

Development of Poly(ϵ -caprolactone) and Poly(L-lactide-co- ϵ -caprolactone) to Improve Mechanical and Thermal Properties for Artificial Cartilage Applications.

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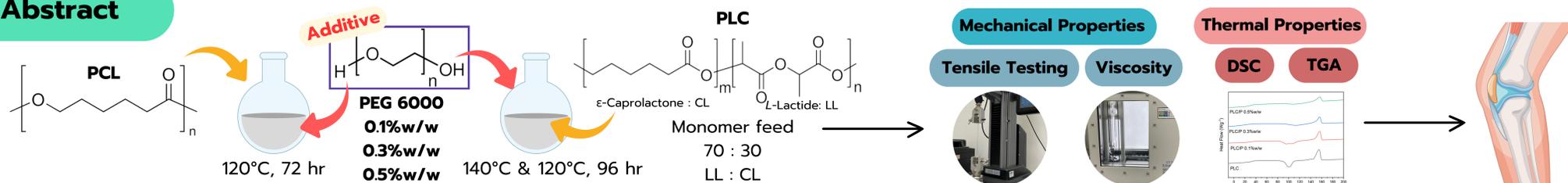
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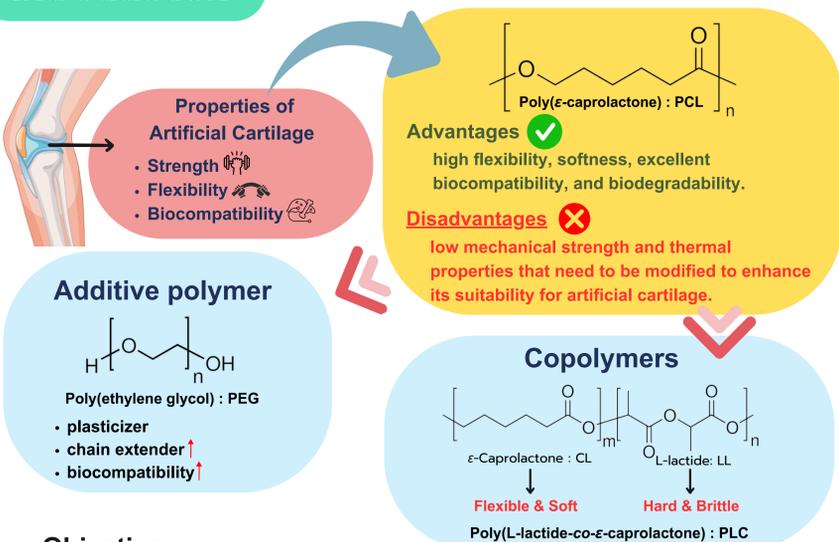
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Abstract



This study aimed to develop biodegradable polymers with appropriate the mechanical and thermal properties for artificial cartilage applications. The poor properties of PLC and PCL were enhanced by incorporating PLC and PCL with poly(ethylene glycol) (PEG) at 0.1, 0.3 and 0.5%w/w via ring-opening polymerization (ROP). The result found that adding 0.3%w/w of PEG into PLC can enhances their mechanical and thermal performance of PLC. Based on the analysis, the Young's modulus of PLC with PEG 0.3%w/w was observed about 231.14 MPa. At the same time, the elongation at break and the tensile strength were 76.37% and 8.06 MPa. Additionally, the inherent viscosity of PLC/PEG was 1.337 dL/g, which is shows an optimal range to maintain both strength and flexibility of PLC/PEG. For thermal properties, the T_g and T_c of PCL/PEG were 19.22 °C and 113.33 °C, respectively. The T_m and T_d were 156.33 °C, and 346.90 °C. These results suggest that PLC with 0.3%w/w PEG exhibits improved mechanical and thermal properties, making it a promising candidate for artificial cartilage applications.

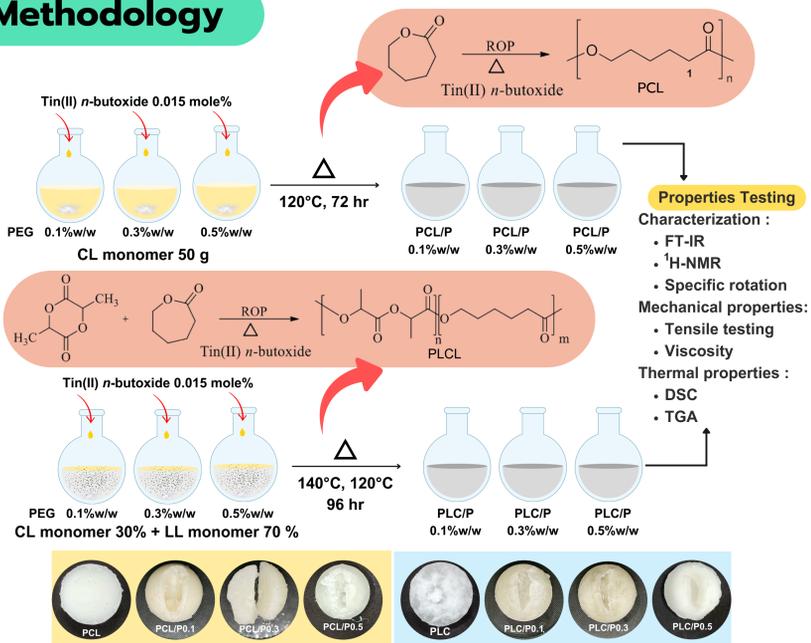
Introduction



Objective :

- To enhance the mechanical and thermal properties of PCL and PLC by incorporating PEG as an additive at concentrations of 0.1, 0.3, and 0.5%w/w.

Methodology



Conclusion

The addition of PEG enhances the mechanical and thermal properties of PCL and PLC. The strength of PCL/PEG was increased, resulting in enhancement the brittleness at high concentration compared to other samples. At the same time, PCL/PEG was increased in T_m and decreased in T_d . Moreover, the flexible property of PLC was improved with adding 0.3%w/w PEG. In conclusion, the addition of PEG into PCL and PLC matrix are the potential candidates for use as artificial cartilage applications.

Result & Discussion

Characterization and Mechanical Properties of Polymers

Table 1 : Polymers characterizations and mechanical properties.

Polymers	%conv. ^a	LL : CL ratio ^b	Specific rotation (°) ^c	Inherent viscosity (dl/g) ^d	Tensile strength(MPa) ^e	%strain at break ^e	Young's Modulus (MPa) ^e
PCL	95.99%	-	-	1.788 ± 0.040	14.88	110.86	244.18
PLC	93.70%	67 : 33	-128.11 ± 1.74	2.102 ± 0.047	12.40	227.53	162.51
PCL/P 0.1%w/w	90.19%	-	-	1.943 ± 0.019	12.28	88.01	309.97
*PCL/P 0.3%w/w	39.89%	-	-	0.473 ± 0.055	n.d.	n.d.	n.d.
PCL/P 0.5%w/w	98.04%	-	-	1.991 ± 0.051	9.730	28.82	302.78
PLC/P 0.1%w/w	75.93%	73 : 27	-126.03 ± 0.81	1.037 ± 0.053	9.154	19.48	269.37
PLC/P 0.3%w/w	91.70%	70 : 30	-127.90 ± 0.47	1.337 ± 0.070	8.064	76.37	231.14
PLC/P 0.5%w/w	92.97%	70 : 30	-124.48 ± 0.40	2.067 ± 0.020	9.158	130.36	149.03

^acalculated by gravimetry method, ^bcalculated by ¹H-NMR, ^ccalculated by polarimeter, ^dcalculated by viscometer, ^ecalculated by digital material tester
*PCL/P 0.3%w/w was not detected (n.d.) in the mechanical properties and IR spectrum because the polymer couldn't form a film.

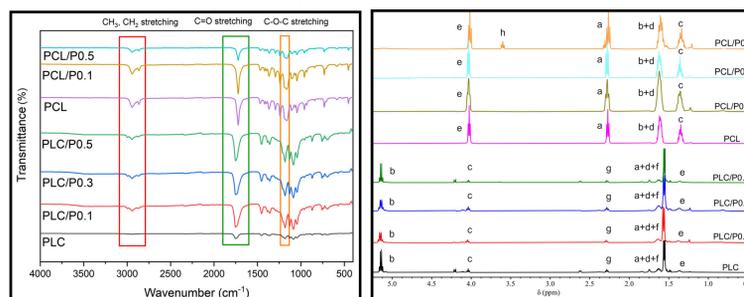


Figure 1 FT-IR spectra of polymers

Figure 2 ¹H-NMR spectra of polymers

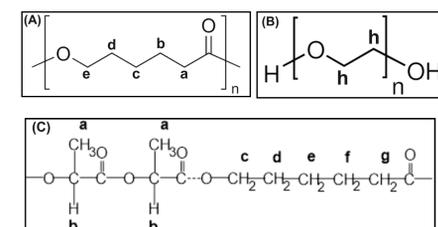


Figure 3 Structure of polymers (A) PCL and (B) PEG (C) PLC

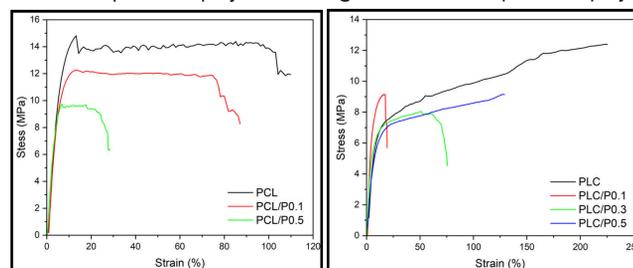


Figure 4 Stress-Strain curves of polymers

FT-IR and ¹H-NMR spectra were confirmed the structure of PCL and PLC. FT-IR spectra shows the Carbonyl and Ester groups, while the O-H group of PEG was disappeared due to low content of PEG. NMR spectra of PCL/P at 0.3%w/w shows a methylene group at δ -3.6 ppm peak, confirming PEG. Specific rotation was confirmed L-lactide characteristic. The addition of PEG into the PCL at 0.1%w/w was increased the stiffness; however the brittleness of PCL/PEG was increased with adding 0.5%w/w PEG. For PLC, the addition 0.1%w/w PEG was increased the brittleness, while 0.3 to 0.5%w/w PEG into PLC matrix were improved the elongation and strength properties, offering better balance.

Thermal Properties of Polymers

Table 2 : Polymers thermal properties.

Polymers	T_g (°C) ^a	T_m (°C) ^b	T_c (°C) ^b	T_d (°C) ^b
PCL	-	-	56.67	439.8
PLC	33.55	100.33	155.17	373.1
PCL/P 0.1%w/w	-	-	59.33	421.6
PCL/P 0.3%w/w	-	-	-3.33, 39.67	422.7
PCL/P 0.5%w/w	-	-	56.17	421.7
PLC/P 0.1%w/w	29.16	95.83	156.33	359.2
PLC/P 0.3%w/w	19.22	113.33	156.33	346.9
PLC/P 0.5%w/w	30.78	-	156.50	351.3

^acalculated by DSC, ^bcalculated by TG-DTA

The addition of PEG into the PCL and PLC matrix had a masked influence on polymers. The addition of 0.1%w/w PEG into PCL was increased the T_m ; however the PCL with PEG 0.5%w/w was decreased the T_d . The result found that the optimal amount should be below 0.5%w/w. Moreover, the T_g and T_c of PLC were depended on the PEG content. The PLC with PEG 0.1 and 0.3%w/w were decreased the T_d ; however the T_d of PLC was increased when adding 0.5% w/w PEG.

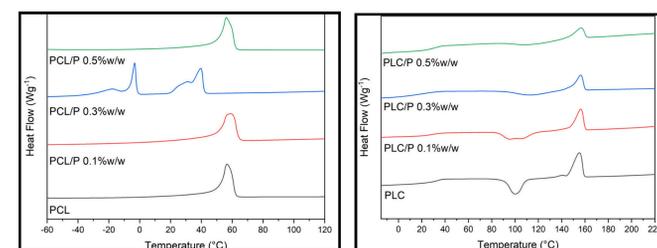


Figure 5 DSC thermograms of polymers

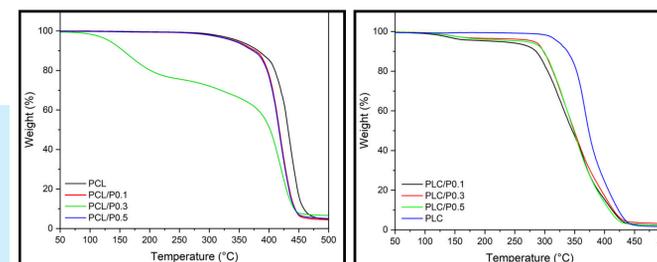


Figure 6 TGA curves of polymers

Acknowledgement

References

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