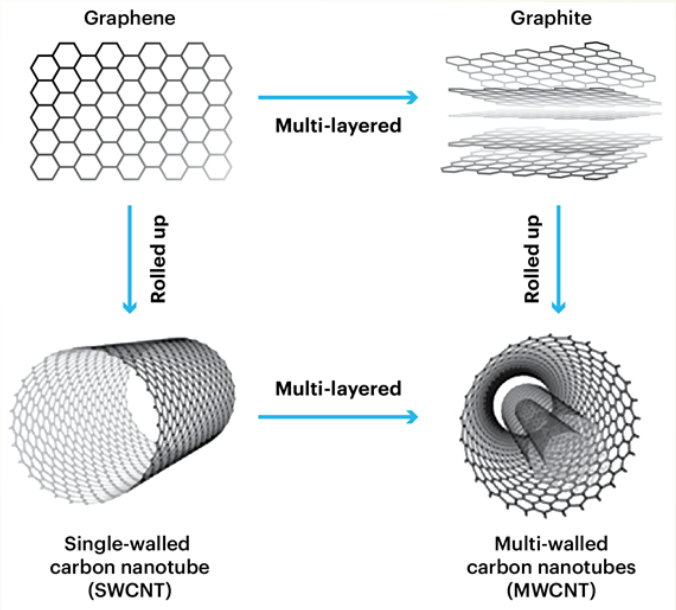
- *High thermal conductivity*
- *High electrical conductivity*
- *CNTs aspect ratio*
- *CNTs have very high tensile strength*
- *CNTs are highly flexible — can be bent considerably without damage*
- *CNTs have a low thermal expansion coefficient*
- *CNTs are good electron field emitters*

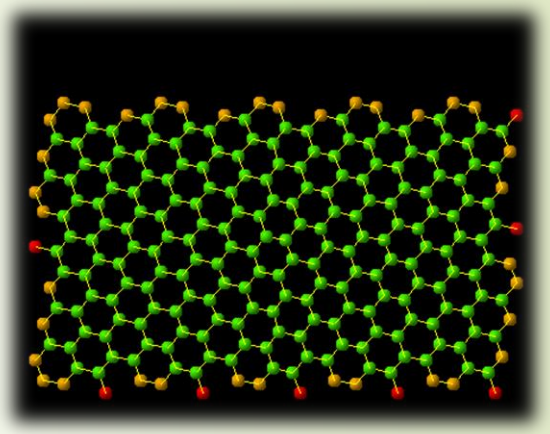
MWCNTs

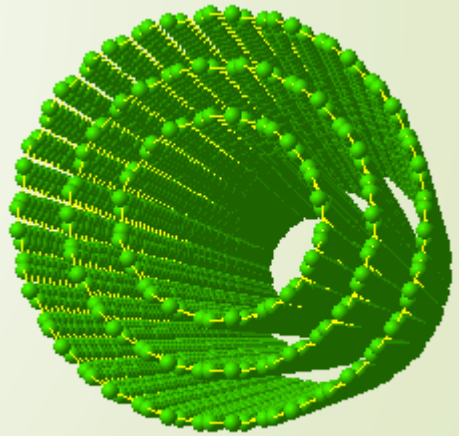


MWCNT

- ***Structure:*** *MWCNT consist of several layers of carbon forming concentric tubes. Each layer can be single-layered or multi-layered.*
- ***Diameter:*** *The diameter of MWCNT is usually larger than that of SWNT and can reach several tens of nanometers.*
- ***Mechanical properties:*** *MWCNT have high mechanical strength and elasticity due to their structure.*

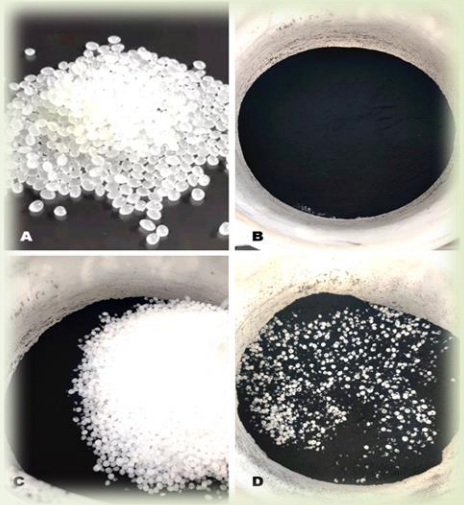






Preparations Nanocomposites

- All materials were previously vacuum dried for 5 h. The indirect technique was applied for mixing; polyesters and MWCNTs were stirred manually before it was blended in the extruder.



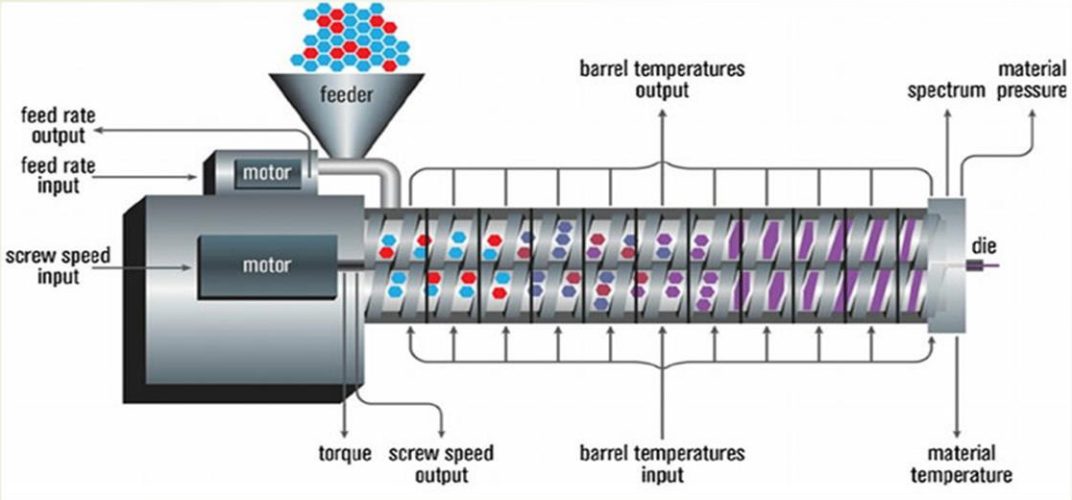
- Polyesters masterbatches with 5wt.% MWCNTs were prepared by using twin screw extruder.

- The polyesters nanocomposites were prepared by melt mixing the masterbatch and pure polyesters pellets in the weight ratio of 20 / 80 using twin-screw extruder. Final products is known as like PET/1%MWCNT and so on.

Parameters

Twin screw extruder parameters

Materials	Screw speed rpm	Temperature °C
PLA	45-52	195-205
PBS	40-55	160-170
PET	34-55	270-280
PBT	46-65	250-260



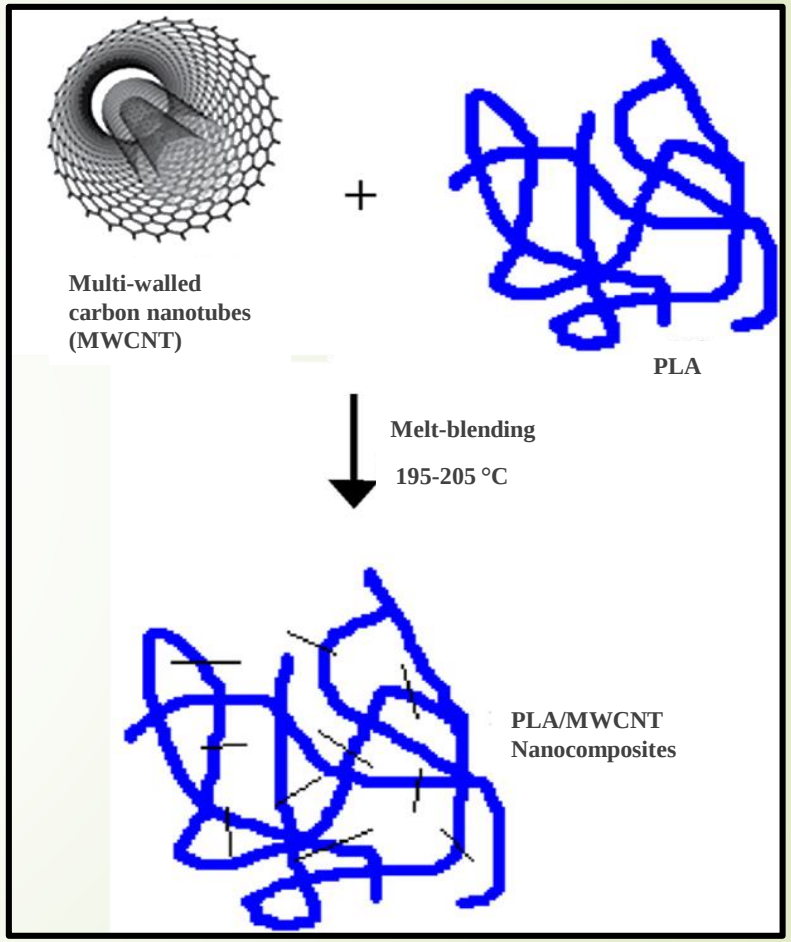
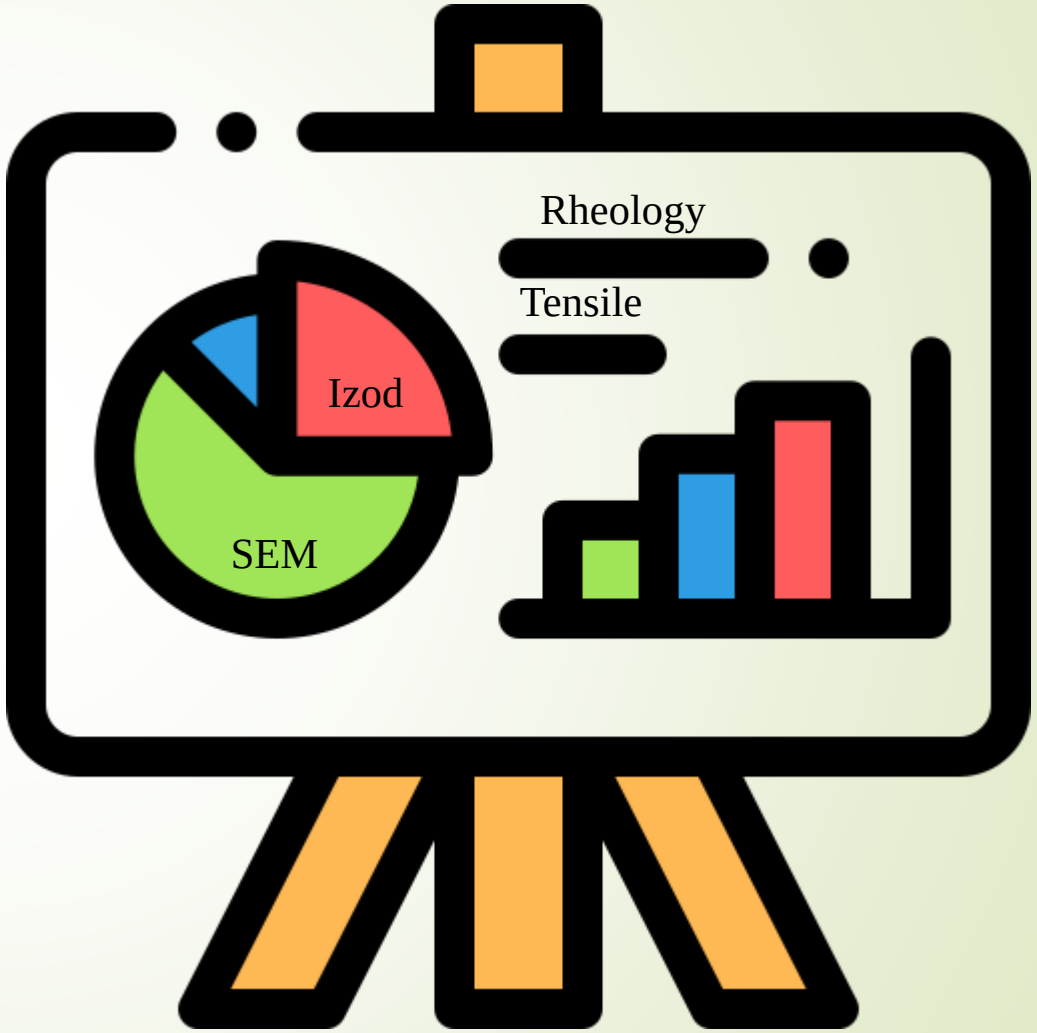
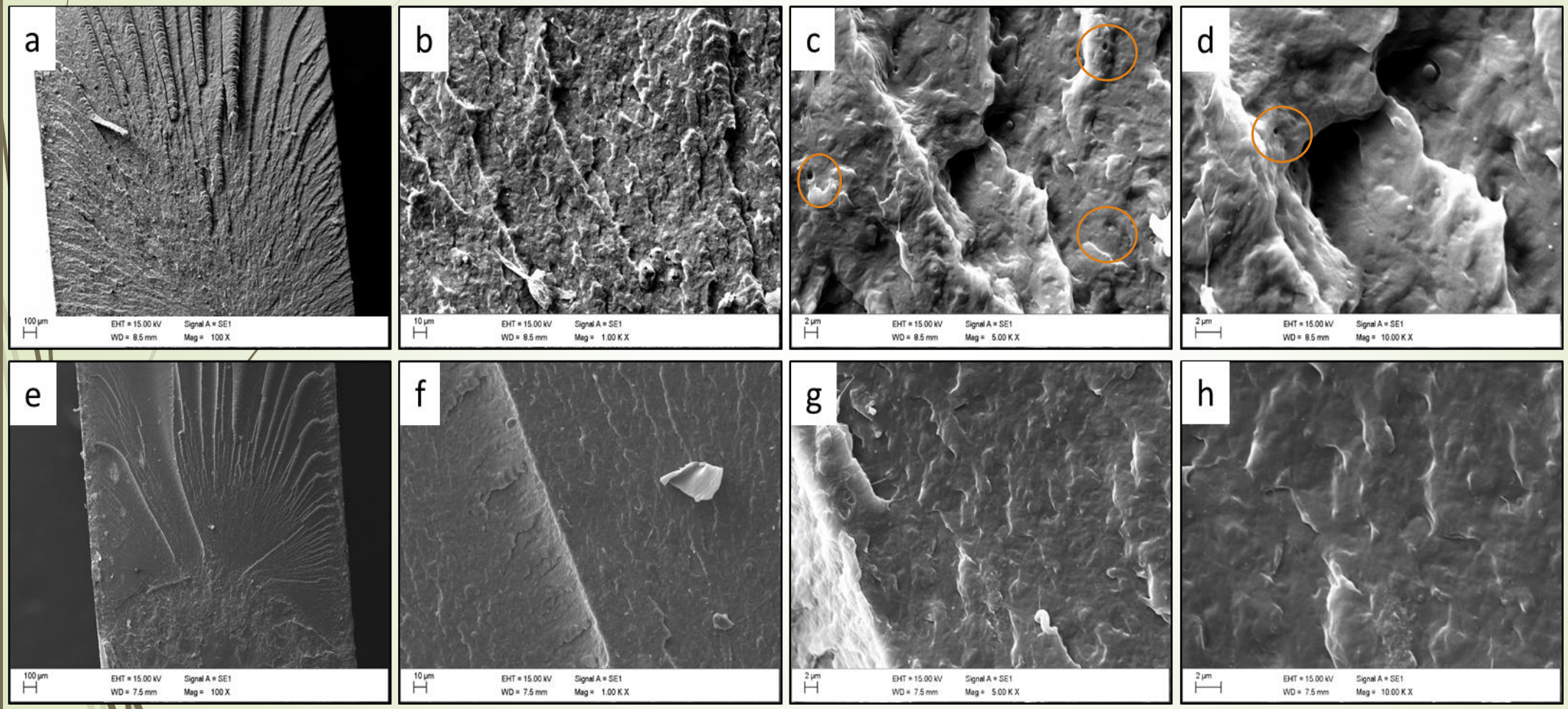


Illustration of melt-blending process for PLA

Results



SEM

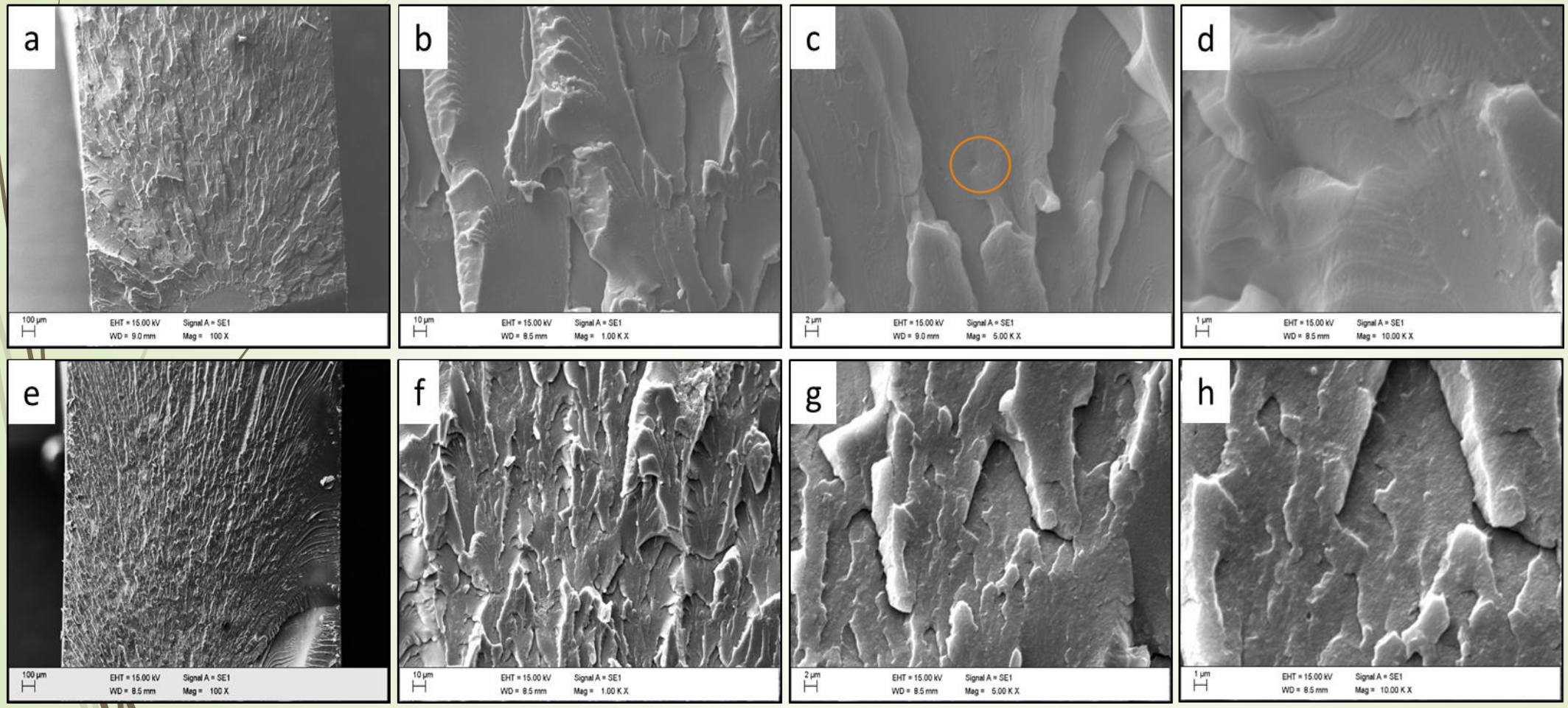


a-d) Neat PBS

e-h) PBS/1%MWCNT

Morphological Properties of PBS and PBS/1%MWCNT

SEM



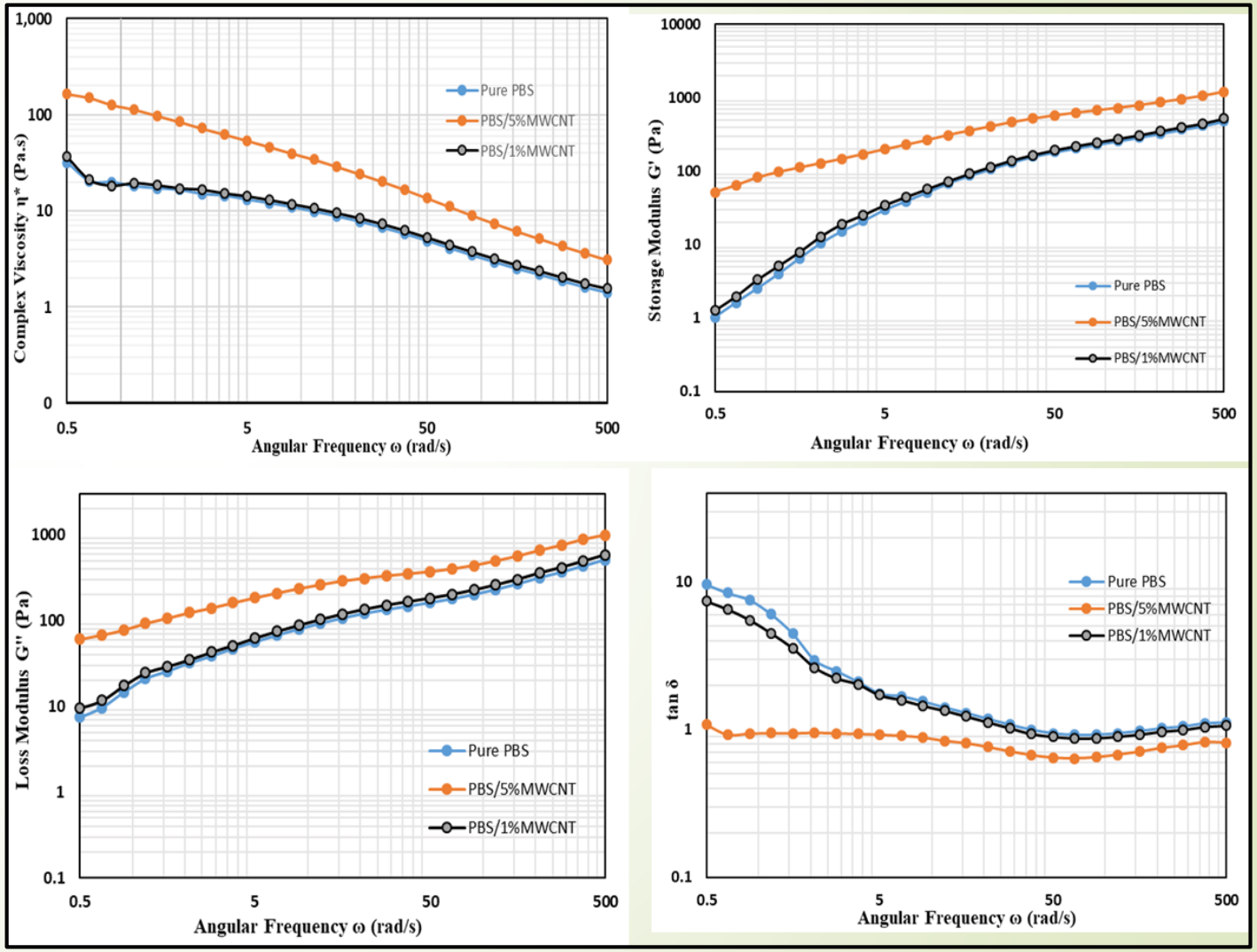
a-d) Neat PET

e-h) PET/1%MWCNT

Morphological Properties of PET and PET/1%MWCNT

Rheology

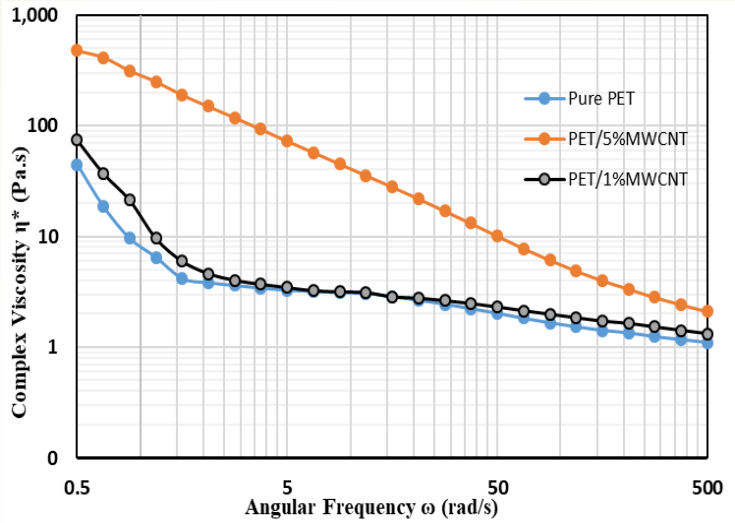
- At low angular frequency, there is a significant difference in the complex viscosity of neat PBS and PBS/5%MWCNT masterbatches.
- With the increase of angular frequency complex viscosity is decreases, which shows the non-Newtonian behavior of the materials.
- The tan δ values decreases with the increase of MWCNT content, which shows that the elastic properties were improved with the addition of MWCNTs.

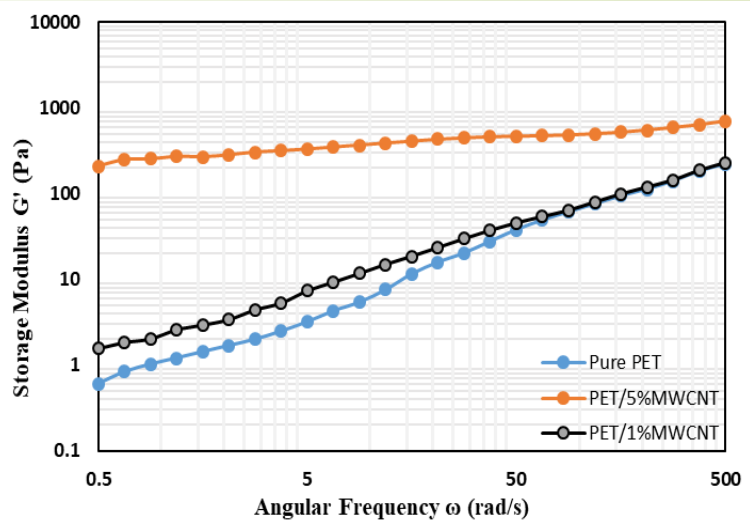


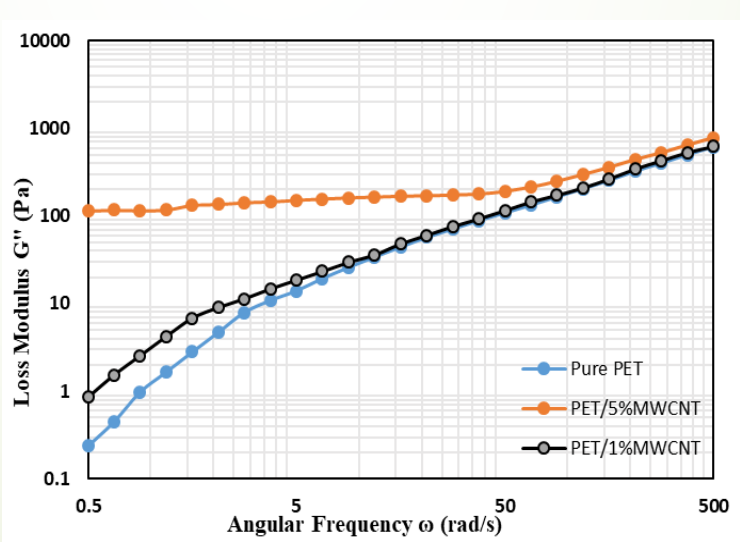
- Frequency dependence rheological properties of PBS and PBS/MWCNT nanocomposites.

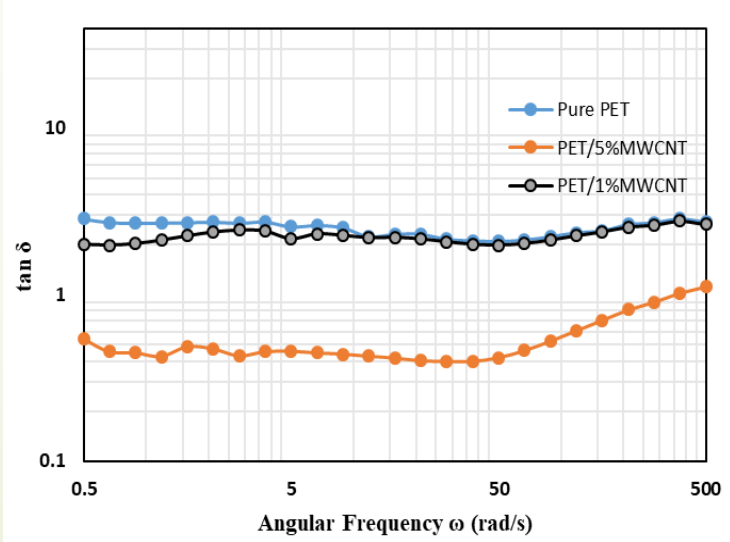
Rheology

- The high amount of MWCNT in the PET matrix shows the stronger shear thinning behavior.
- At low frequency, the stiffness of PET/MWCNT nanocomposites caused an increase in melt elasticity.
- The values of G’ and G” of nanocomposites are higher than the pure PET is due to the MWCNT-MWCNT and MWCNT-PET interactions leads to more elastic than the pure polyesters.





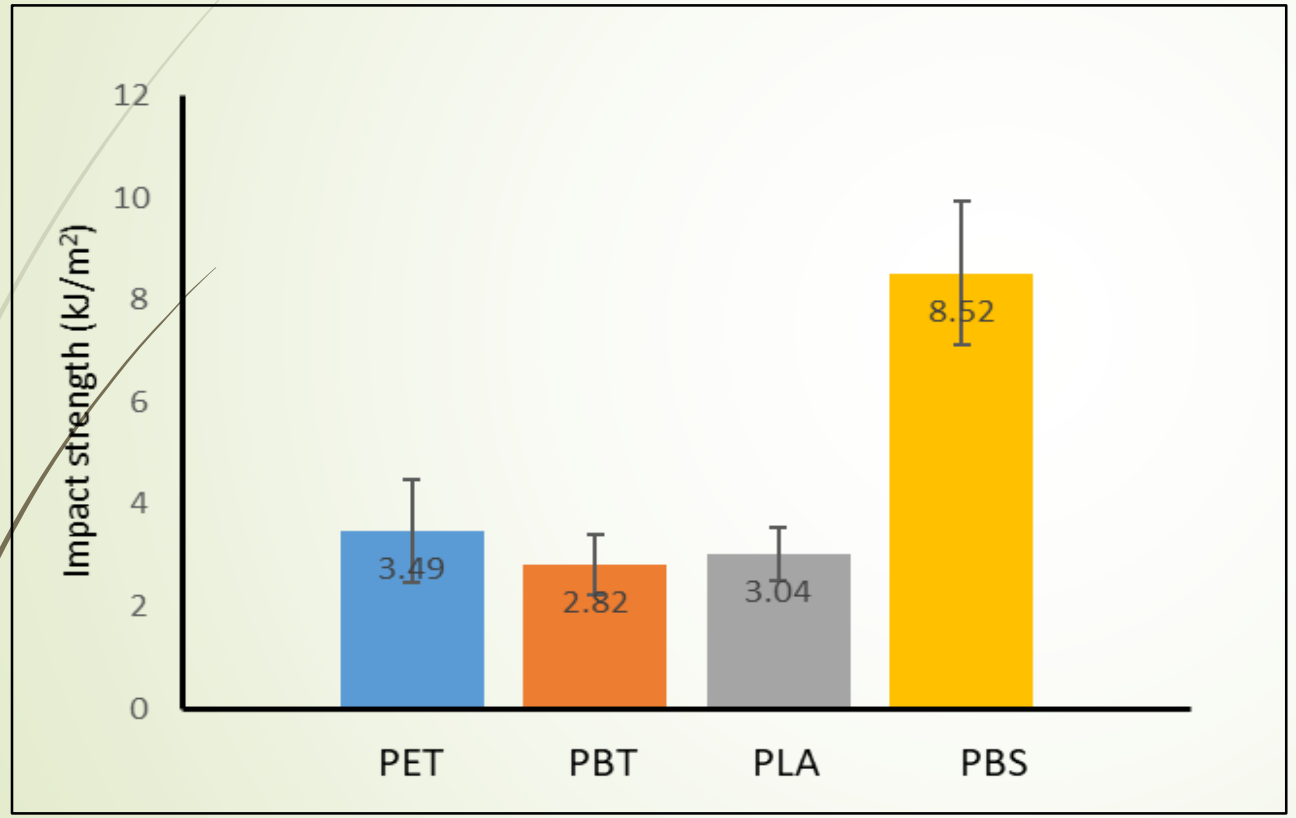




- Frequency dependence rheological properties of PET and PET/MWCNT nanocomposites.

Izod Impact Strength

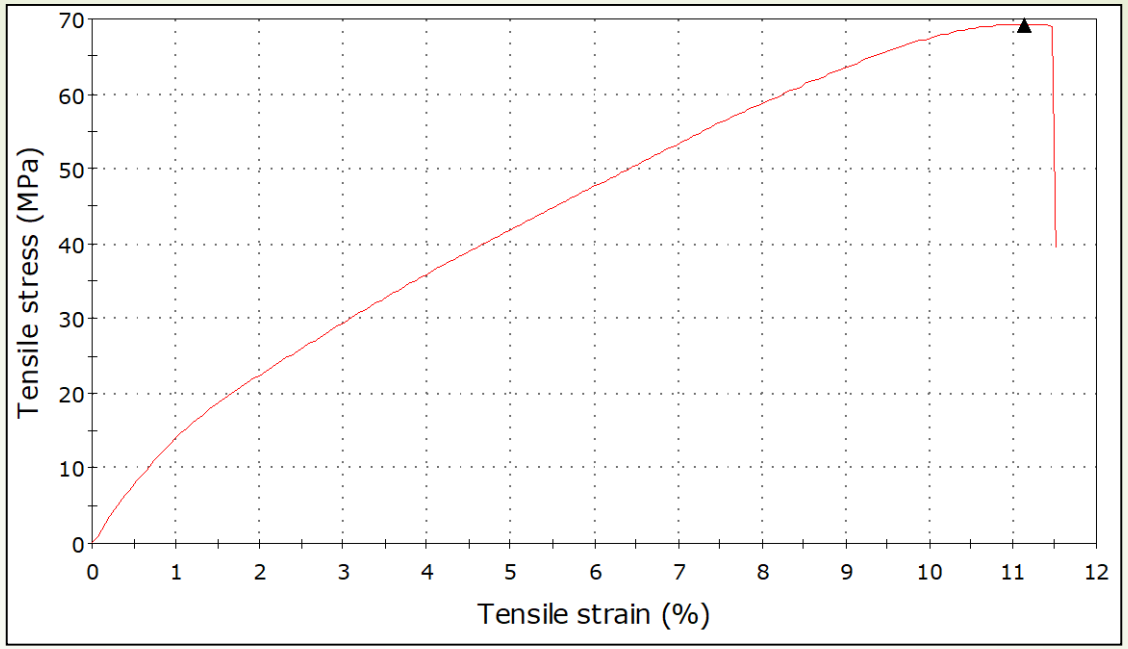
- Izod Impact strength of different polyesters/1%MWCNT nanocomposites.



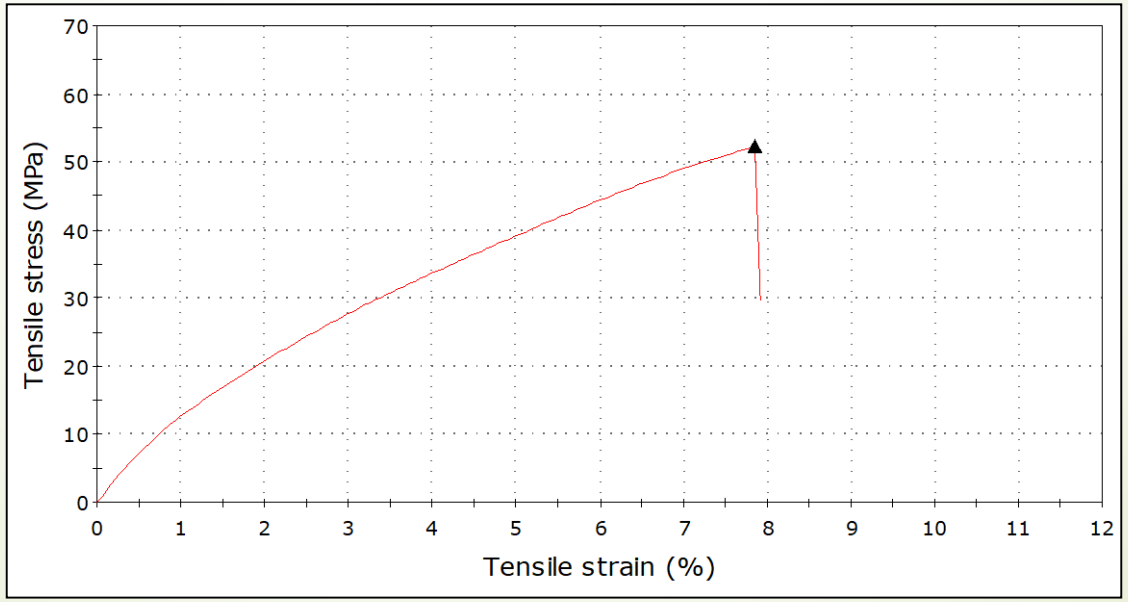
Izod impact: Zwick, 5113.100/01

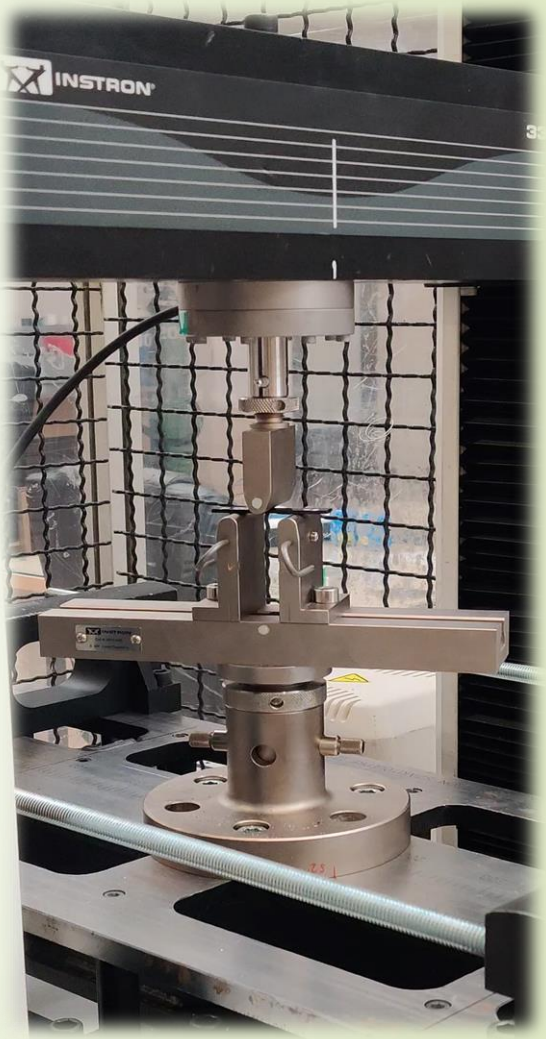
Tensile Properties

PET/1%MWCNT nanocomposites



PBT/1%MWCNT nanocomposites





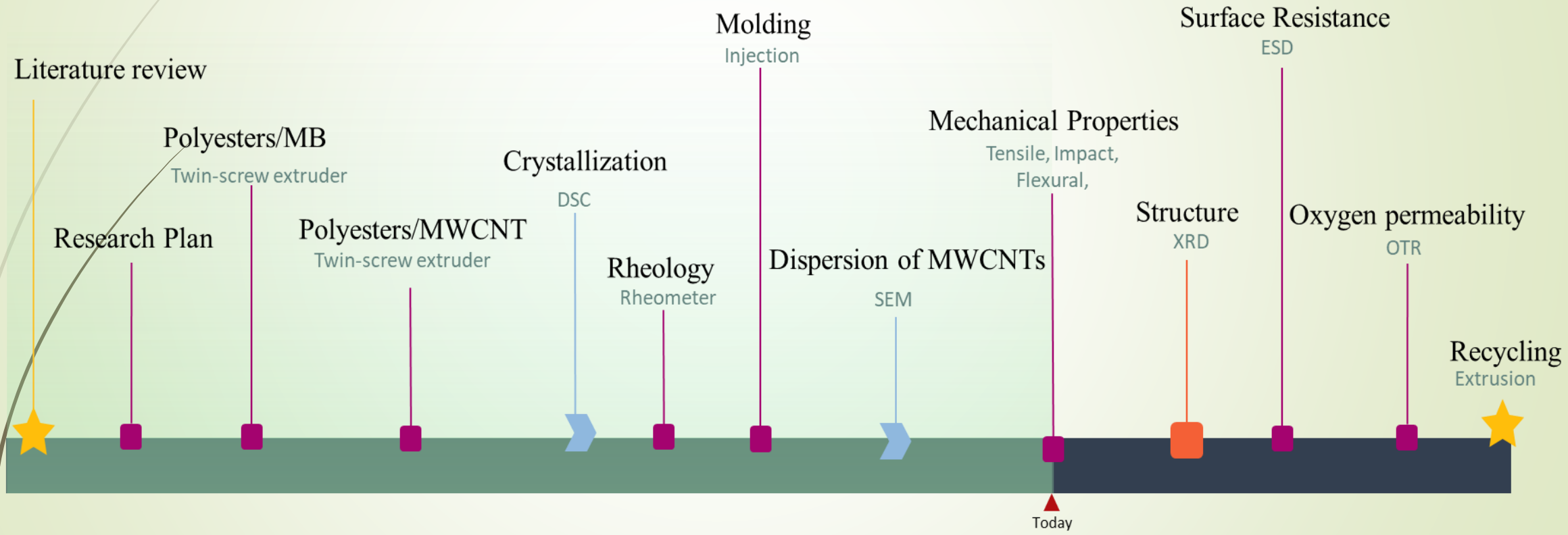
Universal mechanical tester, L3366

Conclusions

- ✓ **The incorporation of small amount of MWCNTs (1wt%) in the PBS matrix allows the surface smoother with small amount of voids because of the hydrophobic nature of PBS and non-polar properties of MWCNTs.**
- ✓ **The homogenous dispersion was achieved by the multiple extrusion as well as the extrusion parameters such as temperature, screw speed, and die diameter.**
- ✓ **The addition of MWCNTs induced elastic behavior of nanocomposites significantly in PET.**
- ✓ **Addition of high amount (5wt%) of MWCNTs in the polyester matrix can caused a significant change in the rheological properties.**
- ✓ **The impact strength of PBS is significantly different among other polyesters nanocomposites.**
- ✓ **The tensile properties of petroleum based polyesters have remarkable differences.**

Work plan

Work plan



Working Timeline

Activities

Research Activities

- **Publications:**

- **First article :** *Kashif Ullah Khan, Andrea Ádámné Major*, **Effects of CNTs on polymer matrix: a focused review with lasers,** *Gradus*, https://doi.org/10.47833/2024.1.ENG.004
- **Second article :** *Kashif Ullah Khan, Andrea Ádámné Major*, **A comprehensive review on polyesters loaded with MWCNTs,** (Publication in process)
- **Third article :** *Kashif Ullah Khan, Andrea Ádámné Major, Ferenc Ronkay,* ***Rheological*** **and morphological properties of petroleum- and bio-based polyesters MWCNTs nanocomposites**, (Publication in process)

- **Conferences:** I have participated in several conferences.

Oral presentations

- 11th International scientific and expert conference of the international TEAM society 2024 (Ostrava, Czech Republic),TEAM2024.
- 5th International Conference on Bio-based Polymers and Composites (Esztergom, Hungary), BiPoCo 2024.
- 25th Scientific Conference Organized by the John Von Neumann University in the frame of the Hungarian Science Celebration (Kecskemét), AGTECO 2024.

Teaching Activities

- I taught chemistry as a Assistant lecturer at **John von Neumann University.**
- Aside from lectures, I had also taken laboratory lessons.

B.Sc. Students of Vehicle Engineering

Thanks for your Attention