Investigation Of The Properties Of Epoxy And Biobase Epoxy Matrices Containing A Natural Waste

Emre ÇELİK
Category Specialist(Marketing-Industrial Coatings)

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Outline

- Introduction
- Aim of the Study
- Materials
- Experimental
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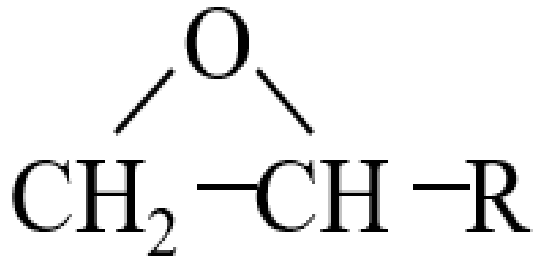
Introduction

Introduction

Epoxy resins;

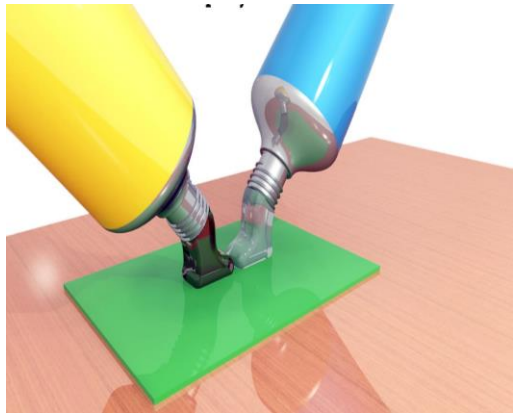
- Discovered by Nikolaj Alexandrovich Prileschajew(1909)**[1]**
- A prepolymer, low molecular weight, containing reactive oxirane ring**[1]**
- Rxn➔with co-reactants such as multifunctional aliphatic and aromatic amines, acid and derivatives and chlorides, amids, esters etc.(*Called hardeners*)**[2]**



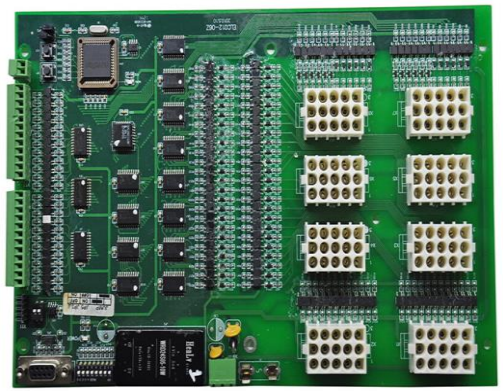
Introduction

Usage areas of epoxy resins;

Coating/Flooring

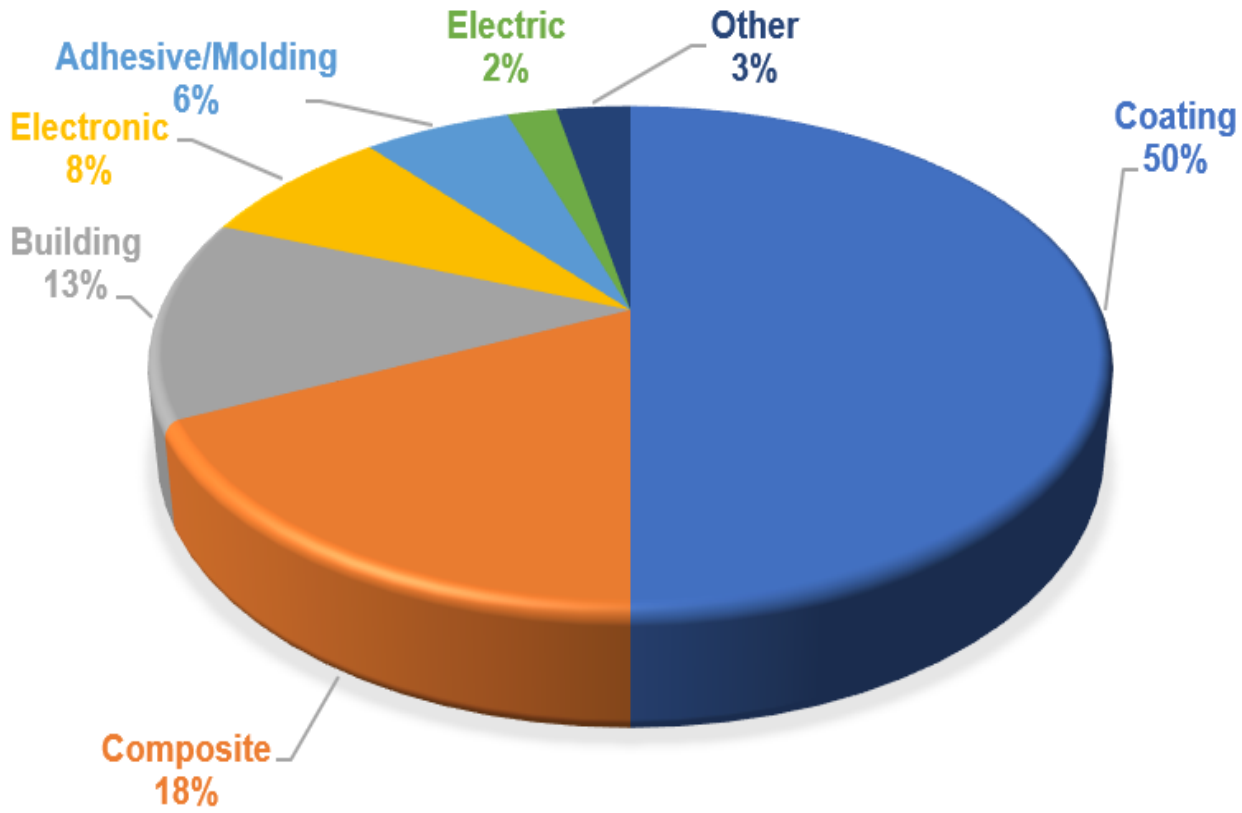


Adhesive



Electronic

Aerospace



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Introduction

Literature review;

1.Sadowski et. Al➔ studied called *«Enhanced adhesive performance of epoxy resin coating by a novel bonding agent»* **[3]**

Materials: Concrete surface, Bisphenol A and epiclorohydrin(MW:700)(resin), Phenalkamine(Hardener), Coconut fibers(Reinforcement)

First coat(2 mm): 100:33(Resin + hardener) + Coconut fibers%➔(Ratios in the table 1)

Second coat(2 mm):100:50(Resin + hardener)➔ Without coconut fibers

Table 1: Composition and pull off performance

Materials	Sample 1 %	Sample 2 %	Sample 3 %	Sample 4 %	Sample 5 %
Coconut fibers %	0	0.50	1	1.5	2
Pull off(MPa)	1.4± 0.33	3.47 ± 0.43	3.48 ± 0.58	2.67 ± 0.62	2.95 ± 0.70

Introduction

2.Campanale et. Al➔ studied called *«Epoxy Resins for Flooring Applications, an Optimal Host for Recycling Deactivated Cement Asbestos»* **[4]**

Materials: PT epoxy resin(Bisphenol A + epiclorohydrin), PF epoxy resin(Bisphenol A + epiclorohydrin/contain barite), hardener, Deactivated Cement Asbestos Powder(DCAP <80 µm)

Table 2: Contents of samples

PF Resin		PT Resin	
Sample	DCAP(%)	Sample	DCAP(%)
PF0	0	PT0	0
PF2	2	PT10	10
PF5	5	PT20	20
PF10	10	PT30	30

@PT Resin➔ DCAP % ↑ Tensile strength and flexural st. ↓ Compressive st. ↔ Shore hardness ↑

$PT_{mechanical\ properties} > PF_{mechanical\ properties}$

PT20 samples➔ Optimum results

Introduction

3. Krzywinski et. Al➔ studied called *«Engineering and Manufacturing Technology of Green Epoxy Resin Coatings Modified with Recycled Fine Aggregates»* **[5]**

Materials: Epoxy resin(Bisphenol A), poliamine epoxy hardener, concrete surface, recycled fine aggregates(RFA), natural fine aggregates(NFA)

Epoxy resin + hardener +(RFA+NFA)➔(Ratios Table 3)

Table 3: Aggregate contents(Added on epoxy resin) and result of pull off test

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
RFA	0%	20%	40%	60%	80%	100%
NFA	100%	80%	60%	40%	20%	0%
Pull off(MPa)	1.2	1.6	1.5	1.6	1.8	1.9

- Replacing NFA with RFA has positive effect on pull-off strength
- The best result➔ Sample 6(%100 RFA)

Aim of the Study

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- The adhesion, thermal, mechanical and morphological properties of Afyon poppy capsule waste added to the standart and bio based epoxy matrix at certain rates were investigated.
- Natural waste into benefit

Materials

Materials

Resin 1: Standart epoxy resin(DGBA)
Epoxy equivalent weight: 190-210 g/eq

Abbreviation: **EPR**

Resin 2: Bio-based epoxy resin
Epoxy equivalent weight: 180-190 g/eq
%27 biocarbon content

Abbreviation: **BEPR**

Hardener: Standart epoxy resin(DGBA)
Active hydrogen equivalent weight: 95 g/eq

Reinforcement: Opium poppy capsule waste
Avarega particle size: 69 µm

Mixing ratio of Resin 1 and hardener➔2.125+1 / Mixing ratio of Resin 2 and hardener➔2.05+1

Tablo 4:Formulation

Sample	Raw EPR	EPR0.5	EPR3	Raw BEPR	BEPR0.5	BEPR3
Poppy capsule waste%	0	0.5	3	0	0.5	3

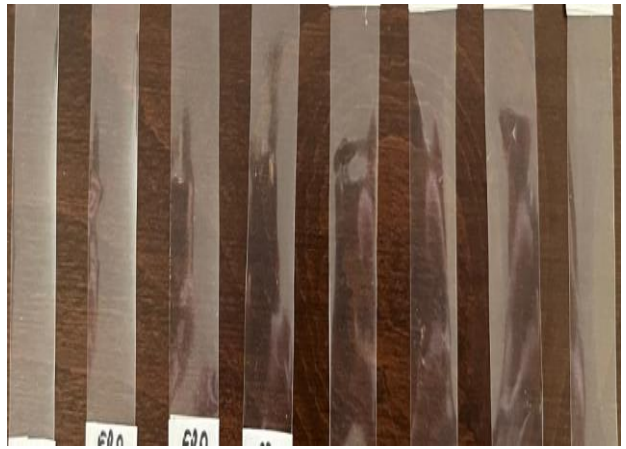
Experimental

Experimental

Pull Off Test

- Equipment: PosiTest AT-A
- Test substrate: ST-37 Black sheet (Thickness: 3 mm)
- Application thickness: 1.2 mm
- Curing Time: 7 days
- Ambient temperature: 23± 2 °C
- Standard: ASTM 4541-22

Tensile Strength



- Equipment: Instron
- Film Thickness: 200 µm
- Curing Time: 7 days
- Ambient temperature: 23± 2 °C
- Standard: ASTM D882

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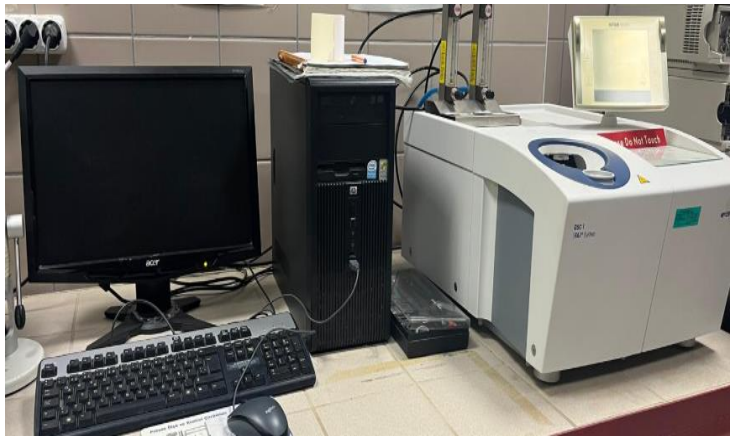
Experimental

DSC(Differential scanning calorimetry)



- Equipment: Mettler Toledo(Star e SW)
- Curing Time: 7 days
- Ambient temperature: 23± 2 °C
- Range:-20-100 °C
- Heating rate: 10 °C/min

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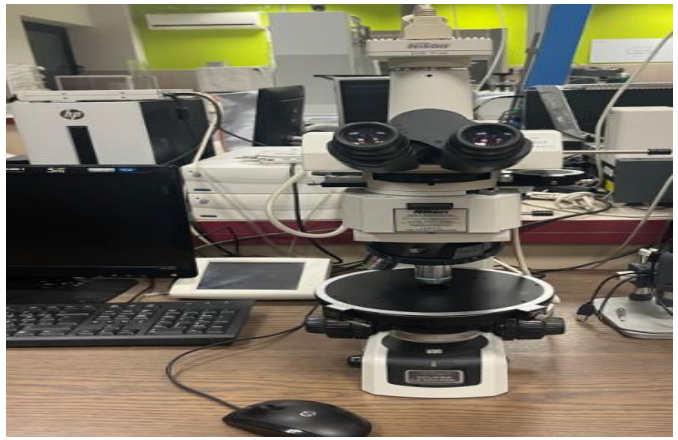
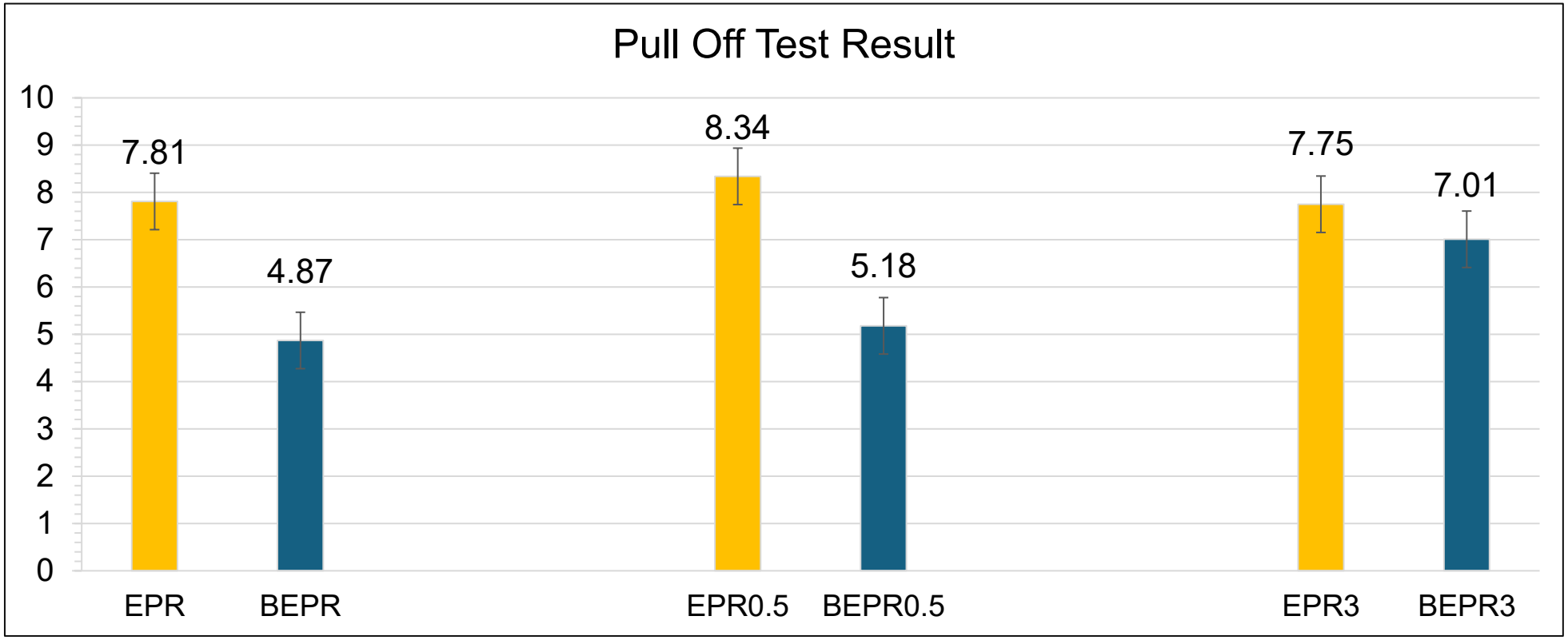


- Equipment: Nikon DS-Fi2
- Curing Time: 7 days
- Ambient temperature: 23± 2 °C
- Measurement: 50 and 100 µm

Result and Discussion

Result and Discussion

Pull Off:



The best for EPR

EPR0.5 (8.34 MPa)

The best for BEPR

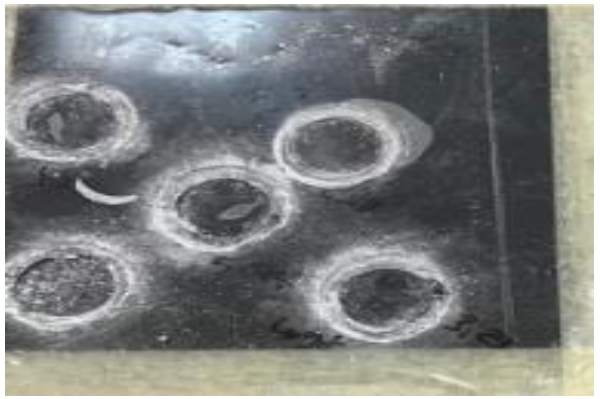
BEPR3 (7.01 MPa)

Figure 1: Comparative pull-off test results

$EPR_{Pull\ off} > BEPR_{Pull\ off}$

Result and Discussion

Pull Off:

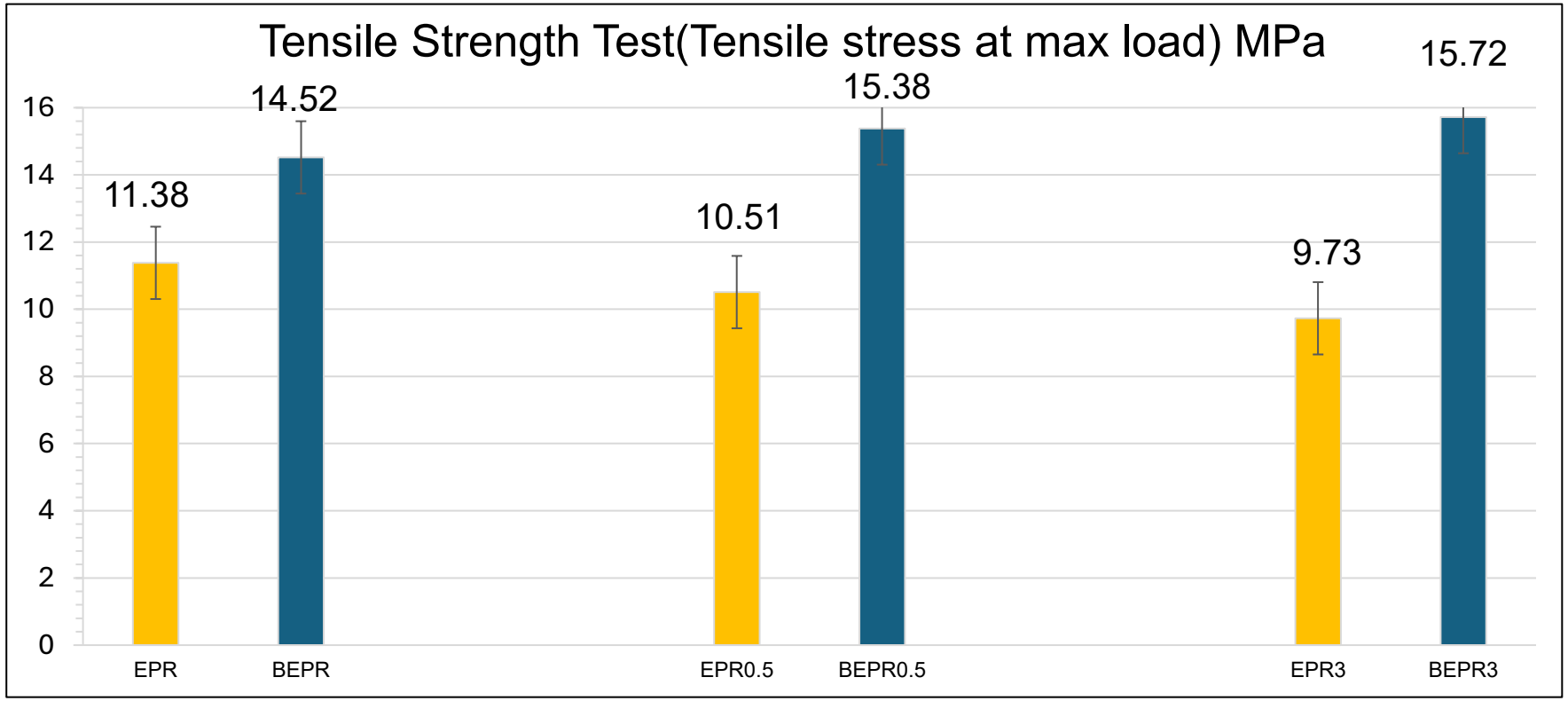


BEPR (Before & After)

EPR3 (Before & After)

Result and Discussion

Tensile Strength:



$BEPR_{Tensile\ st.} > EPR_{Tensile\ st.}$

For BEPR and EPR

Poppy ↑ Tensile St. ↔

Figure 2: Comparative tensile strength test result

Result and Discussion

DSC (Differential scanning calorimetry) :

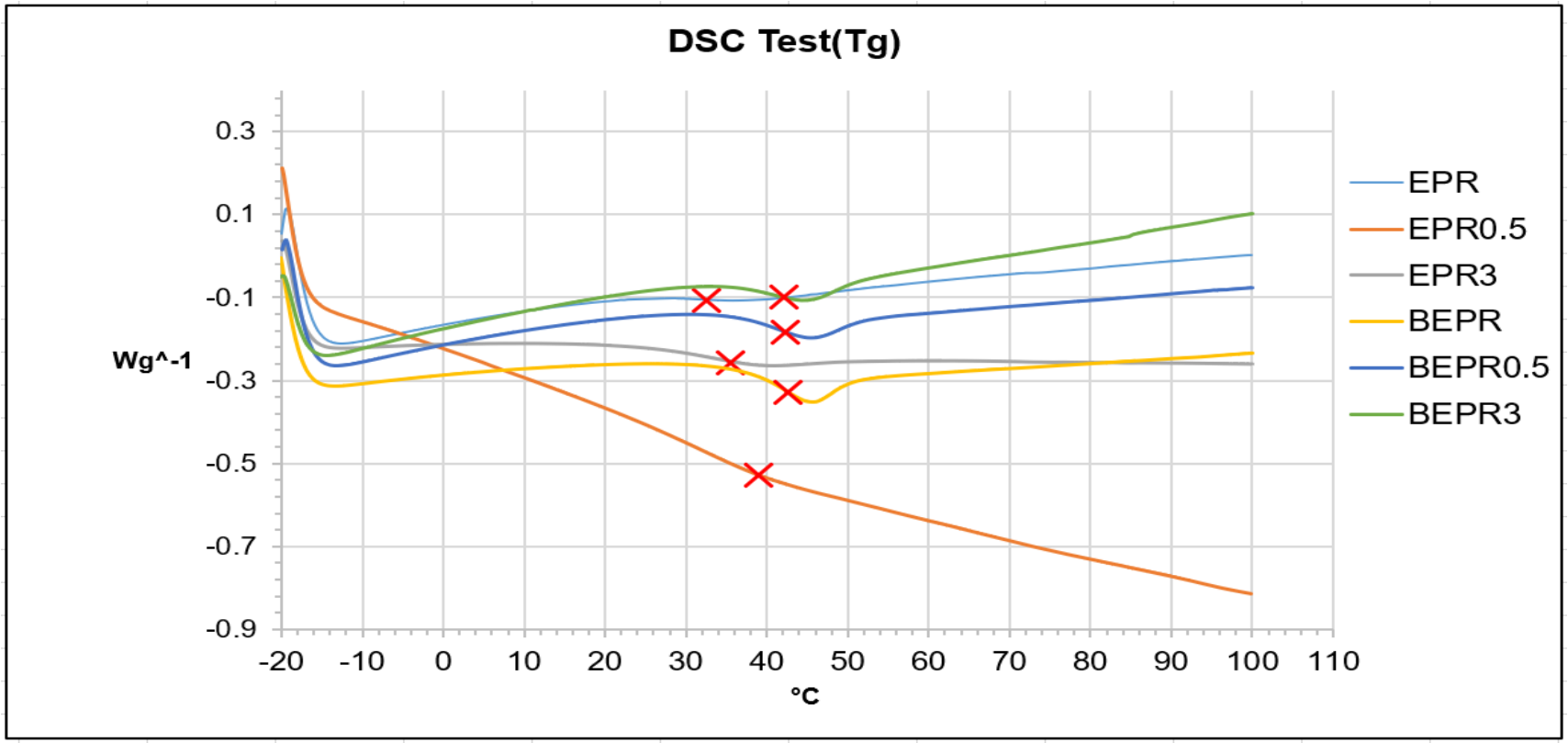


Figure 3: Comparative DSC test(Tg) result

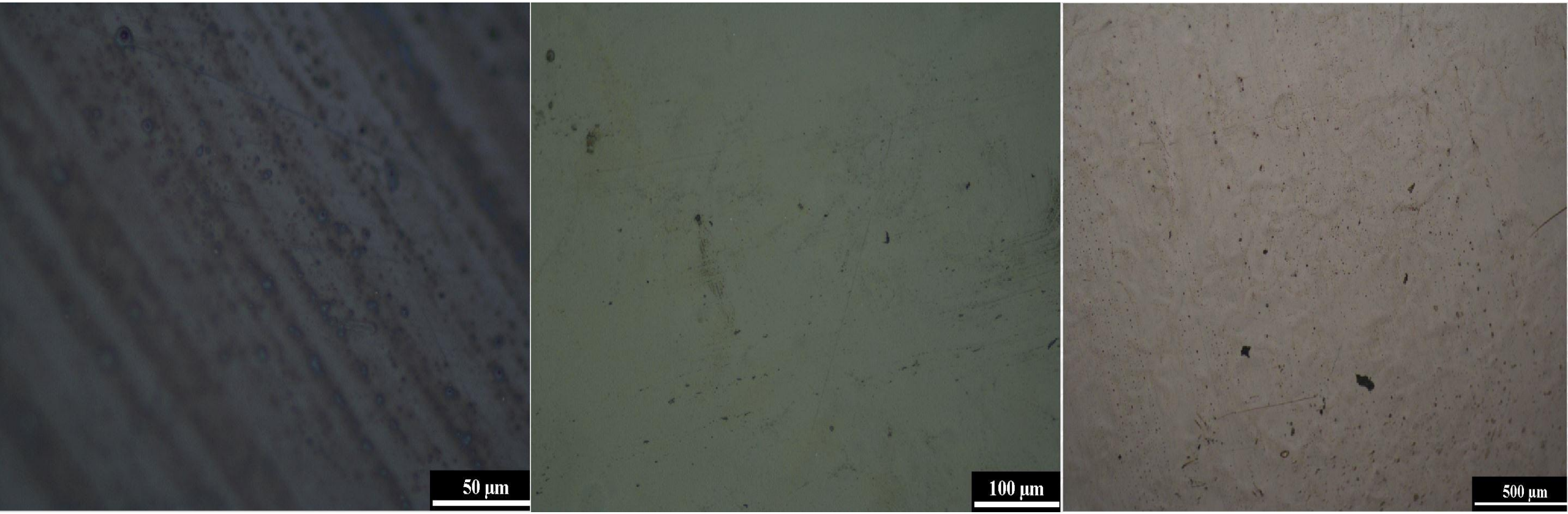
EPR_{Tg} ➔31.41 °C
$EPR0.5_{Tg}$ ➔38.24 °C
$EPR3_{Tg}$ ➔36.18 °C

$BEPR_{Tg}$ ➔42.35 °C
$BEPR0.5_{Tg}$ ➔41.81 °C
$BEPR3_{Tg}$ ➔42.07 °C

$BEPR_{Tg} > EPR_{Tg}$

Result and Discussion

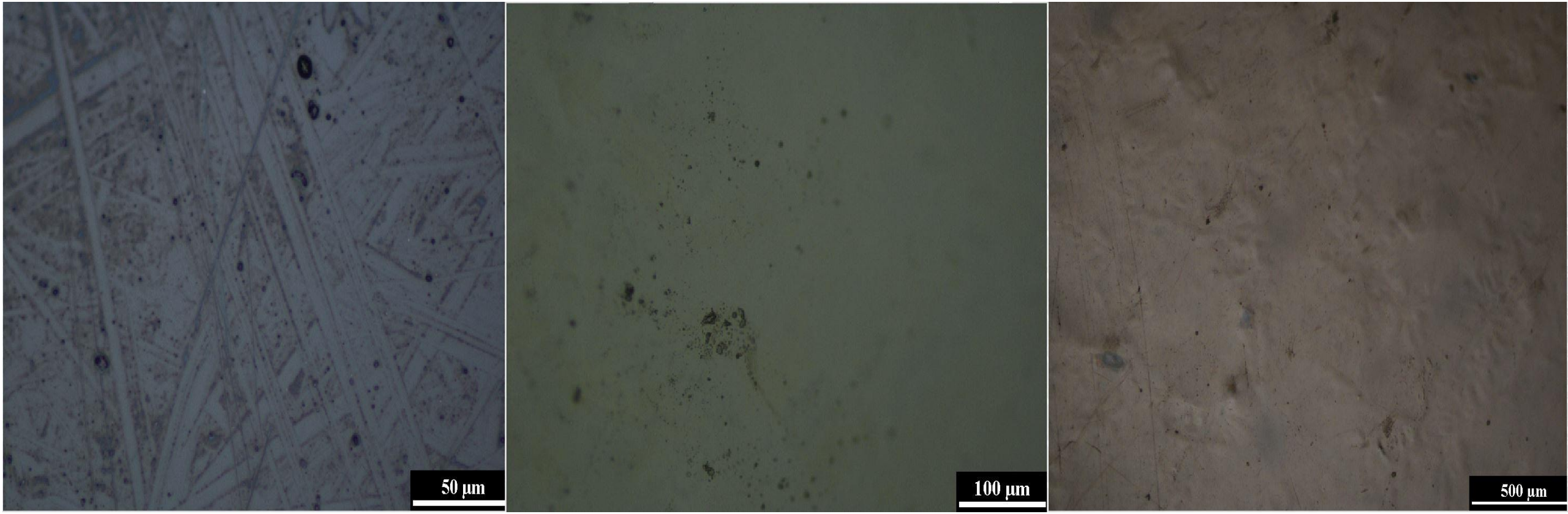
Morphological Properties(POM):



EPR microscop images

Result and Discussion

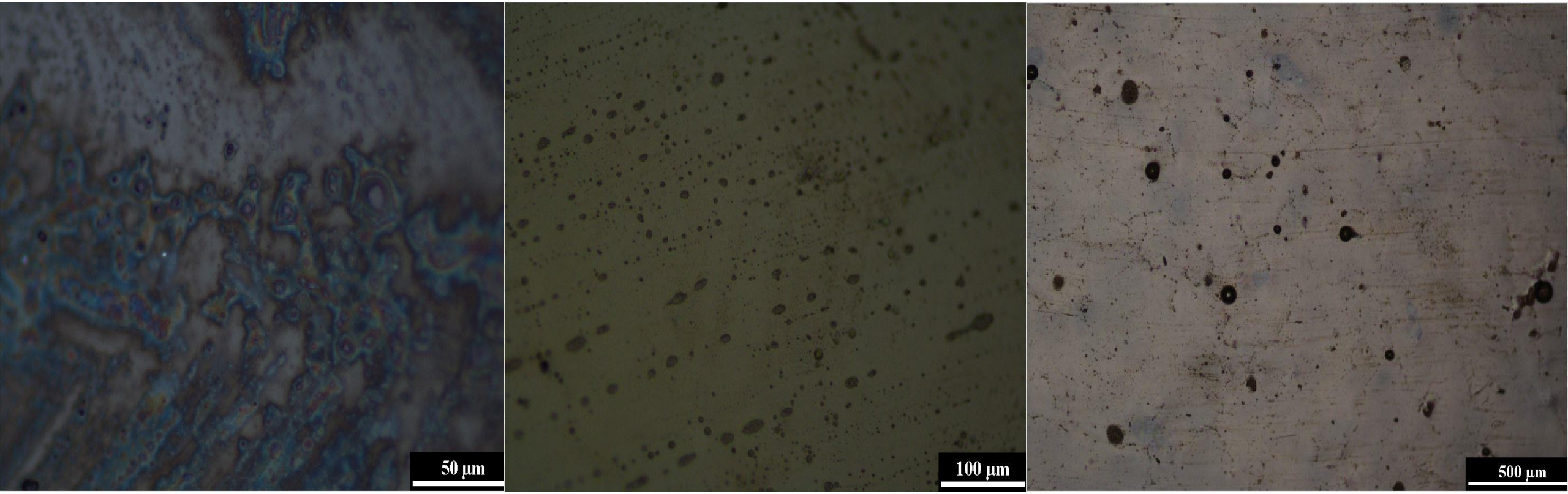
Morphological Properties(POM):



EPR0.5 microscop images

Result and Discussion

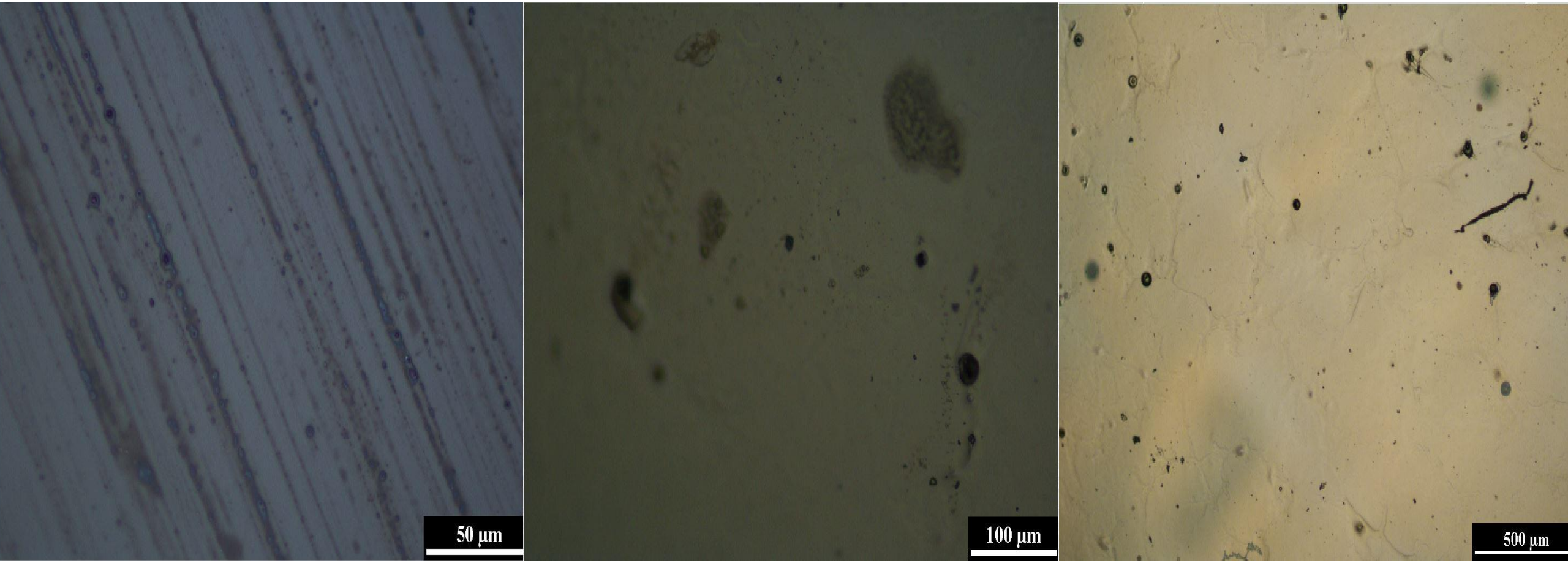
Morphological Properties(POM):



EPR3 microscop images

Result and Discussion

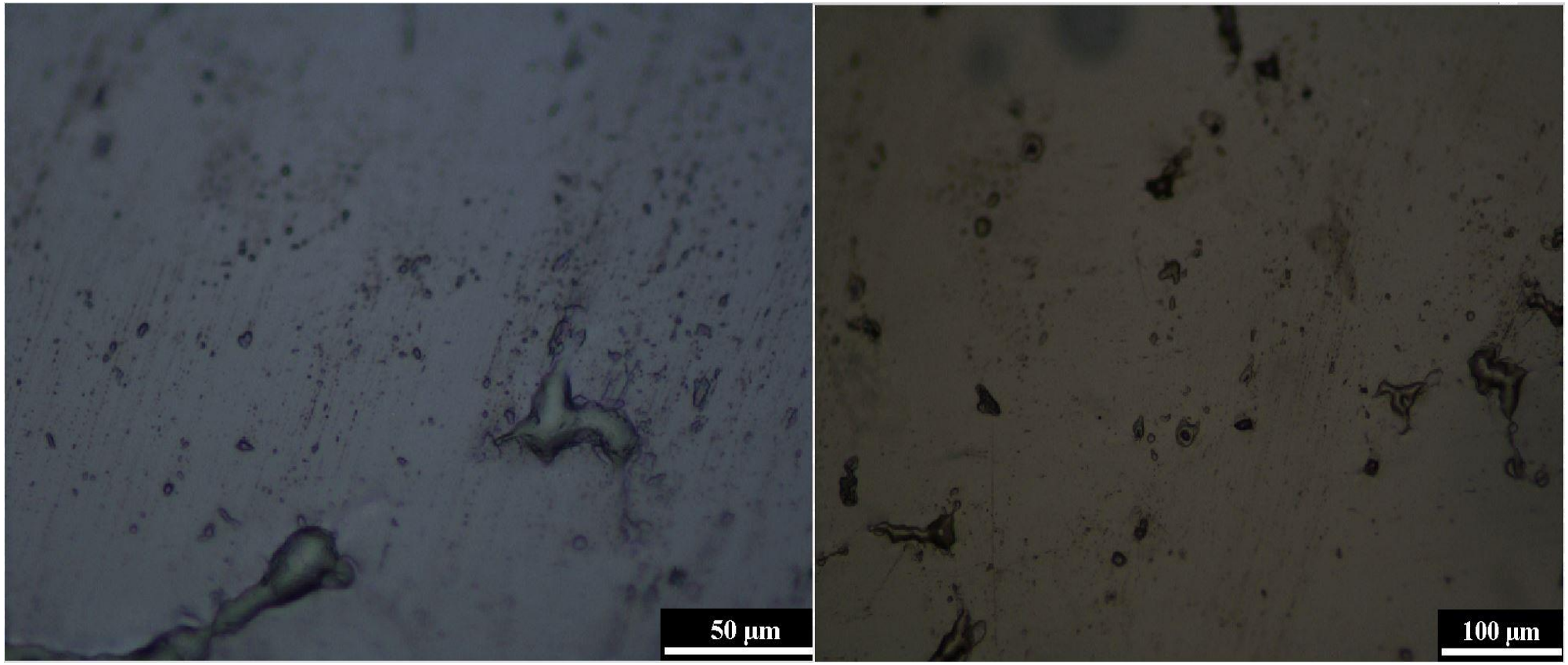
Morphological Properties(POM):



BEPR microscop images

Result and Discussion

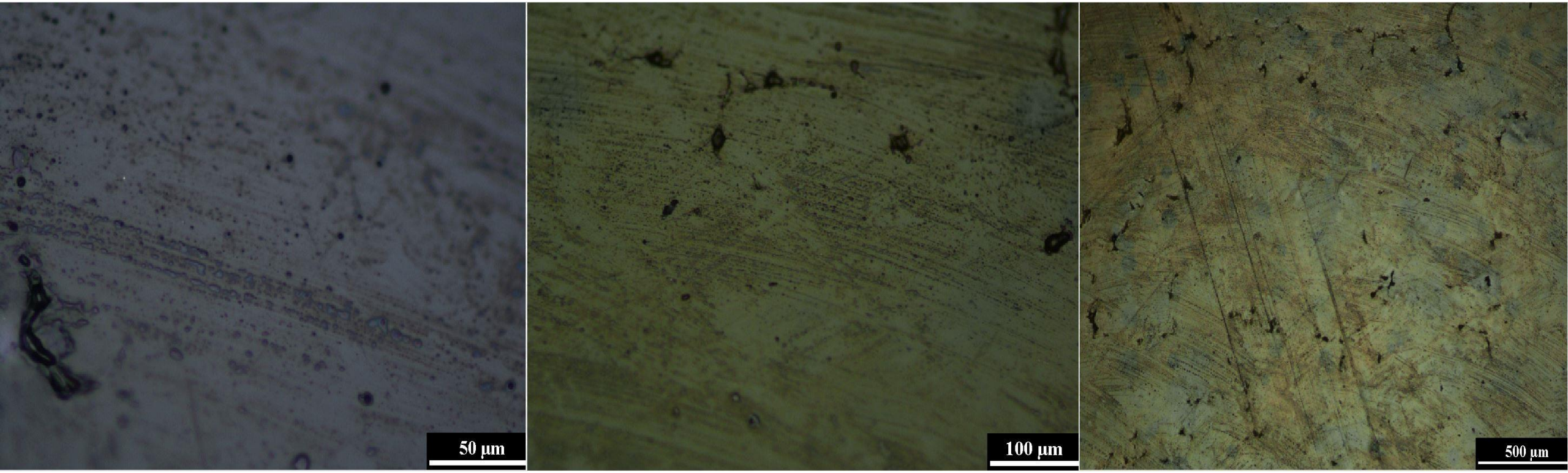
Morphological Properties(POM):



BEPR0.5 microscop images

Result and Discussion

Morphological Properties(POM):



BEPR3 microscop images

Conclusion

Conclusion

- In today's world, recycling waste and evaluating it in other applications is important for sustainability.
- In previous studies➔Reinforced to epoxy structure with coconut fiber, DCAP and recycled fine aggregate and performances were investigated.

- In this study➔ Poppy capsule waste was added to standard and bio epoxy matrices and performances were examined.
- The best results of pull off were obtained with 0.5% reinforcement(EPR0.5) in standard epoxy resin.
- The best results of pull off were obtained with 3% reinforcement(BEPR3) in bio epoxy resin.
- $EPR_{pull\ off} > BEPR_{pull\ off}$ ➔in 3 specimens

- Tensile stress at max load➔ The added additive did not change much
- Glass transition temperature➔The added additive did not change much but BEPR>EPR
- Morphological test➔ As the amount of additive increased, partial agglomeration was observed.

References

References

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«Benim manevi mirasım bilim ve akıldır.» «My spiritual legacy is science and reason.»

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