THERMALLY TRIGGERED SHAPE MEMORY BEHAVIOR OF BIODEGRADABLE PLC COPOLYMERS

CHIANG MAI UNIVERSITY CHEMISTRY

Saranya khamkhiao, Kiattikhun Manokruang , Kittisak Yarungsee , Jutamas Kongsuk
Department of Chemistry , Faculty of Science , Chiang Mai University
E-mail : Saranya_kh@cmu.ac.th and Kiattikhun.m@cmu.ac.th

ABSTRACT

Biodegradable shape memory polymers (SMPs) have attracted significant attention for biomedical and smart material applications. In this study, poly(ε-caprolactone-co-L-lactide) (PLC) with a caprolactone/L-lactide ratio of 70/30 were synthesized and investigated for their thermally triggered shape memory behavior. The prepared copolymers were fabricated into ball-shaped structures to evaluate their shape fixity and shape recovery performance. Thermal and mechanical properties of the copolymers were analyzed to understand the effect of monomer composition on shape memory performance. The PLC samples exhibited reversible deformation and recovery upon heating above their transition temperatures. Differences in recovery efficiency and structural stability were observed depending on copolymer composition, indicating that the ratio of hard and soft segments plays an important role in controlling shape memory properties. The results demonstrate that biodegradable PLC copolymers can function as effective thermally triggered SMPs and can be tailored for potential applications such as biomedical devices, smart drug delivery systems, and temporary implant materials.

Introduction

Shape memory polymers (SMPs) are smart materials that can be deformed into a temporary shape and recover their original shape when exposed to external stimuli, particularly heat. Thermally triggered SMPs have attracted significant interest for biomedical applications such as drug delivery systems, tissue engineering scaffolds, and implantable medical devices. Among biodegradable polymers, poly(L-lactide-co-ε-caprolactone) (PLC) and lactide/poly(ethylene glycol) copolymer (PLE) are promising due to their biocompatibility and tunable thermal and mechanical properties. In this study, PLC and PLE copolymers were synthesized and their chemical structure, thermal properties, and thermally triggered shape memory behavior were investigated to understand the relationship between polymer composition and shape memory performance.

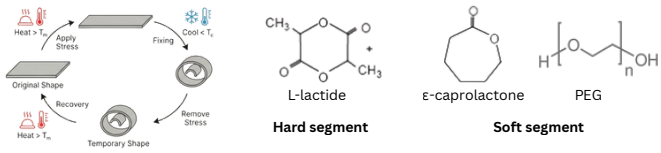


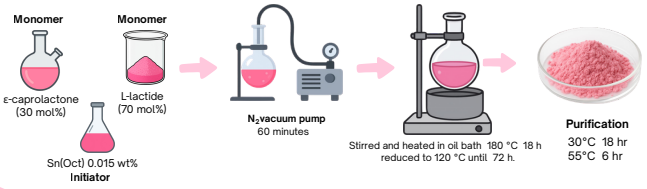
Fig.1 scheme of a Shape memory polymer: a) SMPs Programing , b) Hard segment materials (L-lactide) c) Soft segment (ε-caprolactone and PEG)

Objectives

1. To synthesizePLC with ratio of 70/30 via ring-opening polymerization.
2. To investigate The Thermally Triggered shape memory behavior of the composite materials.
3. To compare the shape memory performance of PLC and PLE in order to identify the more suitable material for shape memory applications.

Methodology

- **Synthesis of PLC and PLE**



Characterization

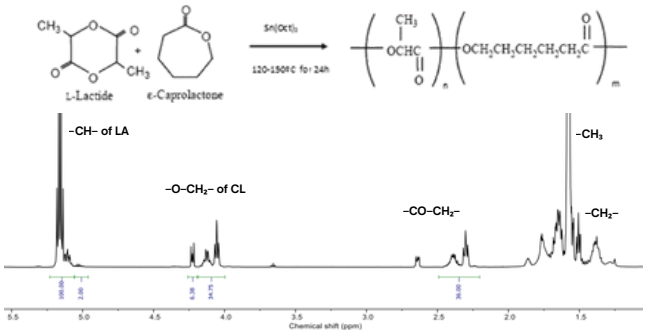


Fig.3 schemeof Proton nuclear magnetic resonance spectroscopy (^{1}H-NMR) PLC 70/30 , Synthetic route for PLC

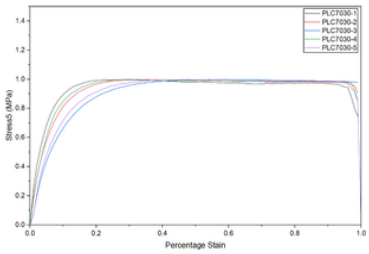
- LL/CL was 74.30/25.70 mol% %conversion ≈ 94.15%
- T_g = 27.59 °C by DSC Analysis T_m = 151.33 °C by DSC Analysis
- Intrinsic viscosity (IV) ≈ 0.5 – 1.5 dL g^{-1}

Reference

- Copolymers and Their Crystallization Performance with PDLA and PLLA Composite Films. *Materials* **2024**, *17*, 2105. https://doi.org/10.3390/ ma17092105
- Yarungsee K. et al. (2025). European Polymer Journal, 234, 113998.
- Nocita D, Forte G, Drakopoulos SX, Visco A, Gianporcaro A, Ronca S, Processing and characterization of bio-polyester reactive blends: From thermoplastic blends to cross- linked networks, Polymer (2017)

Result and Discussion

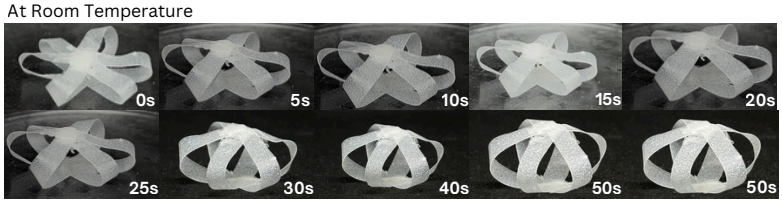
Tensile Mechanical Properties



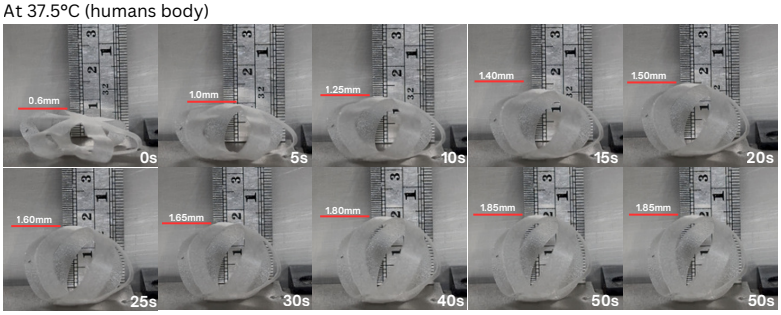
polymer	Stress at break (MPa)	Average ± S.D	Young's modulus. (MPa)	Average ± S.D.
PLC-7030-1	62.98		214.00	
PLC-7030-2	95.43		217.98	
PLC-7030-3	54.18	27.57 MPa	215.06	6.73 MPa
PLC-7030-4	81.81		216.30	
PLC-7030-5	124.57		230.90	

Shape memory Performance

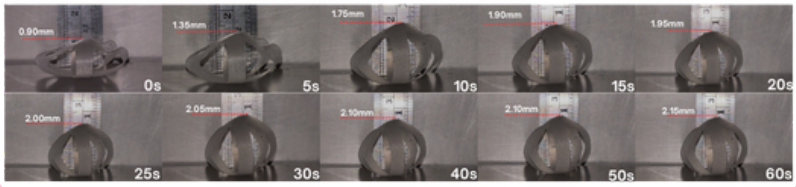
At Room Temperature



At 37.5°C (humans body)



At 50°C



Conclusion

This study investigated the thermally triggered shape memory behavior of biodegradable poly(ε-caprolactone-co-L-lactide) (PLC) copolymers with a 70/30 ratio synthesized by ring-opening polymerization. The copolymer composition was confirmed by ^{1}H-NMR (LL/CL = 74.30/25.70). Thermal and mechanical analyses indicated suitable properties for shape memory performance. The PLC copolymer showed effective shape recovery when heated, demonstrating its potential for biomedical and smart material applications.

Ackhowledgement

we are grateful to Assoc. Prof. Dr. Kiattikhun Manokruang. And both of Co- Advisor , Dr.Kittisak Yarungsee(P'Deam) and Miss Jutamas Kongsuk(P'Pook). This work has been deliberate developed by Research group of ISO Laboratory , Department of Chemistry, Faculty of Science , Chiangmai University.