TAILORING PBS/PHBV BIOPOLYMER BLENDS FOR SUSTAINABLE FOOD PACKAGING

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INTRODUCTION

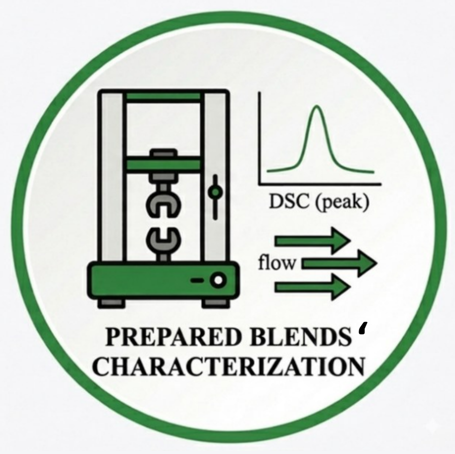
Conventional packaging is largely based on fossil-derived polymers, which are non-biodegradable and difficult to recycle, contributing to growing environmental concerns. Biopolymers offer a sustainable alternative, but their broader application is limited by insufficient mechanical, thermal, and barrier performance. As a result, blending has become a key strategy for tailoring and improving material properties. Poly(butylene succinate) (PBS) and poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV) are promising biodegradable polymers; however, their immiscibility restricts the full utilization of their combined properties. Reactive compatibilization using Joncryl ADR 4468, an epoxy-functional chain extender, enhances interfacial interactions through reactions with polymer end groups, leading to improved compatibility and performance. Optimizing PBS/PHBV blend composition and compatibility enables the development of high-performance, biodegradable materials suitable for food packaging applications.

MATERIALS & METHODS

Materials
- PBS, PTT MCC BIOCHEM CO., LTD., Thailand
- PHBV ENMAT Y1000P, TianAn Biopolymers, China
- Joncryl ADR 4468, BASF, Germany

Blend preparation
- Melt mixing (Brabender kneader): 180 °C • 60 rpm • 10 min
- Compression molding: 180 °C • 5 min • 25 kPa

✓ PBS/PHBV blends (80/20, 85/15, 90/10) were initially prepared, after which the PBS85/PHBV15 blend was further modified with 1, 3 and 5 wt.% (x) Joncryl (PBS85/PHBV/xJ).



Thermal properties

Differential scanning calorimetry (DSC)
- N_2 flow: 50 mL min^{-1}
- Heating and cooling rate: 10 °C min^{-1}
- Cycles: -80 to 200 °C; 200 to -80 °C
- Determination of the polymers' miscibility

Thermogravimetric analysis (TGA)
- N_2 flow: 50 mL min^{-1}
- Heating rate: 10 °C min^{-1}
- Temperature range from 25 to 700 °C
- Determination of the blends' thermal stability

Barrier properties
- → Sample area: 50.0 cm^2
- → Film thickness: ~100 µm

Oxygen transmission rate (OTR)
- Standard: ASTM D3985
- 23.0 °C, 0.0% RH

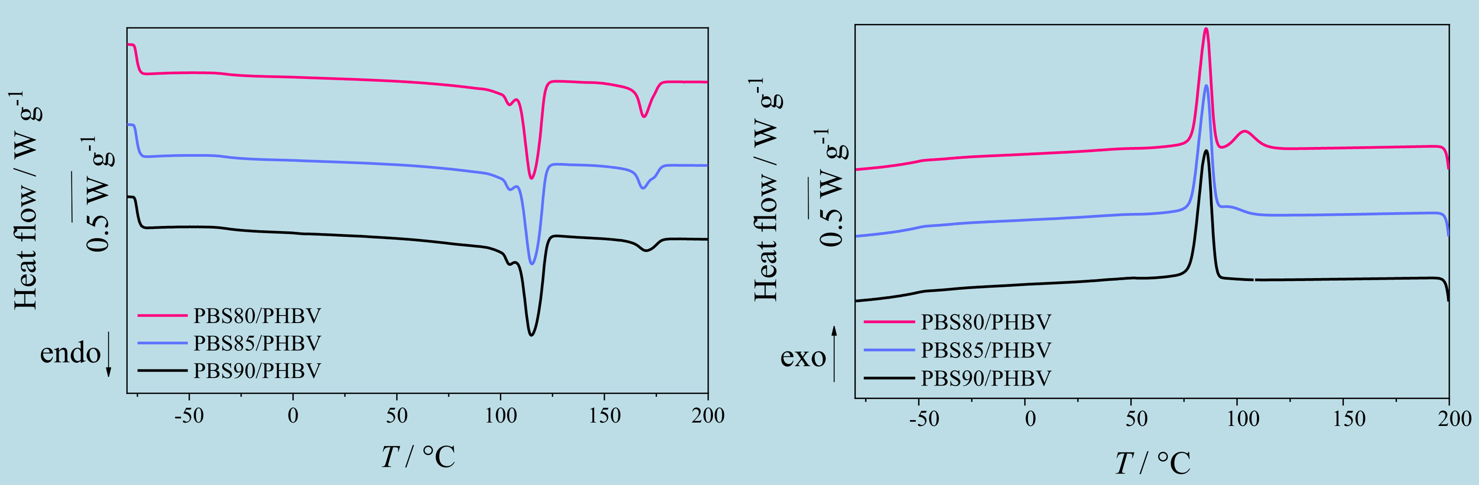
Water vapour transmission rate (WVTR)
- Standard: ASTM F1249
- 38.0 °C, 90.0% RH

Morphology and mechanical performance

Scanning electron microscopy (SEM)
- Accelerating voltage 20 kV
- Magnification: 500x

Tensile test
- Standard: ISO 527
- Cross-head speed of 50 mm min^{-1}
- Gauge length: 100 mm
- Tester capacity: 5000 N

RESULTS

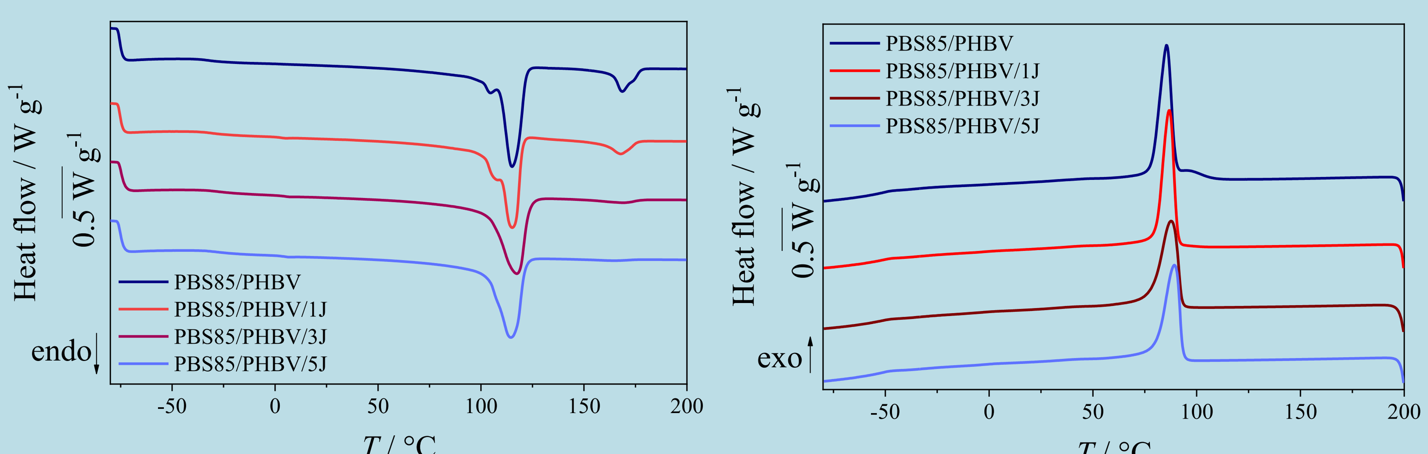


a) heating curves b) cooling curves

Fig. 1. DSC curves of PBS/PHBV blends at 80/20, 85/15 and 90/10 ratios.

Table 1. Results of the DSC analysis of PBS/PHBV blends.

Sample	T_{g1} / °C	T_{g2} / °C	T_{m1} / °C	T_{m2} / °C	T_{m3} / °C	ΔH_m / J g^{-1}	T_{c1} / °C	T_{c2} / °C	ΔH_c / J g^{-1}
PBS80/PHBV	-32.07	0.15	104.29	114.99	169.18	-85.79	85.49	103.55	76.30
PBS85/PHBV	-30.98	-	104.62	114.99	168.57	-82.49	85.52	95.49	75.83
PBS90/PHBV	-33.82	0.57	104.57	114.91	170.08	-83.78	85.46	-	68.28

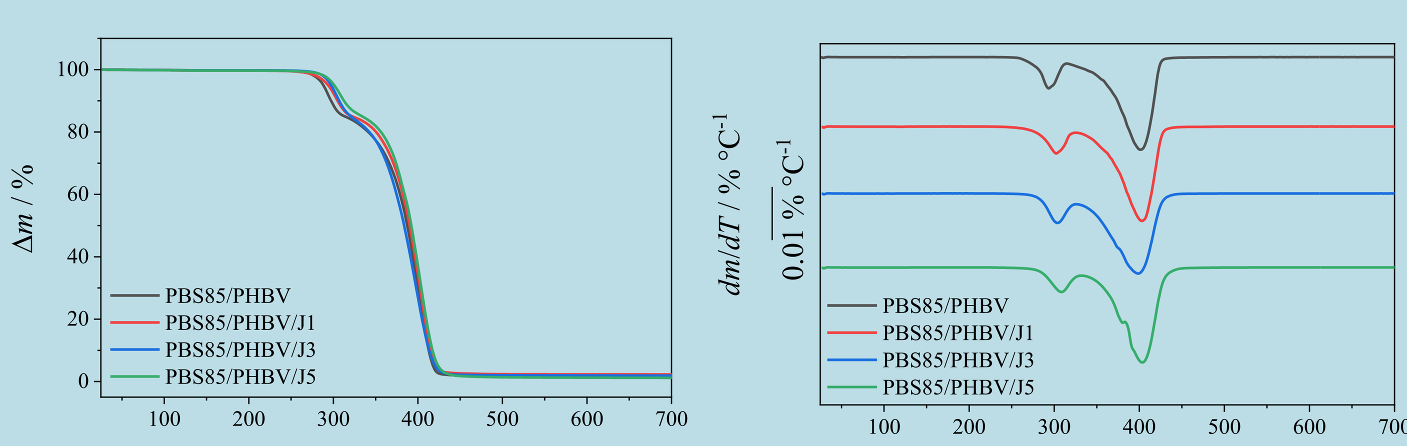


a) heating curves b) cooling curves

Fig. 2. DSC curves of PBS85/PHBV with 0–5 wt. % Joncryl.

Table 2. Results of the DSC analysis of PBS85/PHBV with 0–5 wt. % Joncryl.

Sample	T_{g1} / °C	T_{g2} / °C	T_{m1} / °C	T_{m2} / °C	T_{m3} / °C	ΔH_m / J g^{-1}	T_{c1} / °C	T_{c2} / °C	ΔH_c / J g^{-1}
PBS85/PHBV	-30.98	-	104.62	114.99	168.57	-82.49	85.52	95.49	75.83
PBS85/PHBV/1J	-31.30	1.86	107.79	115.09	167.98	-77.97	86.78	-	64.05
PBS85/PHBV/3J	-29.79	4.36	117.39	169.32	-	-73.94	87.68	-	66.12
PBS85/PHBV/5J	-30.46	4.26	114.39	-	-	-68.28	89.22	-	63.06



a) TG curves b) DTG curves

Fig. 3. TG/DTG curves of PBS85/PHBV with 0–5 wt. % Joncryl.

Table 3. Results of the TGA analysis of PBS85/PHBV with 0–5 wt. % Joncryl.

	TG				DTG		
Sample	T_{onset} / °C	T_{end} / °C	Δm / %	$R_{600°C}$ / %	T_{max1} / °C	T_{max2} / °C	T_{max3} / °C
PBS85/PHBV	279.10	416.51	98.55	1.40	293.44	-	401.33
PBS85/PHBV/1J	286.16	418.37	97.65	2.28	302.22	-	402.89
PBS85/PHBV/3J	288.35	417.01	98.05	1.90	303.65	-	398.74
PBS85/PHBV/5J	291.26	420.55	98.75	1.18	308.47	380.51	403.47

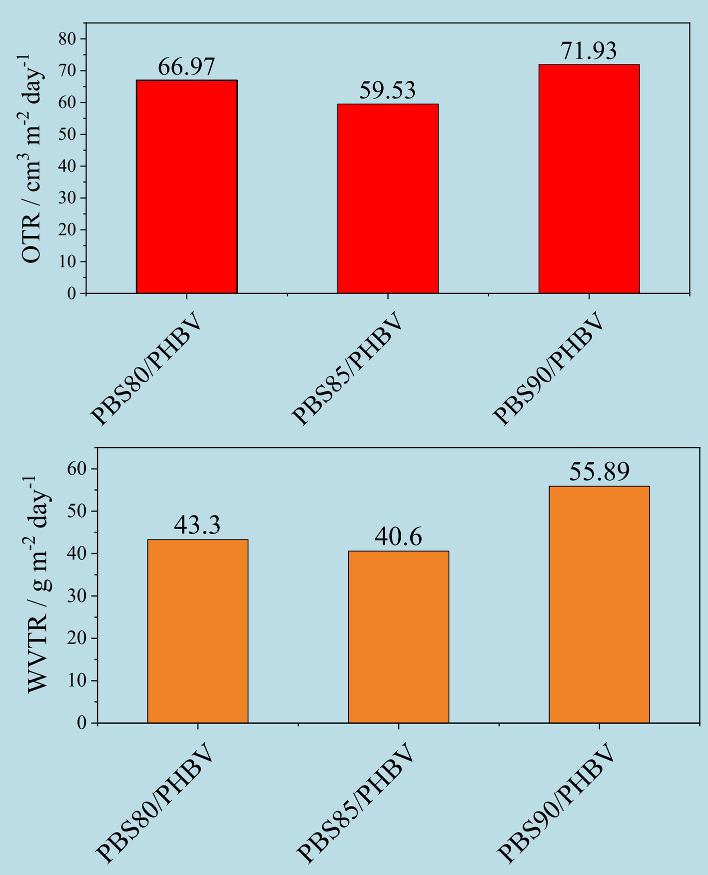


Fig 4. Barrier properties of PBS/PHBV blends at 80/20, 85/15 and 90/10 ratios.

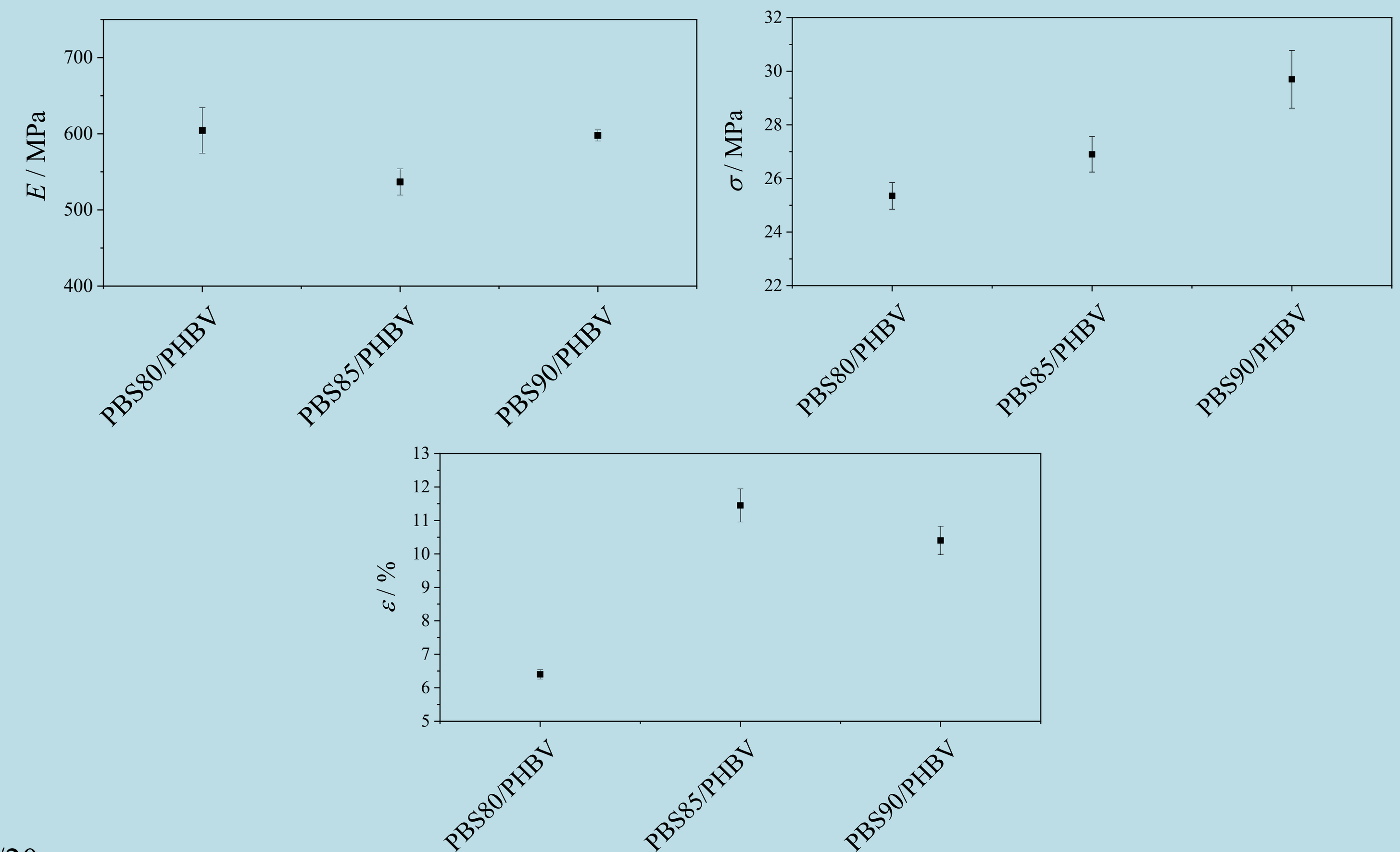


Fig. 6. Mechanical properties of PBS/PHBV blends at 80/20, 85/15 and 90/10 ratios

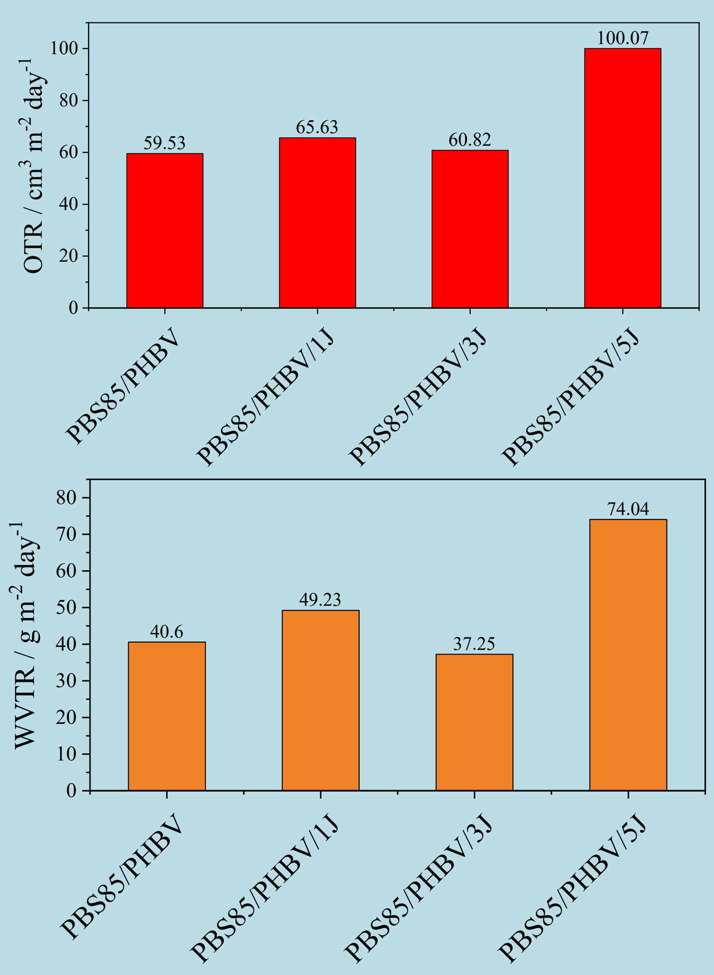


Fig 5. Barrier properties of PBS85/PHBV with 0–5 wt. % Joncryl.

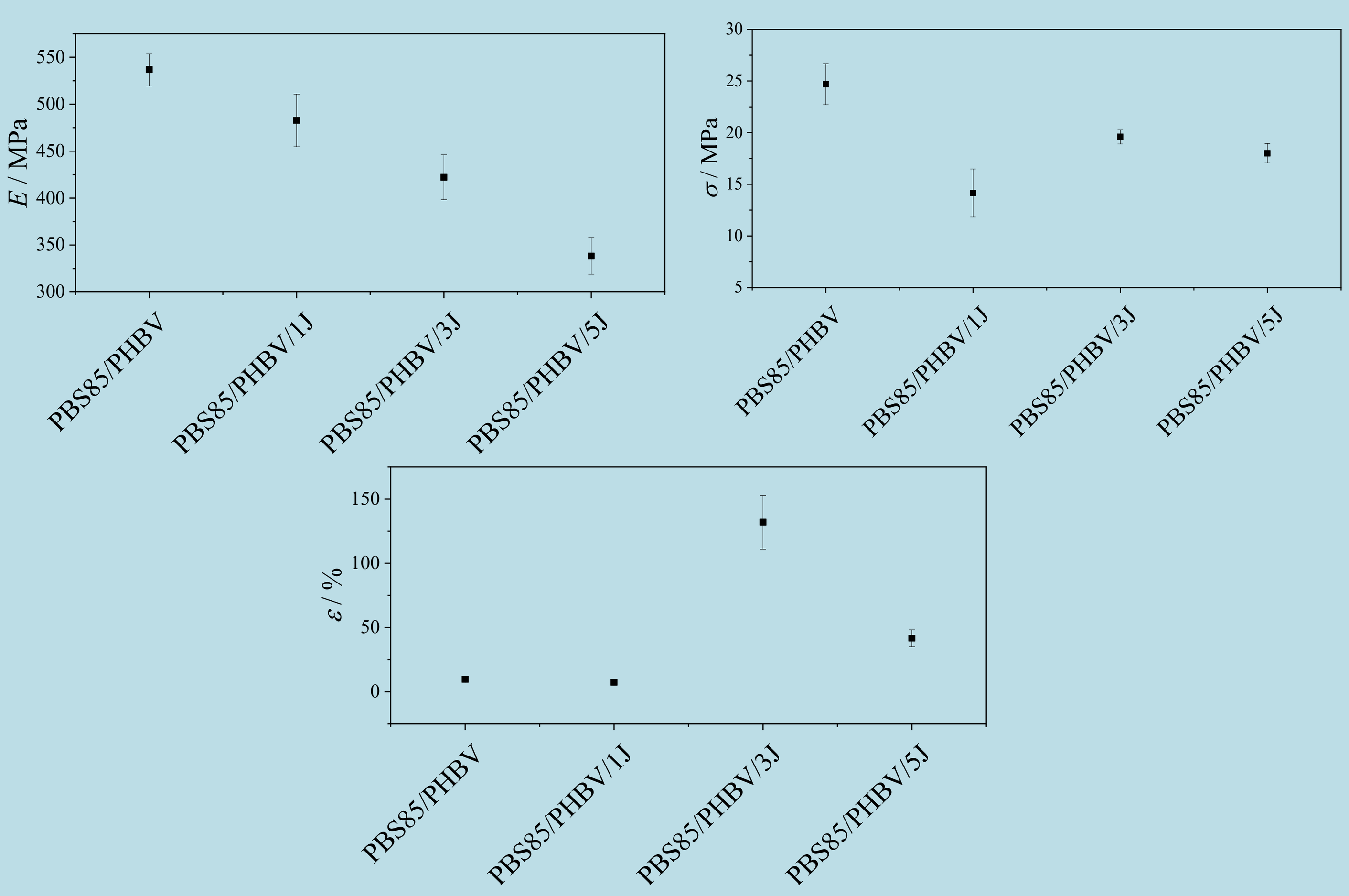


Fig. 7. Mechanical properties of PBS85/PHBV with 0–5 wt. % Joncryl.

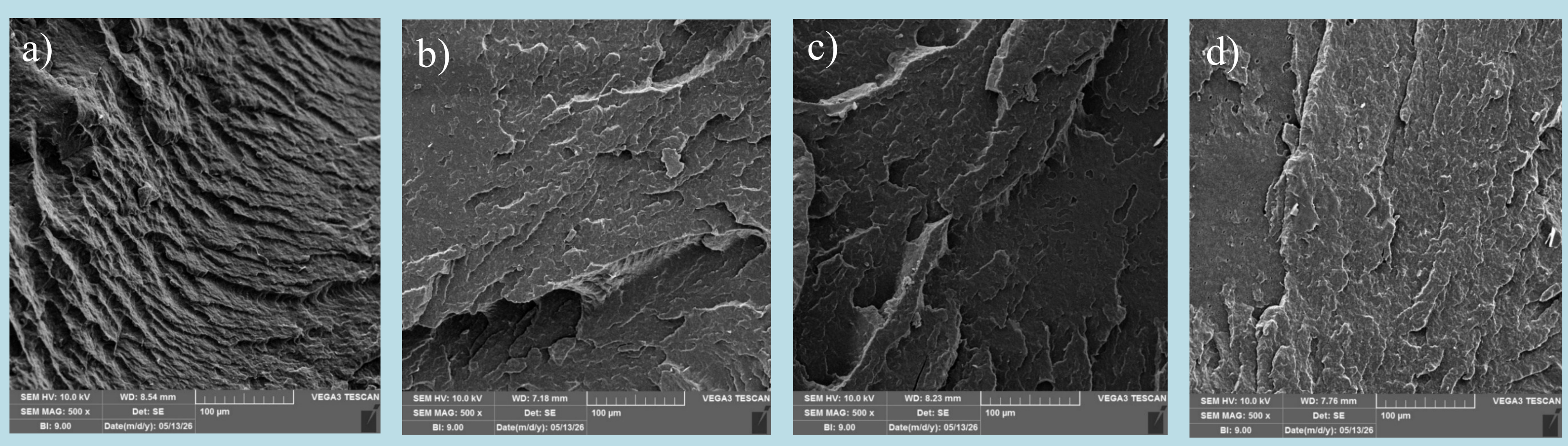


Fig.8. SEM micrographs of a) PBS85/PHBV b) PBS85/PHBV/J1 c) PBS85/PHBV/J3, and d) PBS85/PHBV/J5 at 500x magnification.

CONCLUSIONS

Initial screening of PBS/PHBV blends using thermal, mechanical, and barrier analyses identified PBS85/PHBV as the most suitable composition for further development. Further modification with Joncryl ADR 4468 showed that the blend containing 3 wt.% Joncryl exhibited the best overall performance. This composition demonstrated a significant increase in ductility, with elongation at break rising from 9.7% to 102%, along with improved barrier properties. Structural and thermal analyses supported these findings: SEM revealed improved phase dispersion, while DSC indicated enhanced compatibility between polymer phases. In addition, TGA/DTG analysis confirmed increased thermal stability of the modified blends. Overall, the PBS85/PHBV blend with 3 wt.% Joncryl represents a well-balanced biodegradable material, combining mechanical flexibility, thermal stability, and barrier performance suitable for food packaging applications.

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