EXPERIMENTAL INVESTIGATION OF THE MECHANICAL AND TRIBOLOGICAL BEHAVIOR OF Al2O3-MgO REINFORCED EPOXY COMPOSITES

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DEPARTMENT of METALLURGY and MATERIALS SCIENCE ENGINEERING

SUMMARY

In this study, Al_2O_3–MgO reinforced epoxy composites were investigated using tensile, bending, wear, and nanoindentation tests. The results show that hybrid reinforcement improves mechanical strength, deformation behavior, and wear resistance compared to pure epoxy.

INTRODUCTION

Epoxy resins are widely used but limited by their brittle behavior and low wear resistance. To improve these properties, Al_2O_3 and MgO reinforcements are added, where Al_2O_3 increases hardness and MgO enhances interfacial bonding. This study aims to determine how different MgO ratios affect mechanical and tribological performance and to identify the optimum composition.

METHODOLOGY

Al_2O_3–MgO reinforced epoxy composites were fabricated using epoxy resin and hardener together with Al_2O_3 and MgO particles as reinforcements. The required amounts of Al_2O_3 and MgO were weighed according to selected ratios and added to the epoxy resin. The mixture was initially hand-mixed, followed by magnetic stirring to ensure uniform particle distribution. After obtaining a homogeneous mixture, the hardener was added and mixed thoroughly. The mixture was then poured into molds and cured at room temperature to obtain composite specimens. The prepared samples were subjected to tensile, three-point bending, wear, and nanoindentation tests.

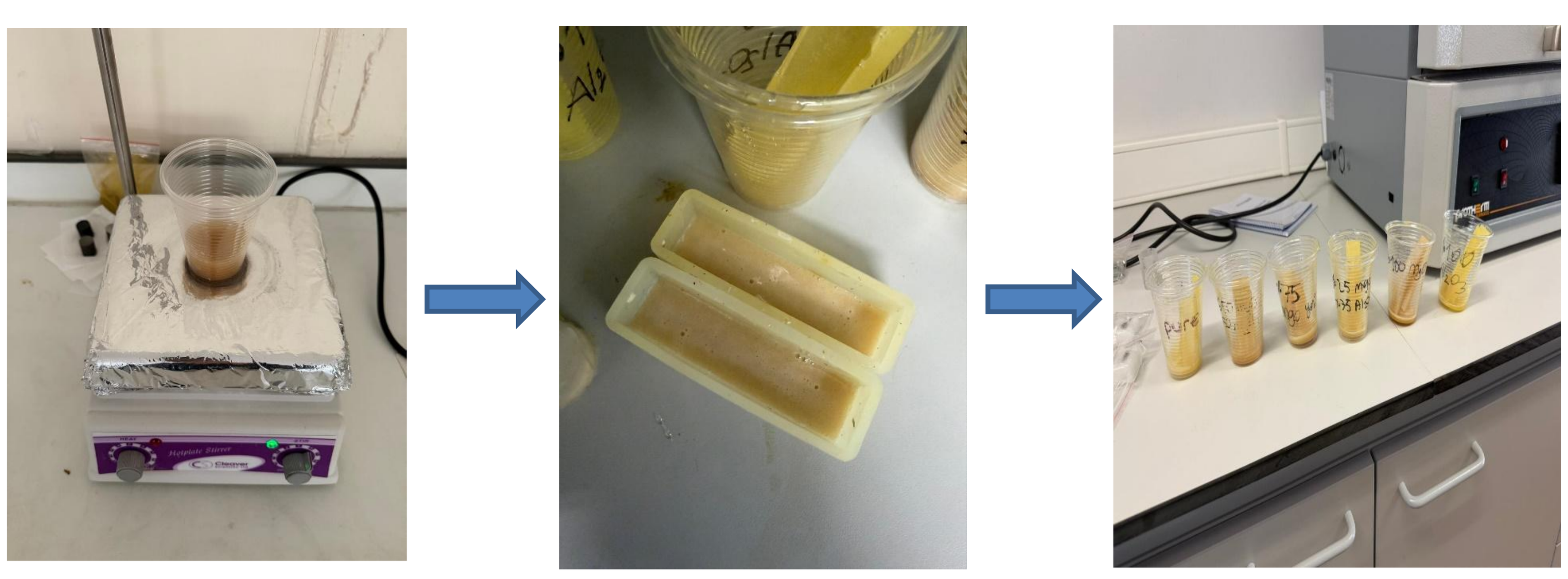

Figure 4. The procedure for producing Al_2O_3-MgO reinforced epoxy polymer composites

OBJECTIVE

The aim is to evaluate the effect of different Al_2O_3–MgO ratios on composite performance and determine the optimum reinforcement level.

RESULTS

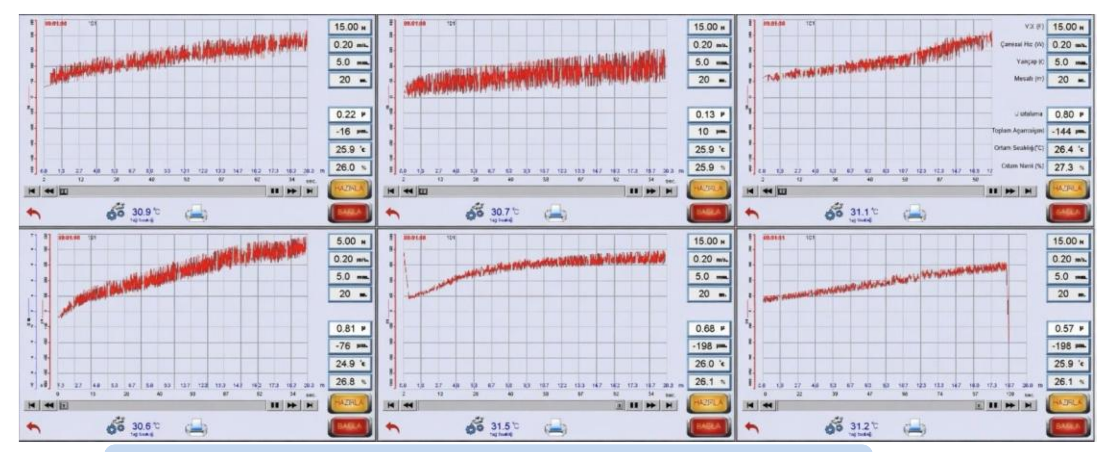

Figure 1 Coefficient of friction results

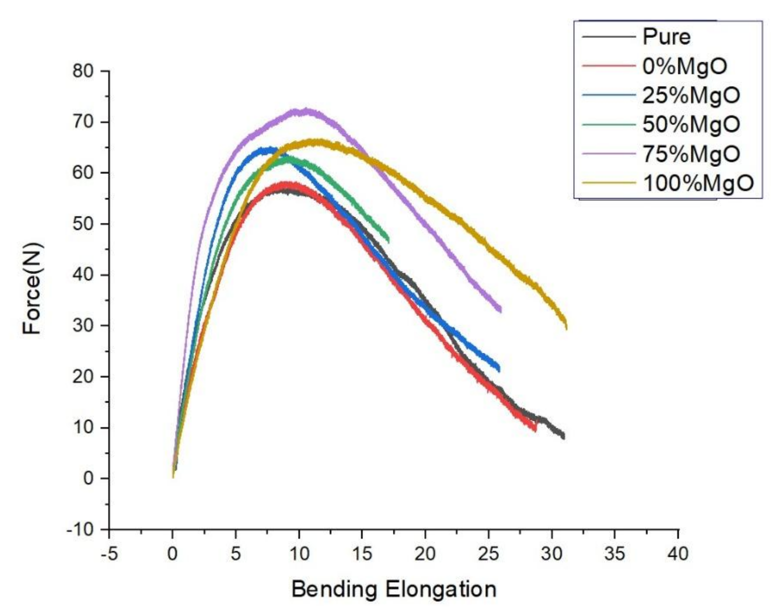

Figure 1. Three point Bending Test Results

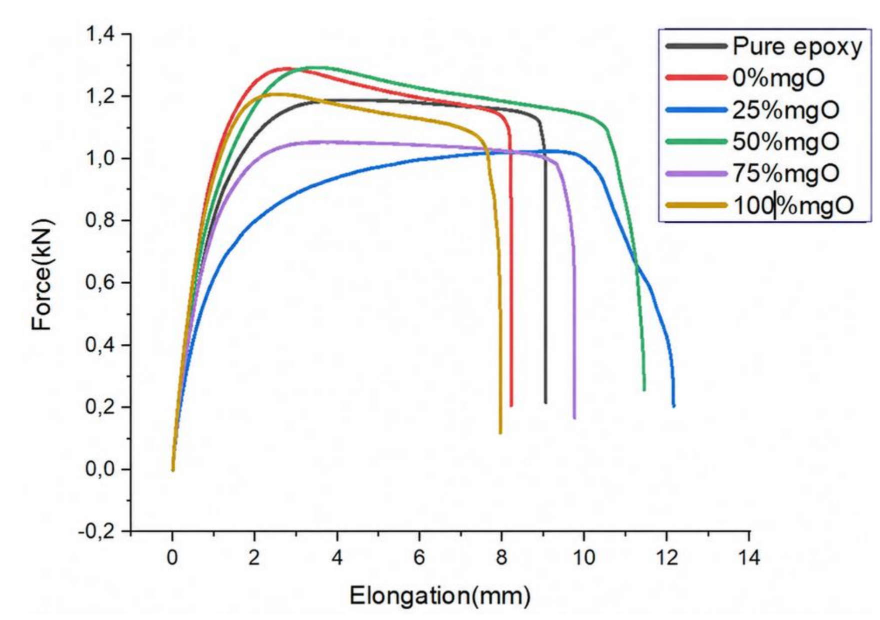

Figure 2. Tensile Test Results

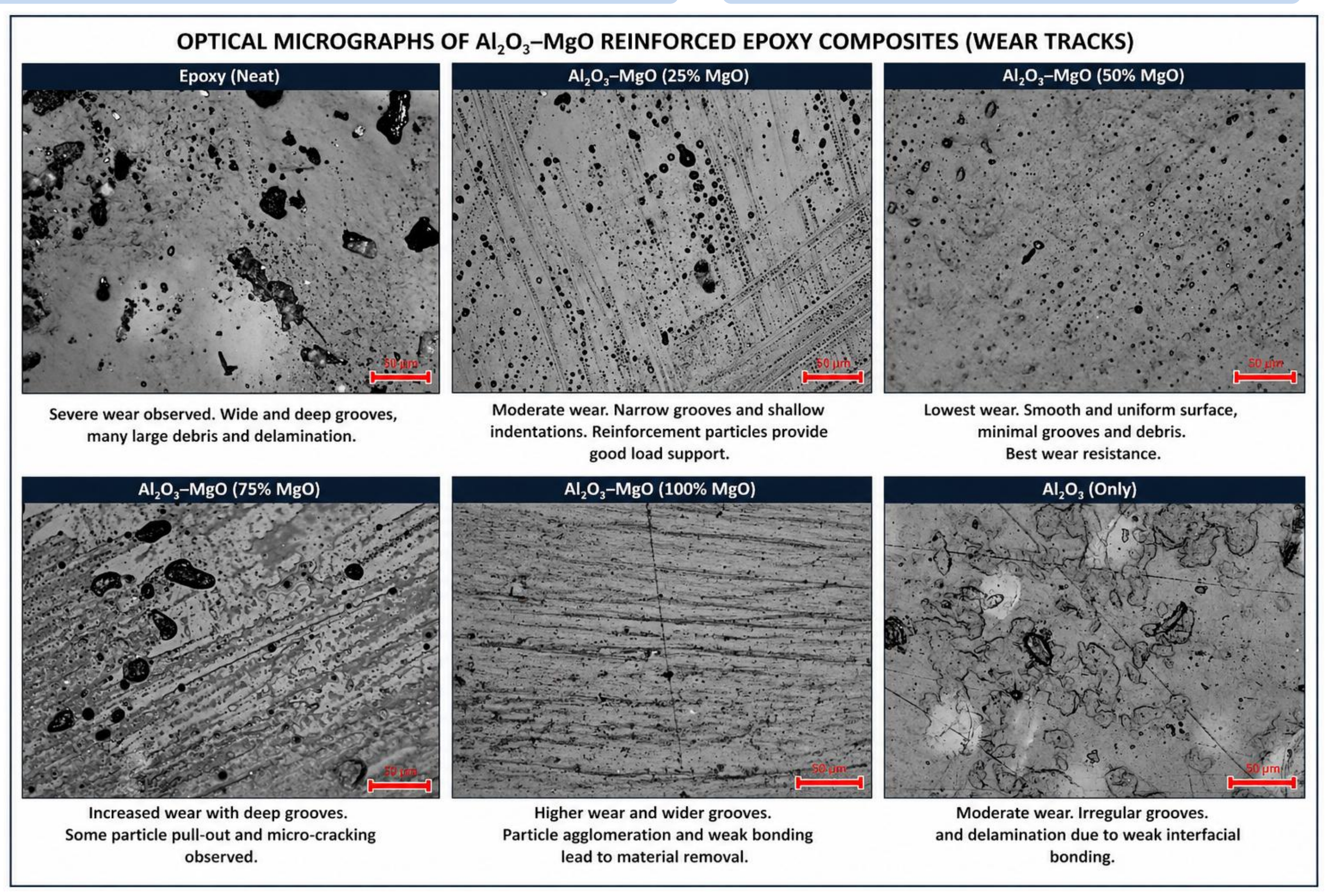

Table 3. 20x microscope images of Al_2O_3 -MgO reinforced Epoxy Polymer Composites

CONCLUSION

The results clearly indicate that MgO content has a significant effect on the mechanical and tribological properties of the composites. The 50% MgO sample exhibited the highest load-bearing capacity, showing the best tensile strength among all compositions. The 25% MgO sample showed the highest elongation, indicating improved ductility. Excessive MgO content (75% and 100%) led to reduced performance due to particle agglomeration and weak interfacial bonding. Overall, 50% MgO was determined as the optimum composition, providing the best balance between strength and deformation behavior.

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Multipurpose Alloy Electrodes via Electrodeposition from Ionic Liquids: Bridging Electrochromism, Flexibility and Energy Storage

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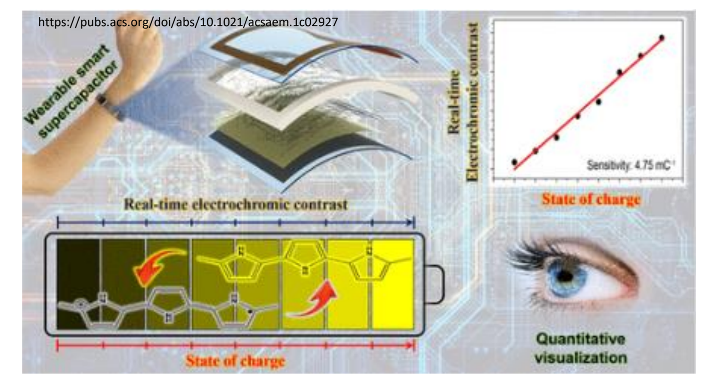
SUMMARY

Multipurpose CoNi electrodes were electrodeposited from an ionic liquid.
CoNi on ITO showed redox activity with slight electrochromic color change.
The system was further explored for flexible energy storage applications.
CoNi-coated polyester exhibited clear electrochemical activity in KOH.
The results highlight potential for flexible, multifunctional energy storage systems.

OBJECTIVE

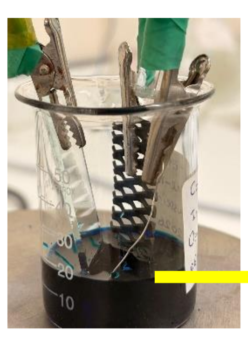
To develop and understand multipurpose CoNi-based electrodes electrodeposited from an ionic liquid by evaluating their electrochromic response, flexibility, and electrochemical energy storage behavior.



INTRODUCTION

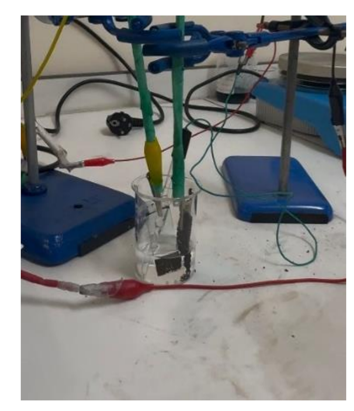
Flexible electrodes are important for lightweight, bendable, and wearable energy storage devices, and are also widely used in sensors and flexible electronic systems. Their mechanical adaptability enables integration into next-generation technologies such as wearable devices and smart textiles. Electrochromic materials add further functionality by showing reversible color changes under applied voltage, enabling applications in smart displays and visual monitoring systems. Therefore, combining flexibility, electrochromism, and energy storage in a single electrode platform represents a promising strategy for developing multipurpose smart materials.

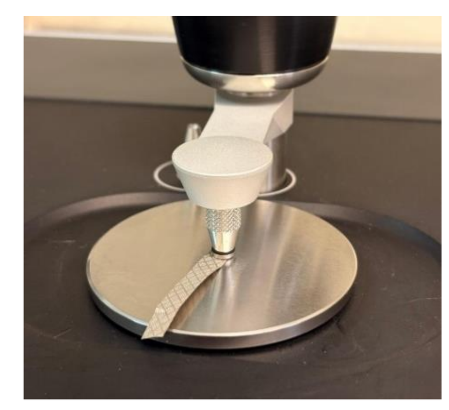
METHODOLOGY


Electrodeposition

CoNi coated ITO

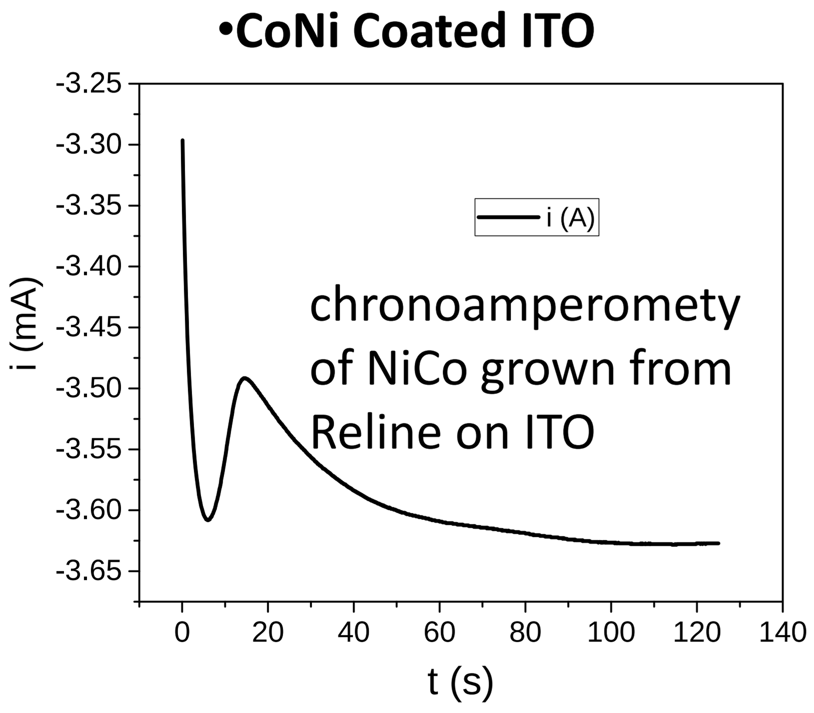
- **Electrolyte:** Ethylene Glycol and Urea were mixed in a 2:1 molar ratio at 67°C to synthesize Reline Deep Eutectic Solvent.
- **Electodeposition:** Potentiostatic −1.8 V was applied by means of three electrode system
- **Trials:** Coatings were deposited on ITO and polyester
- **Characterisation:** FTIR, microscopy, energy storage


CoNi cycling in KOH

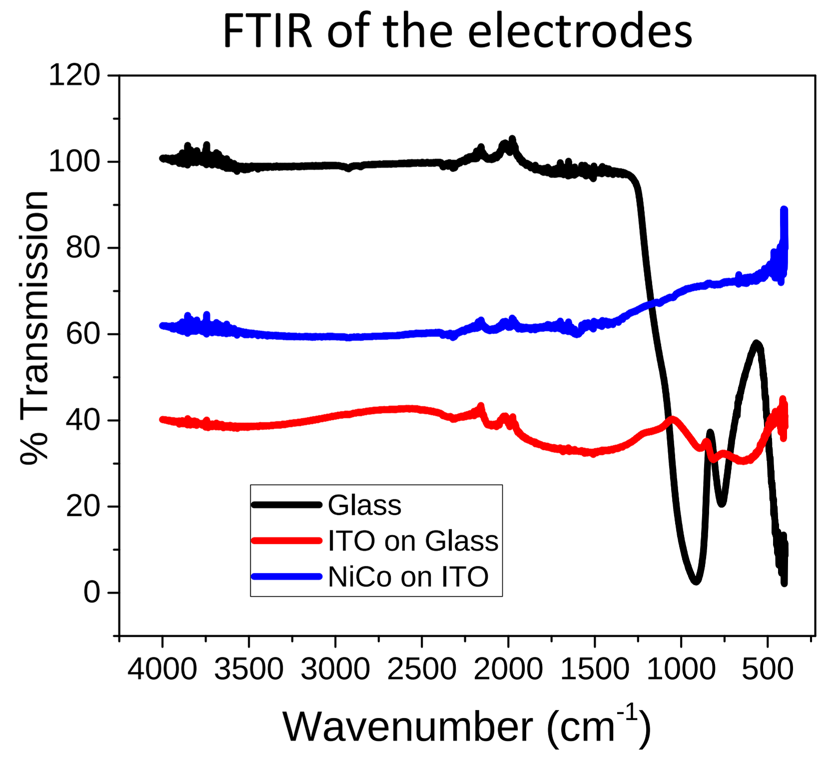

FTIR Analysis

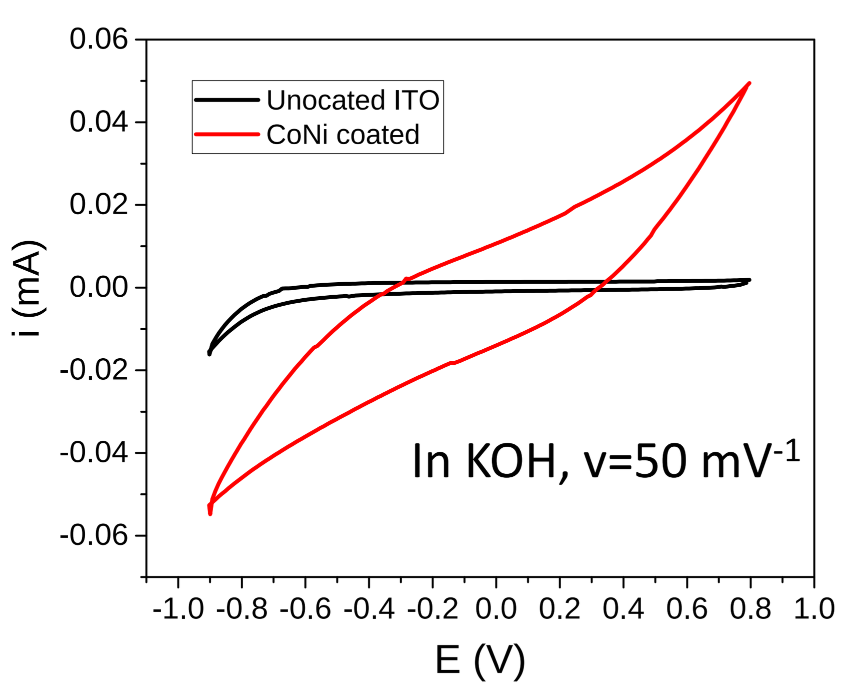
RESULTS/FINDINGS

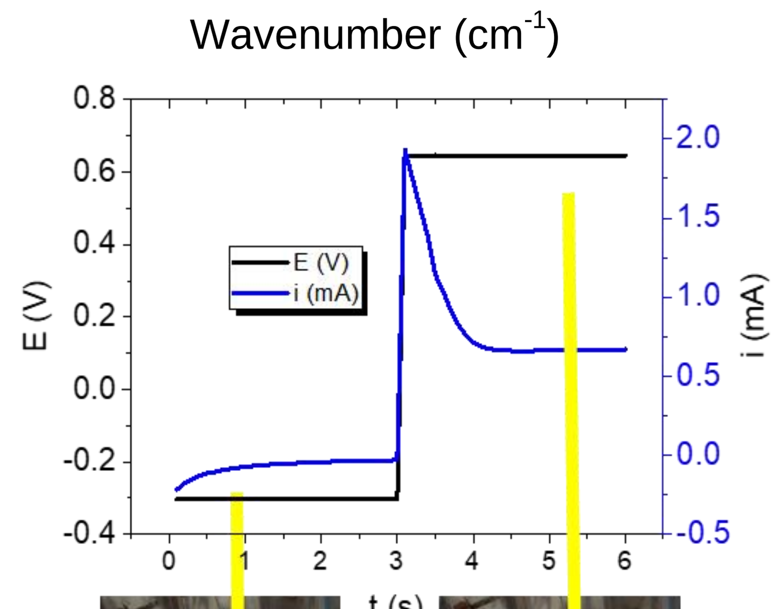
CoNi Coated ITO

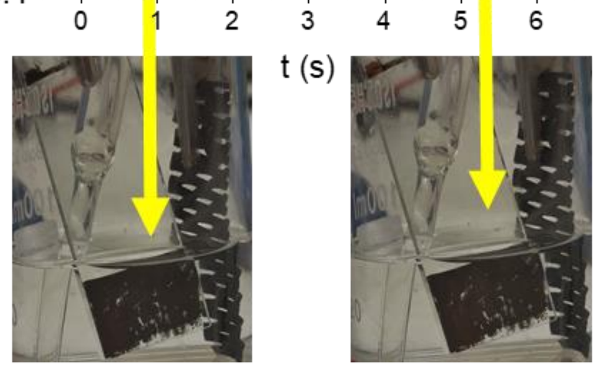


FTIR of the electrodes





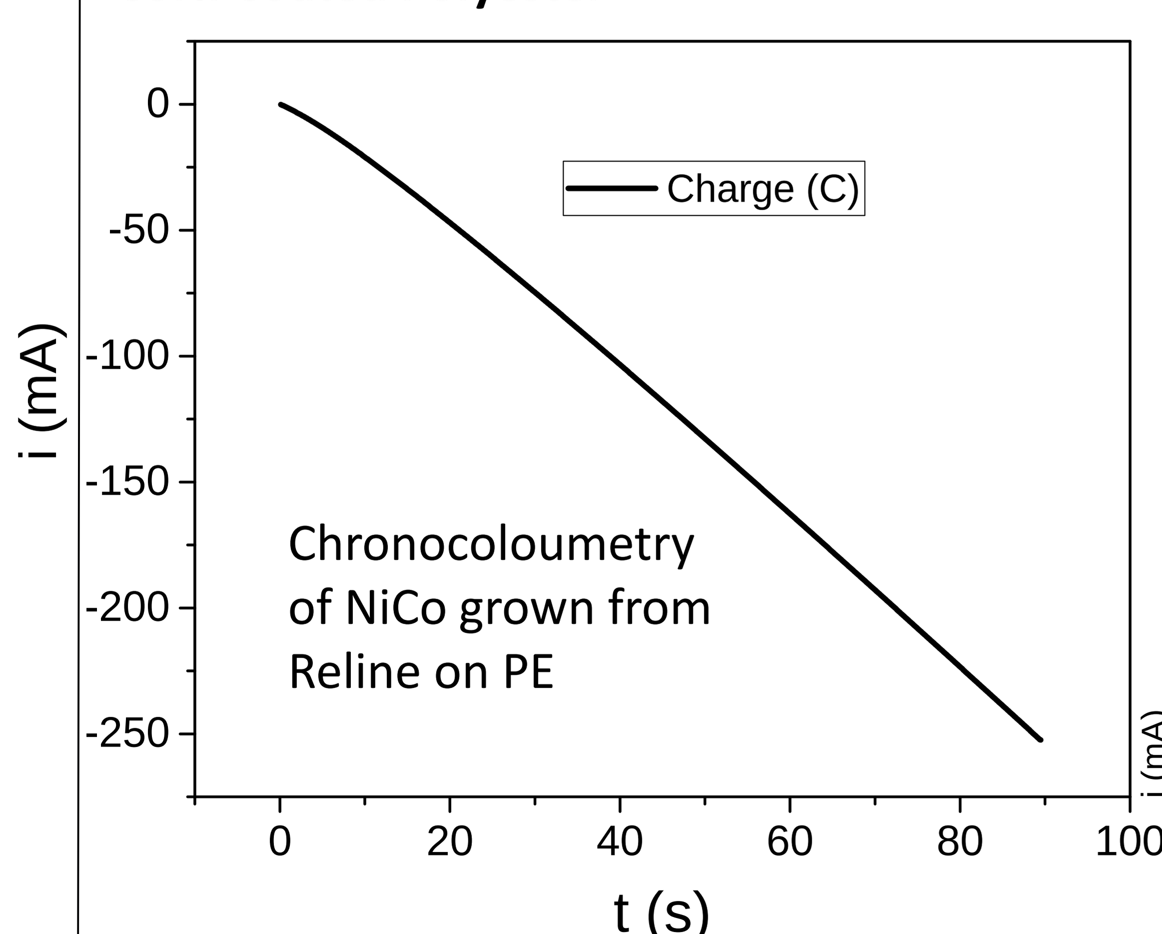


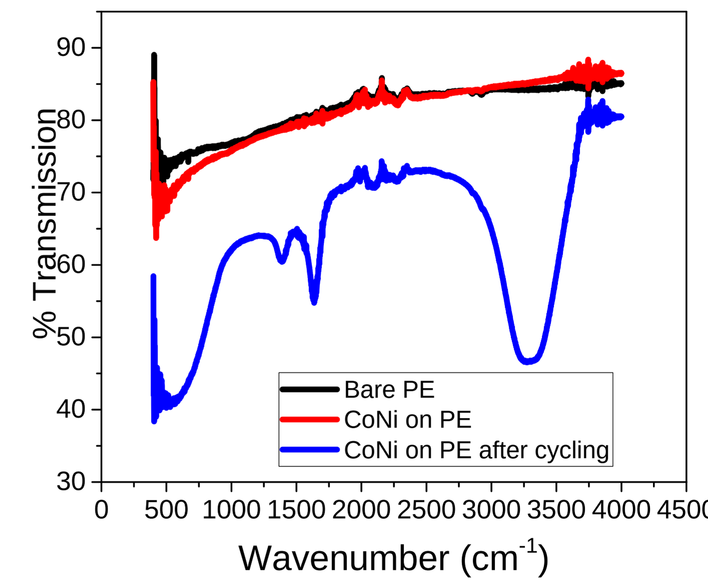


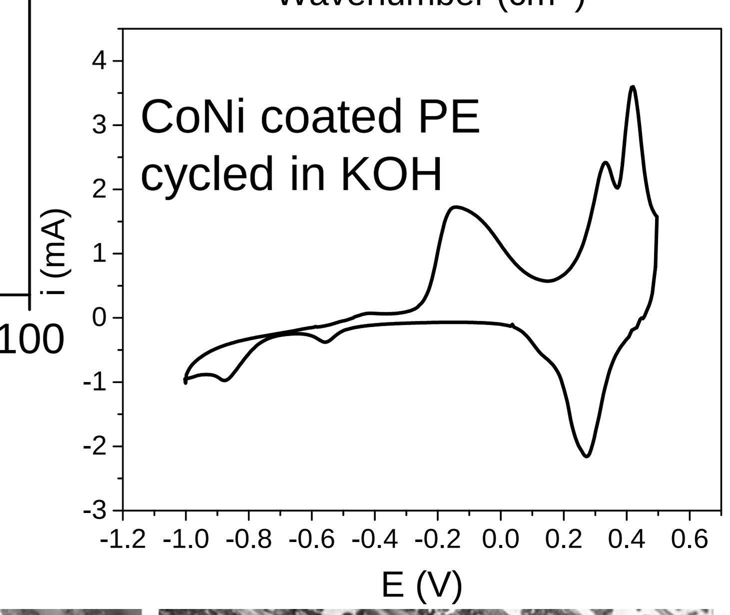
Electroactive CoNi electrode was obtained

Slight colour change

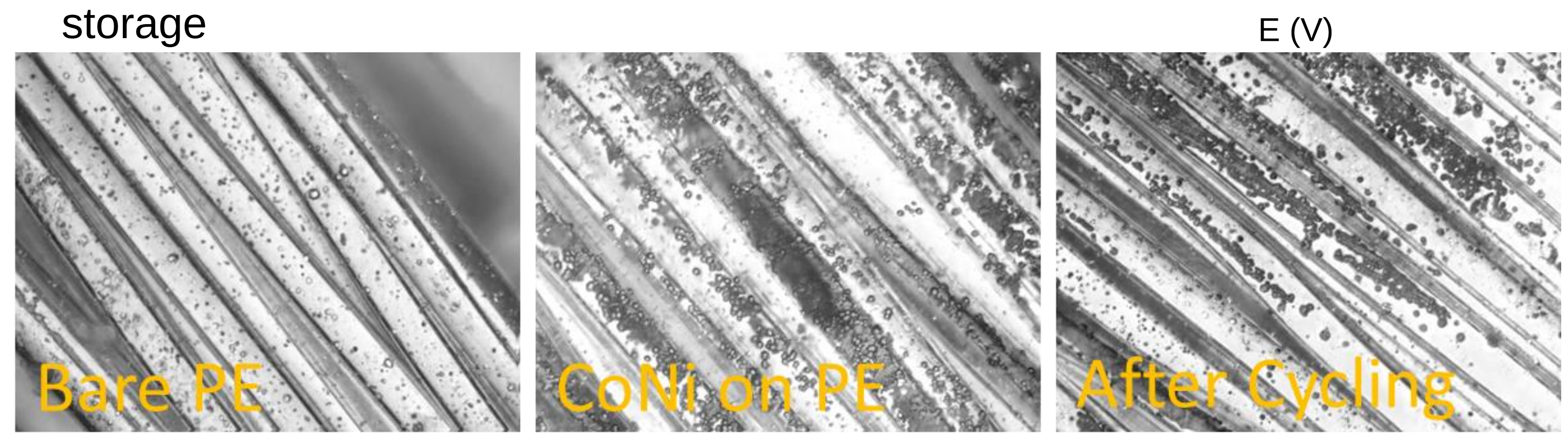
CoNi Coated Polyester







CoNi coated PE could be used as energy storage



Optical microscopy images of bare polyester (PE), Co–Ni coated PE, and the coated surface after electrochemical cycling.

CONCLUSION

- CoNi electrodes were successfully electrodeposited from an ionic liquid.
- The coating showed clear redox activity on ITO.
- A slight electrochromic color change was observed.
- This indicates limited but detectable electrochromic behavior.
- CoNi was also deposited on flexible polyester.
- The flexible electrode showed electrochemical activity in KOH.
- The results support its potential for energy storage applications.
- Overall, CoNi electrodes are promising for flexible, multifunctional smart systems.

RECOMMENDATIONS

- Optimize electrodeposition conditions and composition to enhance electrochromic response and color contrast.
- Investigate long-term electrochemical and mechanical stability of flexible electrodes under cycling and bending.
- Integrate the electrodes into prototype flexible devices for energy storage and sensing applications.

REFERENCES

Jiao, X., Li, G., Yuan, Z., & Zhang, C. (2021). High-performance flexible electrochromic supercapacitor with a capability of quantitative visualization of its energy storage status through electrochromic contrast. ACS Applied Energy Materials, 4(12), 14155-14168.

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ACKNOWLEDGMENT

I would like to express my sincere gratitude to my supervisor and the laboratory staff for their invaluable guidance and support throughout this research project.

Engineering Faculty **Proje Arastası** **2025-2026 Spring**

MITIGATION OF LAYER DELAMINATION AND THERMAL DEBINDING OPTIMIZATION IN FFF-PRINTED 316L PARTS

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SUMMARY

Green specimens were FFF-printed using BASF Ultrafuse 316L filament. Layer separation was eliminated under the tested conditions by maintaining the closed chamber at 50 °C. DTA–TGA–DTG analysis was used to define a pre-thermal-debinding schedule up to 310 °C.

INTRODUCTION

Metal–polymer fused filament deposition (FFF) enables the production of 316L stainless steel green parts before debinding and sintering. This study investigates whether controlled chamber heating can reduce layer separation and whether DTA–TGA–DTG analysis can guide a preliminary thermal debinding schedule for printed 316L specimens.

OBJECTIVE

This study aims to improve the printability of BASF Ultrafuse 316L filament by eliminating layer separation through controlled chamber heating and to define a preliminary thermal debinding schedule using DTA–TGA–DTG analysis to prevent blister formation.

Figure 3. Layer separation

METHODOLOGY

A closed-chamber FFF printer was used to fabricate green parts. The chamber was heated with a halogen lamp controlled by a dimmer circuit, while a thermocouple connected to a digital controller maintained the setpoint at 50 °C. The printed green sample was analysed by DTA–TGA–DTG, and the heating rates and dwell steps were selected based on the observed thermal transitions and mass-loss regions.

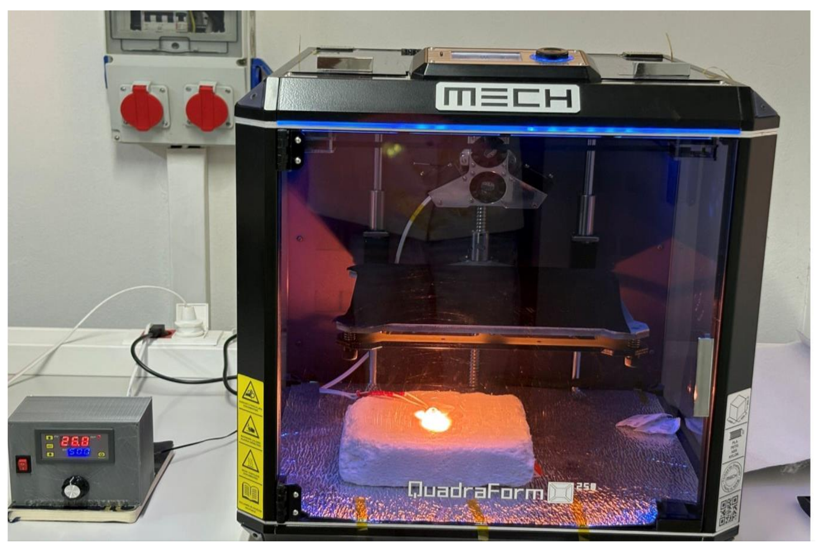

Figure 1.FFF Printer

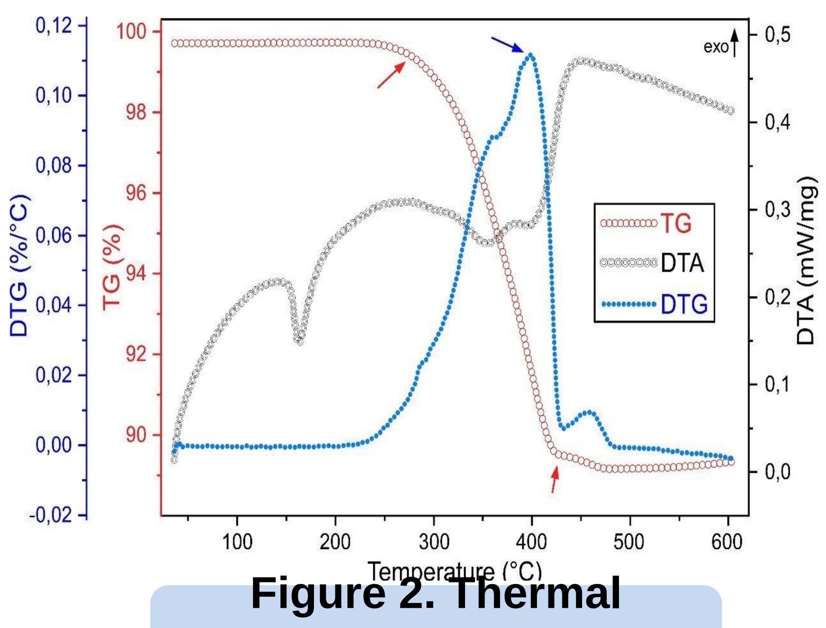

Figure 2. Thermal analysis of the printed green sample.

Start (°C)	End (°C)	Heating rate (°C/min)	Time (min.)	Dwell (min)
25	100	1.5	50	10
100	115	0.5	30	10
115	157	0.75	56	10
157	175	0.5	36	10
175	220	0.75	60	15
220	310	0.45	200	15

Table1. Pre-Thermal Debinding Schedule

Specimen	Green (g)	Brown (g)	Sintered (g)
MHLA	16,6215	11,2577	11,0155
MHCA	12,695	11,343	11,3350

Table2. Weight schedule

RESULTS/FINDINGS

- Successful Delamination Control: Maintaining a constant chamber temperature of 50 °C effectively eliminated layer separation in the green parts, ensuring high structural integrity and surface quality.
- Thermal Behavior Analysis: DTA–TGA analysis identified the critical binder degradation zones, showing a significant mass-loss region beginning at 150 °C and peaking between 310 °C and 405 °C.
- Optimal Debinding Efficiency: The pre-thermal debinding schedule (Table 1) successfully achieved an 89–90% residual mass by 310 °C without the formation of blisters or internal cracks.
- Controlled Mass Loss: Using a slow heating ramp (0.45 °C/min) during the final stage (220–310 °C) allowed for safe binder outgassing, preventing the structural defects typically caused by rapid thermal expansion.

Figure 4.green part

Figure 5. Brown part

Figure 6. Sintered part

CONCLUSION

At 50 °C chamber temperature, visible layer separation was prevented under the tested conditions. TGA showed about 89–90% residual mass, while the main mass-loss region continued above 310 °C with a DTG peak near 390–405 °C. Therefore, the 220–310 °C slow ramp was selected as a cautious pre-debinding step, requiring validation by mass loss and sintered part quality.

RECOMMENDATIONS

The effects of the size and geometry of the manufactured part should also be analyzed.

REFERENCES

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Engineering Faculty **Proje Arastası** **2025-2026 Spring**

SILICA-ALGINATE HYBRID BEADS FOR WASTEWATER TREATMENT

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SUPERVISOR: Assoc. Prof. Dr. DERYA KAPUSUZ YAVUZ

Department of Metallurgical and Materials Engineering

SUMMARY

Silica-alginate hybrid beads were synthesized, and the dyes we tested were evaluated for their potential in visual detection of wastewater adsorption. The effects of synthesis parameters such as syringe tip size, $CaCl_2$ and sodium alginate concentrations, and the addition of TEOS were investigated. The prepared beads were tested in different dye solutions to observe color changes and evaluate their potential for visual detection applications. After the beads were left to stand in the dye solutions, measurements were taken using a UV-Vis spectrophotometer.

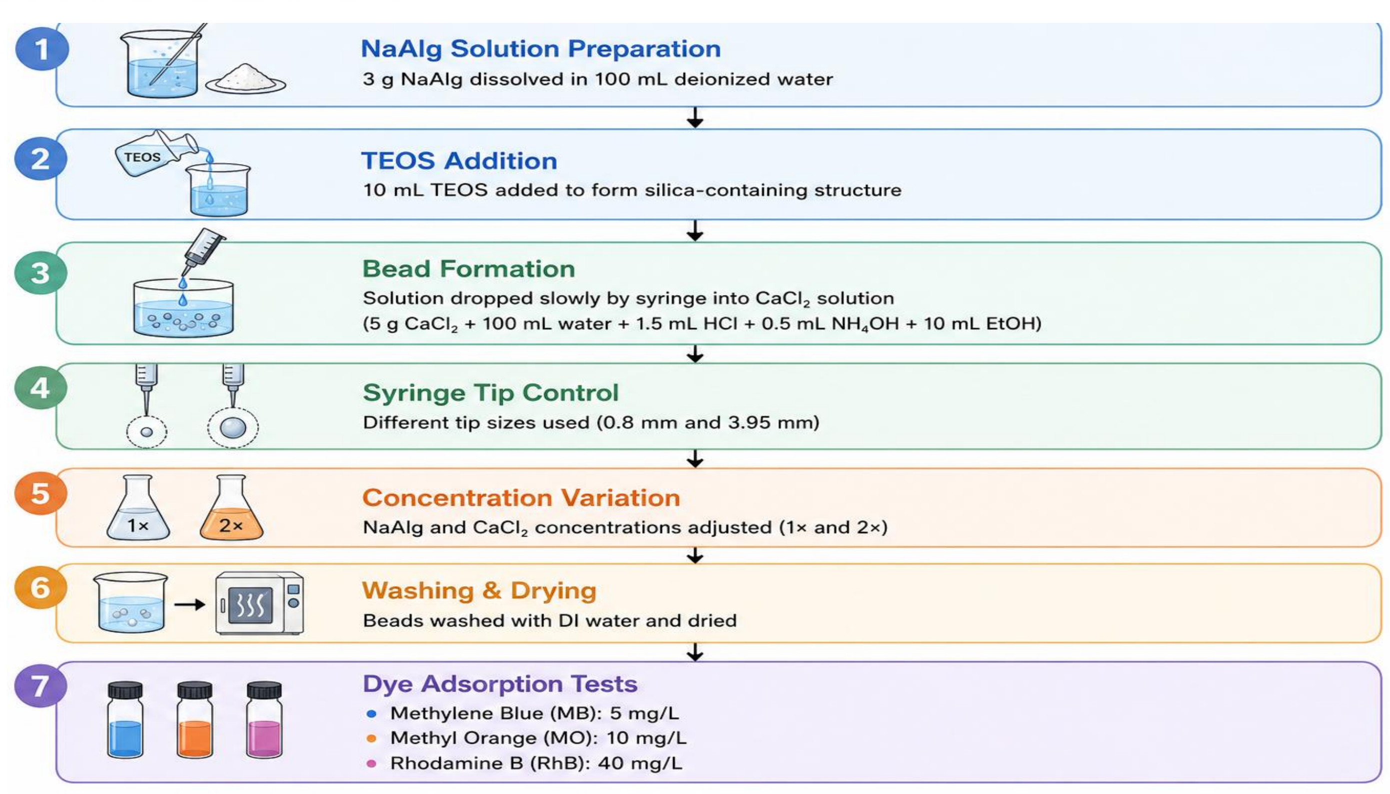
OBJECTIVE

- To produce stable silica-alginate hybrid beads
- To investigate the parameters affecting the size and structure of the beads
- To evaluate their adsorption capacities for textile dyes
- To observe the color change caused by the solution dropped onto the beads and to examine the beads' suitability for dye uptake

INTRODUCTION

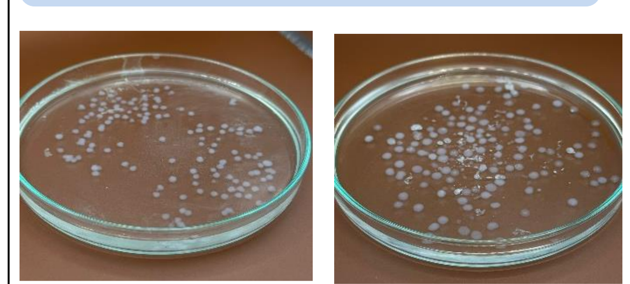
Textile dyes in wastewater pose a significant environmental problem. Adsorption is one of the most effective methods for removing harmful substances from aqueous solutions. Hybrid adsorbent materials have recently attracted significant attention due to their high adsorption efficiency, environmental compatibility, and low cost. Silica-based hybrid structures improve the stability and surface properties of alginate beads, making them promising materials for wastewater treatment applications. Sodium alginate is widely used due to its biocompatibility and ability to form gels with Ca^{2+} ions [1]. The incorporation of silica (via TEOS) into alginate beads can enhance their mechanical strength and adsorption performance. This study focuses on the development of hybrid beads and the analysis of their structural and functional properties [2].

METHODOLOGY



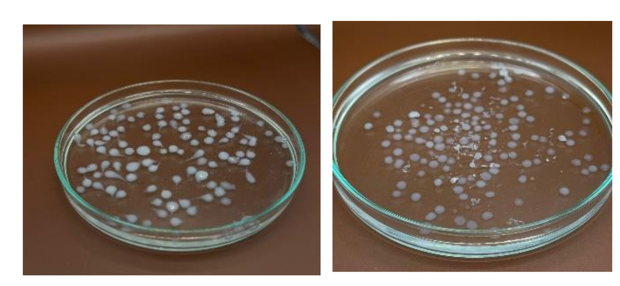
RESULTS/FINDINGS

Effect of TEOS Addition



-TEOS addition did not significantly affect bead size.

Effect of Syringe Tip Size

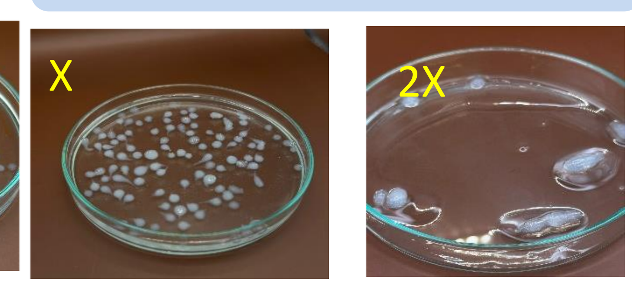


Large Tip (3.95 mm)

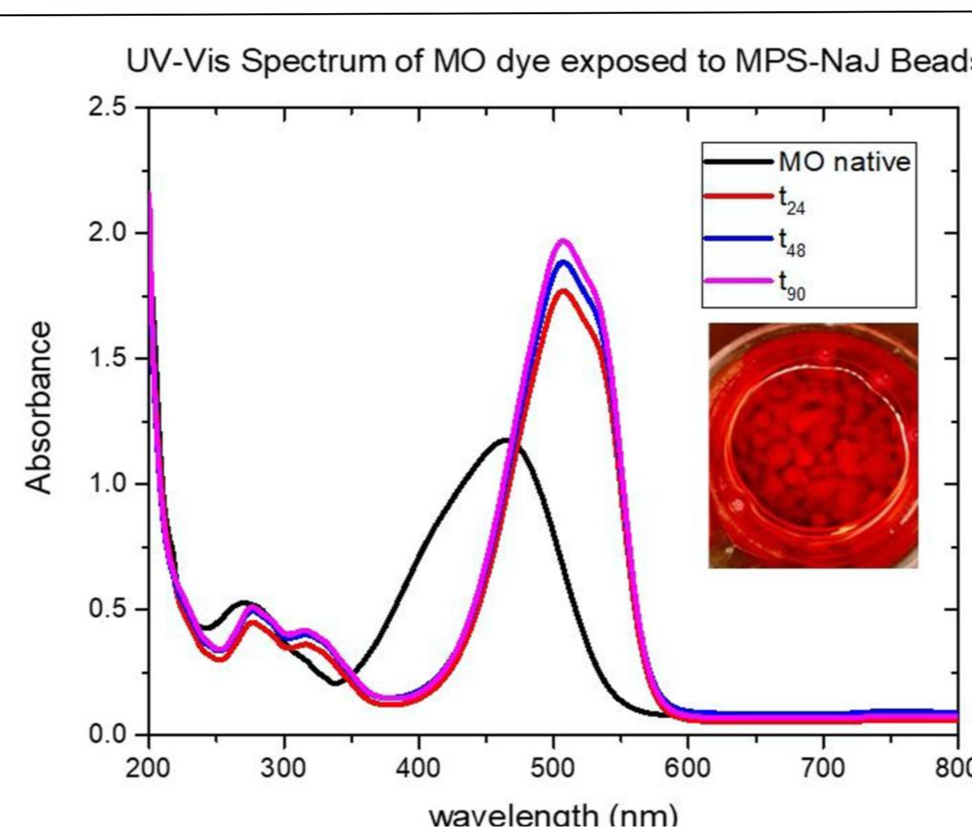
Small Tip (0.8 mm)

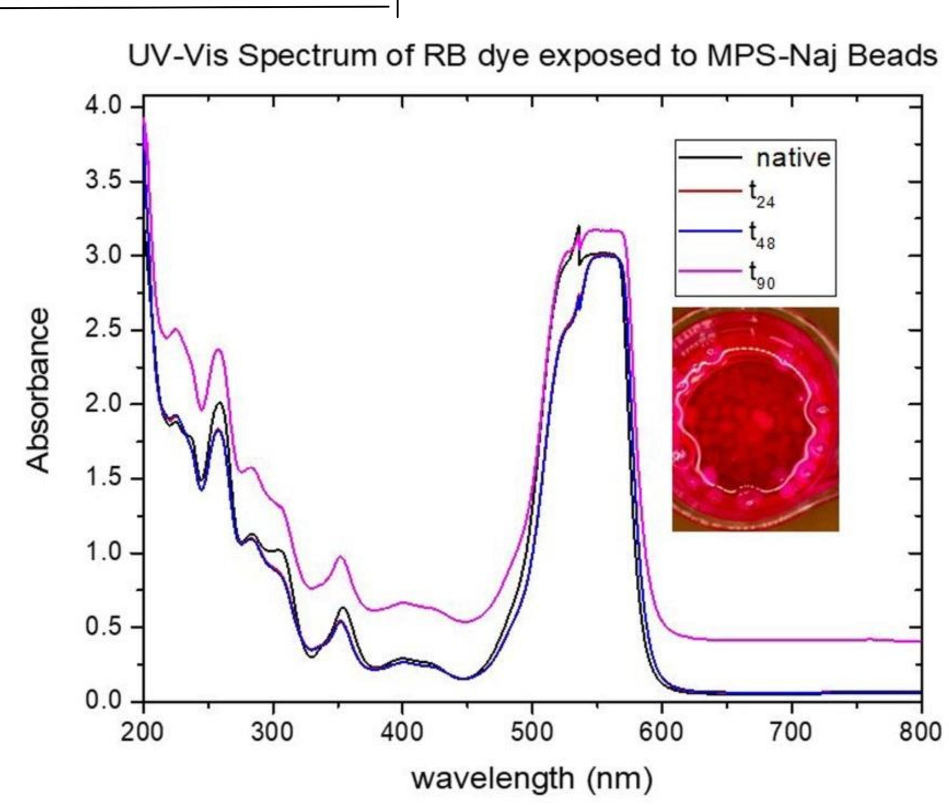
-Smaller tip produced smaller beads.

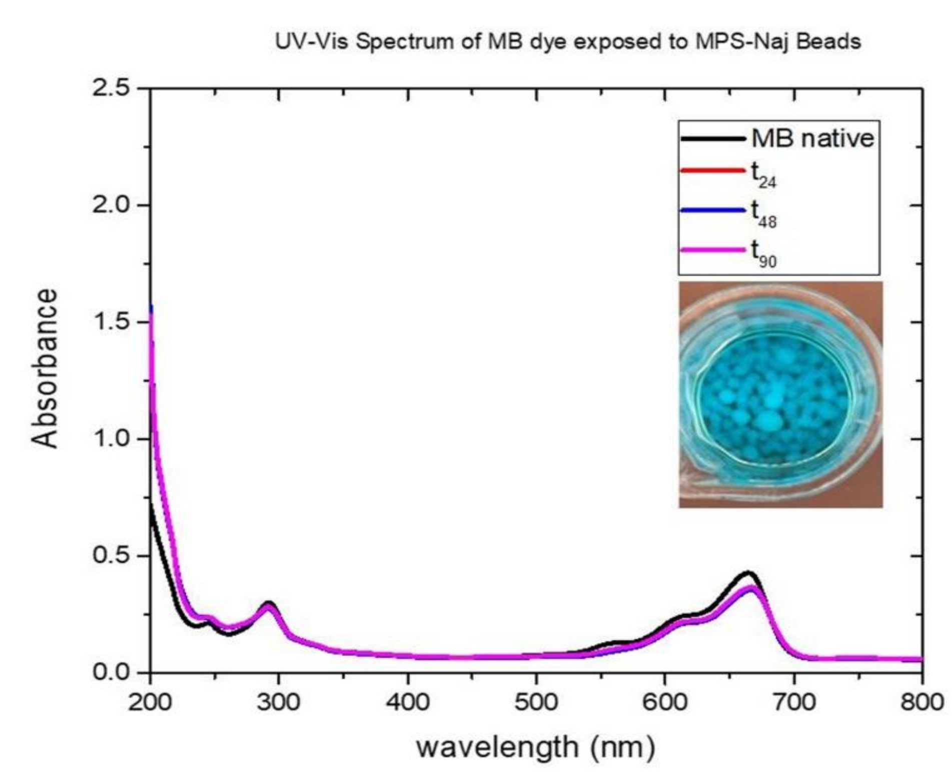
Effect of $CaCl_2$ and NaAlg Concentration



-Doubling the concentration caused formation of irregular shapes.







Methyl Orange (MO) – Changes in absorbance values were observed following adsorption. The MO molecules were retained by the bead surface. No changes were observed in the bead structure.

Rhodamine B (RB) – Significant changes occurred as the contact time increased. This indicates that RB molecules adsorb by interacting with the porous structure of the beads. The dye retention was also visually confirmed in the images of the beads.

Methylene Blue (MB) – Following adsorption, a decrease in the peak absorbance intensity was observed. This result indicates that the MB dye was removed from the solution in some way. Although no visible decrease in the solution's color intensity was observed, the UV-Vis results supported this finding.

CONCLUSION

Silica-alginate hybrid beads were successfully synthesized. While bead size was primarily controlled by the size of the syringe tip, the addition of TEOS had no significant effect on size. Higher concentrations negatively affected bead morphology. The beads exhibited distinct color changes in different dye solutions and were analyzed via UV-Vis spectroscopy. Based on these results, they demonstrated potential for the adsorption of wastewater.

RECOMMENDATIONS

- Additives can be incorporated to accelerate dye adsorption.
- Real wastewater samples can be tested for practical applications.
- Experimental parameters such as pH, contact time, and bead dosage can be optimized.
- Reusability and regeneration studies can be investigated for long-term applications.

REFERENCES

Lee, K. Y., & Mooney, D. J. (2012). Alginate: properties and biomedical applications. Progress in Polymer Science, 37(1), 106–126.

• Wang, J., & Chen, C. (2009). Biosorbents for heavy metals removal and their future. Biotechnology Advances, 27(2), 195–226.

ACKNOWLEDGMENT

I thank my advisor, Assoc. Prof. Dr. Derya Kapusuz Yavuz, and my department for their support.

Structural Analysis of a Metallic Component Using SolidWorks® and Altair® Simulation Tools

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ADVISOR: Assoc. Prof. Dr. Derya KAPUSUZ YAVUZ

Department of Metallurgical and Materials Engineering

SUMMARY

In this project, a wishbone suspension arm was designed using SolidWorks and structurally analyzed using SolidWorks Simulation and Altair® SimLab®. The study aims to compare the performance and sustainability profile of different material architectures under high loading conditions. The obtained results validate, through simulation, the critical balance between lightweight design and structural safety.

OBJECTIVE

The primary objective of this project is to simulate the structural performance and strength limits of a wishbone suspension arm under a load of 2575 N using SolidWorks Simulation and Altair® SimLab®. The research aims to determine the safest and most sustainable material architecture for automotive applications by comparing the factor of safety of a lightweight aluminum alloy and conventional steel[1].

METHODOLOGY

1. Modeling: The wishbone geometry was modeled using SolidWorks.

2. Simulation: The model was transferred to Solidworks Sim®, Altair SimLab®, and material properties were assigned[3].

3. Applied Conditions: The chassis points were fixed, and a vertical load of 2575 N was applied to the ball joint.

4. Analysis: Stress and factor of safety calculating with this software.

Figure 1.
Original Lower Wishbone Component Design.

Figure 2.
Lower Wishbone Integrated into the Vehicle Suspension System.

CONCLUSION

As a result of the FEA analyses, it was confirmed that AISI 1020 steel meets operational safety standards with a factor of safety of 1.26. Although the use of Aluminum 6061-T6 significantly reduces weight, it remains at the critical failure threshold with a FOS of 0.99 under a vertical load of 2575 N. This study demonstrated that material selection for high-performance automotive components must prioritize not only lightweight design, but also structural integrity and sustainability.

INTRODUCTION

In the automotive industry, optimizing suspension components is crucial for both vehicle safety and fuel efficiency. Traditional materials like AISI 1020 steel provide high strength but increase overall weight. Integrating lightweight alternatives, such as Aluminum 6061-T6, requires precise structural evaluation to ensure reliability under static and dynamic loads[2]. Computational analysis serves as a vital tool to predict performance before the manufacturing stage.

RESULTS

Maximum Stress: Under a vertical load of 2575 N, a maximum Von Mises stress ranging between 245.5 MPa and 277.8 MPa was observed for both materials.

Aluminum Performance: Aluminum 6061-T6 reached its yield limit (275 MPa) with a factor of safety of 0.99, remaining in the critical failure region.

Steel Performance: AISI 1020 steel maintained its structural integrity under the same loading conditions, with a FOS of 1.26, remaining within the safe region.

Weight and Strength Balance: Although aluminum provides a weight reduction advantage of approximately 65%, it was determined that, under this specific loading scenario, steel offers a more sustainable safety margin.

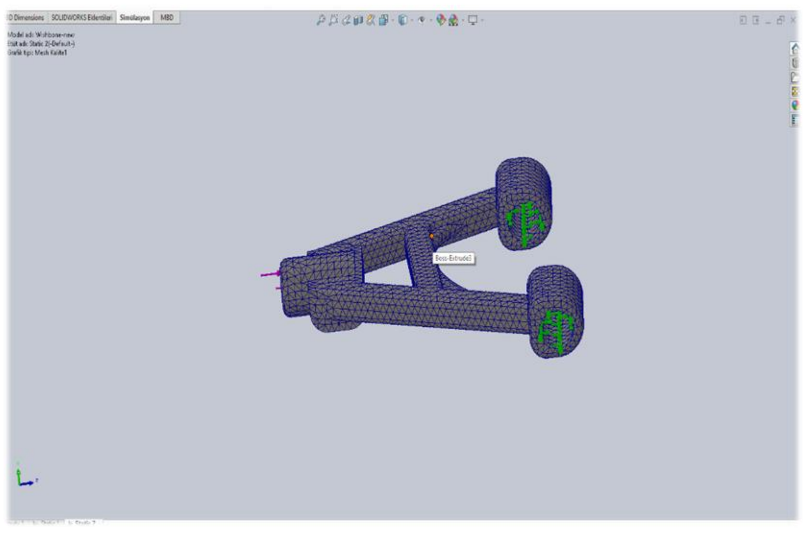

Figure 3.
Finite Element Mesh Generation of the Wishbone Structure.

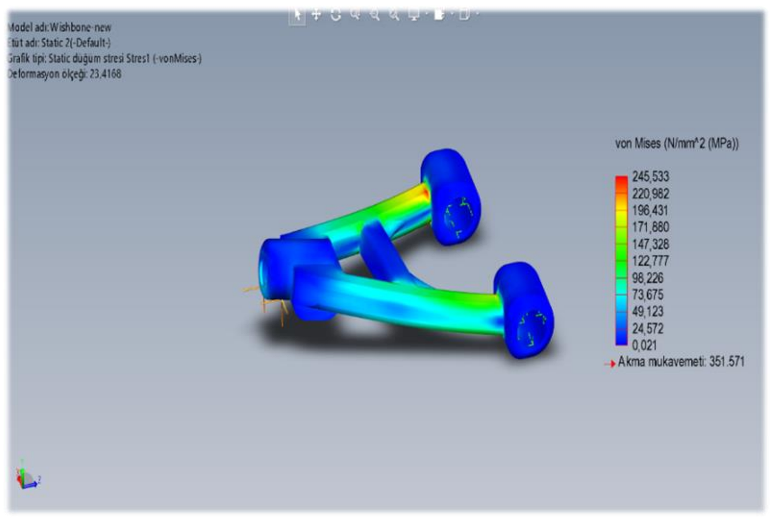

Figure 4.
Von Mises Stress Distribution under 2575 N Vertical Load.

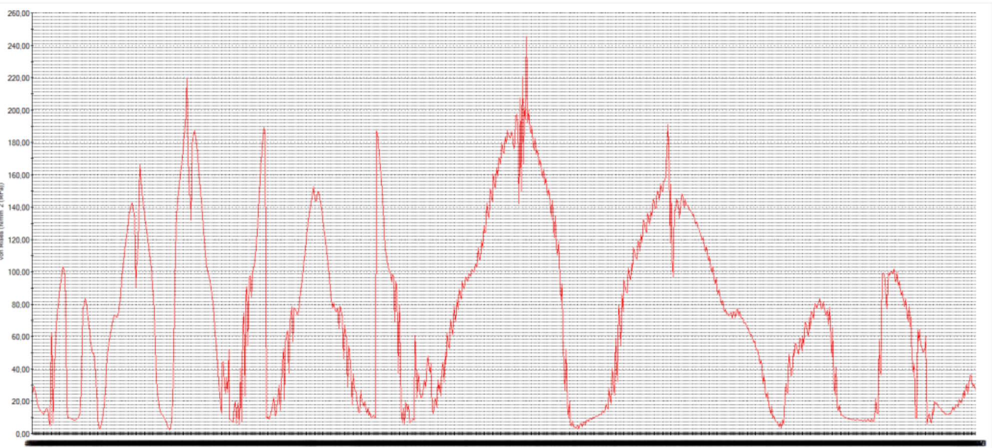

Figure 5.
Von Mises Stress Distribution Across Nodal Points

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[2] MatWeb Material Property Data. (2026). *AISI 1020 Steel and Aluminum 6061-T6 Properties*.

[3] Altair Engineering. (2024). *HyperWorks & SimLab Simulation Guide for Structural Analysis*.

FUTURE RECOMMENDATIONS

- To make the use of Aluminum 6061-T6 more sustainable, it is recommended to increase the wall thickness in critical stress regions.
- High-strength aluminum alloys or composite structures should be tested to optimize the balance between lightweight design and strength.
- Dynamic Loading: Fatigue and impact simulations should be performed to fully validate structural integrity.

ACKNOWLEDGMENT! I would like to express my sincere appreciation to Assoc Prof. Dr. Derya Kapusuz Yavuz for her guidance and support throughout this project. I also thank Gaziantep University Engineering Faculty for providing the facilities and resources that made this work possible.

Chemical and Mechanical Properties of Poly (lactic acid) Composites Reinforced by Almond Shell Powder

AUTHORS: Hüseyin Emin Kalkan

DEPARTMENT of METALLURGY and MATERIALS SCIENCE ENGINEERING

SUMMARY

Poly(lactic acid) biocomposites reinforced with almond shell powder improves sustainability; filler content reduces tensile strength but enhances eco-friendly performance.

OBJECTIVE

The study aims to evaluate how ASP affects the chemical and mechanical properties of PLA composites for sustainable material applications.

INTRODUCTION

Poly(lactic acid) (PLA) is a biodegradable polymer widely used in sustainable materials due to its renewable origin and environmental advantages. However, its limited mechanical and thermal properties can restrict broader applications. Reinforcing PLA with natural fillers such as almond shell powder (ASP) offers a cost-effective and eco-friendly solution to improve performance while utilizing agricultural waste. This study investigates the influence of ASP on the chemical and mechanical behaviors of PLA composites.

METHODOLOGY

PLA/ASP composites were fabricated using PLA as the polymer matrix and ASP as the natural reinforcement. The required amounts of ASP were weighed according to the selected weight fractions and suspended in chloroform by using a magnetic stirrer. Then, PLA pellets were added to these suspensions and the mixtures were mixed thoroughly to ensure homogeneous distribution of the filler within the PLA matrix. Thin films of the resulting composite mixtures were prepared using solvent casting technique. The prepared samples were conditioned under controlled conditions and used for FTIR and mechanical characterization tests.

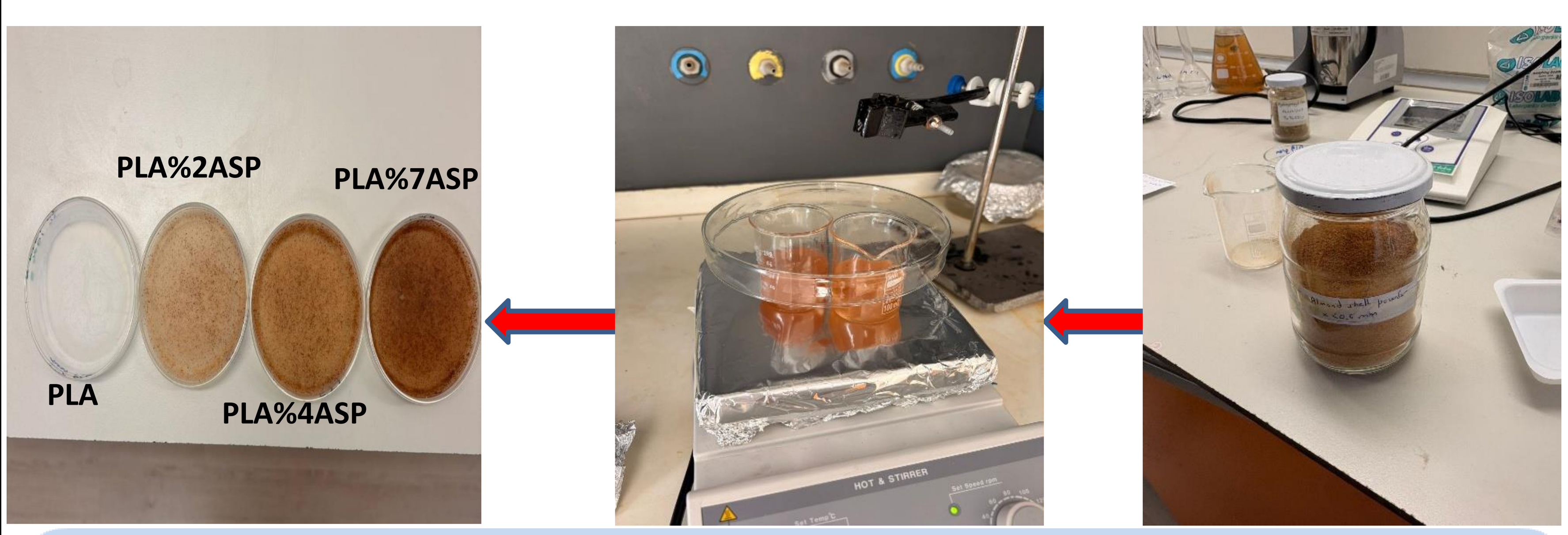

Figure 1. Preparation of PLA/ASP composites

RESULTS

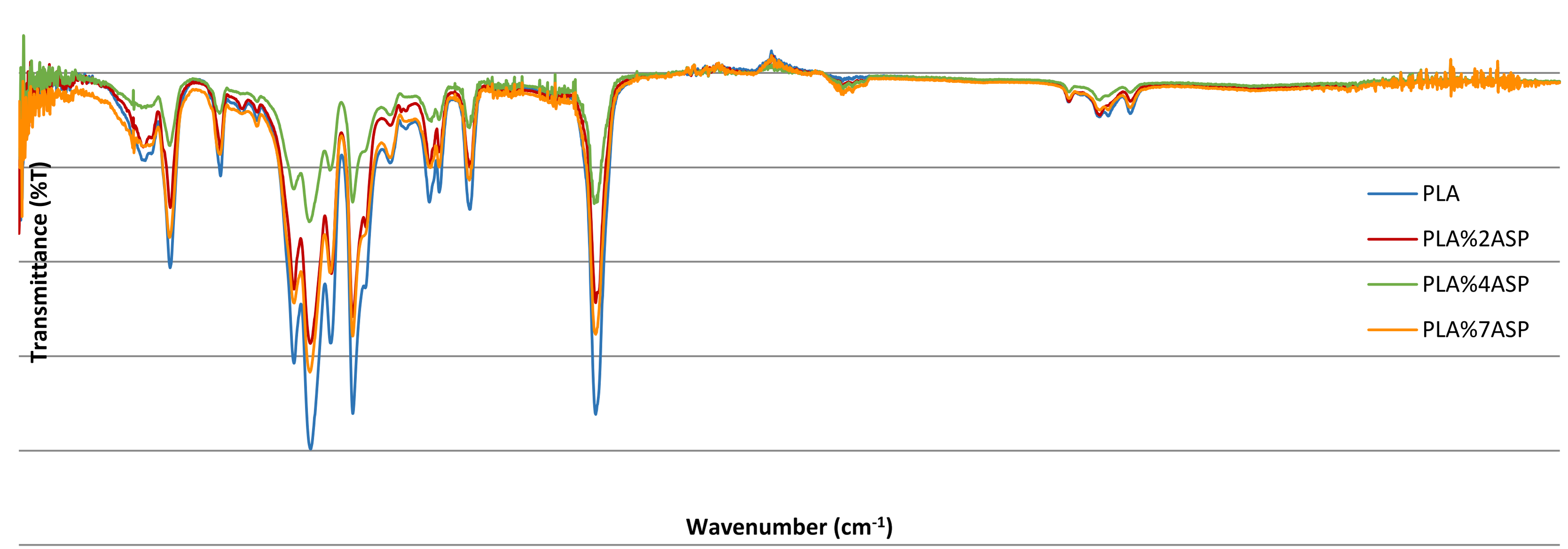

Figure 2. FTIR spectra of PLA/ASP composites

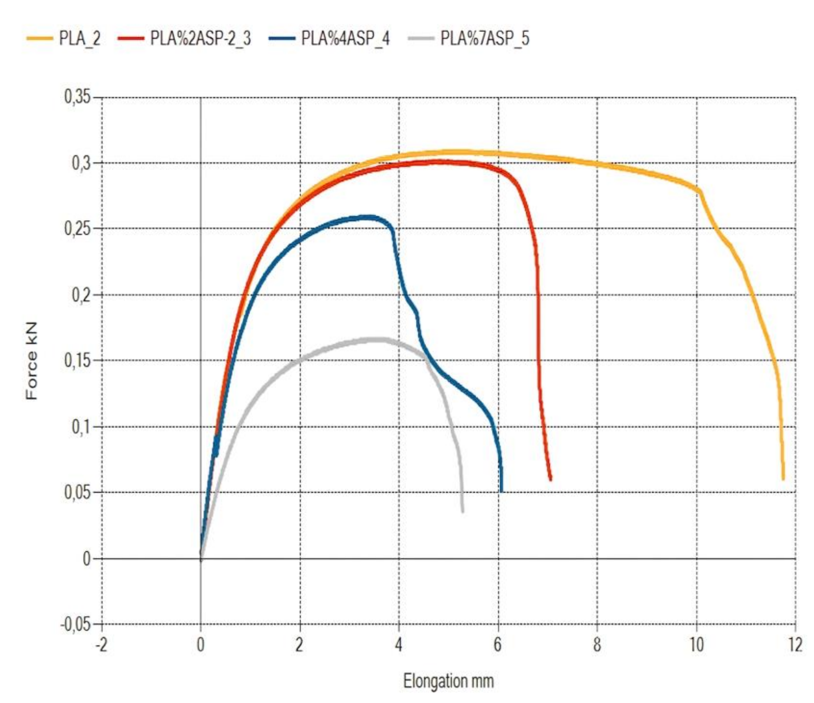

Figure 3. Force and elongation graph of PLA/ASP composites

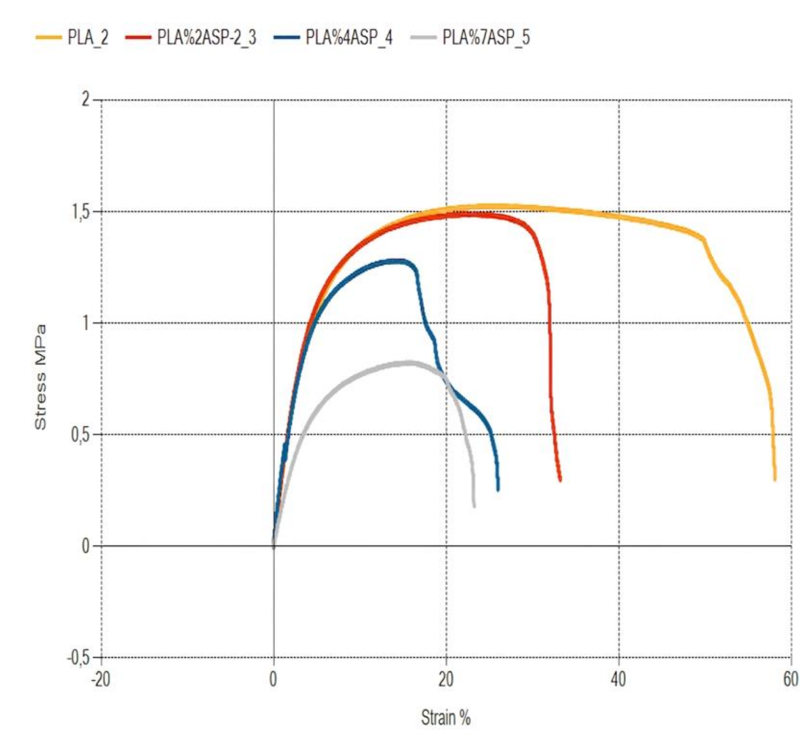

Figure 4. Stress and strain graph of PLA/ASP composites

Table 1 Tensile test results of PLA/ASP composites

Numune	F_{max} (kN)	E (GPa)	ReH (MPa)	ReL (MPa)	Rm (MPa)	ΔLf (%)	σ_a (N/mm^2)	ε (%)
PLA	0,309	0,025	0,786	0	1,525	58,072	0,919	58,114
PLA%2ASP-2	0,301	0,026	0,813	0	1,488	33,213	0,995	33,249
PLA%4ASP	0,259	0,023	0,777	0	1,279	25,966	0,945	26,002
PLA%7ASP	0,167	0,014	0,46	0	0,823	23,222	0,559	23,263

CONCLUSION

The incorporation of ASP into PLA improved the overall sustainability of the composite by utilizing agricultural waste as a natural filler. The results indicate that filler content significantly influences the chemical and mechanical properties of PLA, generally decreasing tensile performance while reducing percent elongation performance due to interfacial limitations. FTIR analysis confirmed the presence of characteristic functional groups and suggested interactions between the PLA matrix and ASP. Overall, ASP shows potential as a cost-effective and eco-friendly reinforcement for PLA-based biocomposites, particularly in applications where moderate mechanical performance and sustainability are prioritized.

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