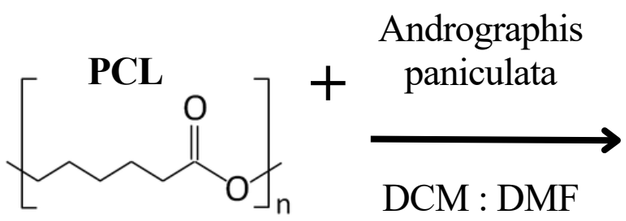
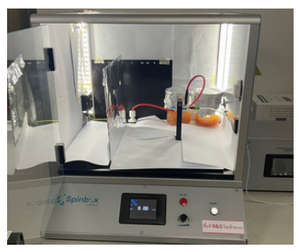
Design and Fabrication of Poly(ε-caprolactone) Nanofibers for Use as Biodegradable Wound Dressing Applications.

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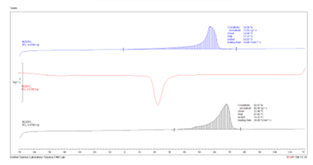
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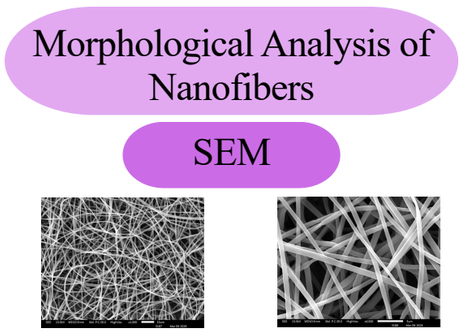
Abstract









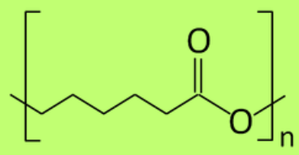


Chronic wounds, particularly pressure ulcers in bedridden patients, remain a major clinical challenge due to persistent inflammation, elevated risk of infection, and impaired tissue regeneration. The development of wound dressing materials that provide both structural support for cellular infiltration and intrinsic biological functionality is therefore of significant importance. This study aimed to fabricate electrospun nanofibrous wound dressings based on poly(ε-caprolactone) (PCL) incorporated with an extract of Andrographis paniculata to enhance anti-inflammatory and antioxidant performance. PCL was synthesized via ring-opening polymerization (ROP) of ε-caprolactone monomers. The resulting polymer was characterized in terms of solution viscosity and thermal properties to ensure suitability for electrospinning. Electrospinning parameters were systematically investigated, including polymer solution concentrations 8, 10, 12, 14,16, 18 and 20% w/v, flow rates 0.05, 0.10 and 0.20 ml/min, a fixed collector distance of 15 cm, and an applied voltage of 15 kV. The polymer solutions were supplemented with A. paniculata extract at concentrations ranging from 1, 3 and 5% v/v prior to fiber fabrication. The morphology of the electrospun fibers was evaluated using Scanning Electron Microscopy (SEM), and fiber diameters were measured using ImageJ software. The results demonstrated that increasing extract content significantly affected fiber diameter and mechanical properties, indicating that extract incorporation alters both solution characteristics and fiber formation behavior. Mechanical performance was likewise influenced in a concentration dependent manner. Overall, the incorporation of Andrographis paniculata extract into electrospun PCL nanofibers represents a promising strategy for developing multifunctional wound dressings that integrate structural integrity, mechanical robustness, and bioactive functionality within a single material platform. This work highlights a materials driven design approach toward clinically relevant wound dressings suitable for long term therapeutic applications.

Introduction



Conventional wound dressings often provide limited functionality, as they mainly act as physical barriers and may not actively support the healing process.



Advantages
high flexibility, softness, excellent biocompatibility and biodegradability

Disadvantages
PCL itself lacks intrinsic antibacterial and anti-inflammatory properties, which are important for preventing infection and promoting wound healing.

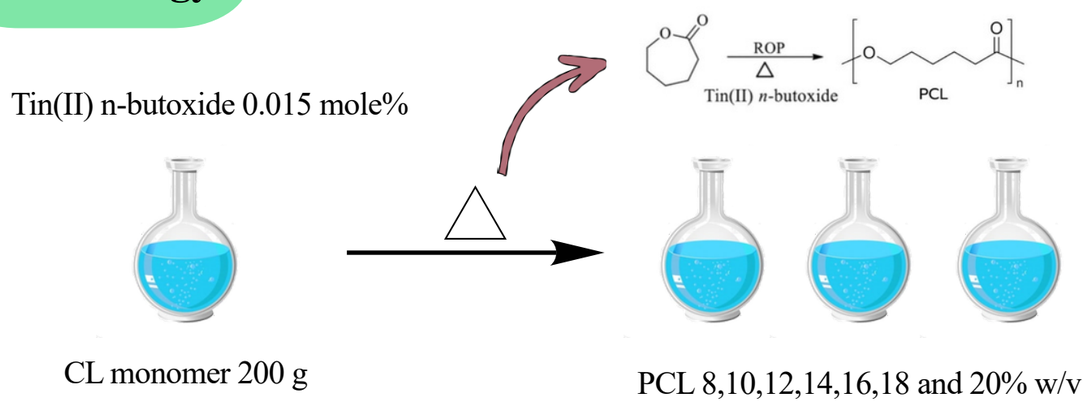
antimicrobial, anti-inflammatory, and antioxidant properties.



Objective :

- design and fabricate PCL nanofibers incorporated with A. paniculata extract using the electrospinning technique.
- The morphology and characteristics of the fabricated nanofibers were investigated to evaluate their potential application as biodegradable wound dressing materials.

Methodology



Properties Testing
Mechanical properties :
- Viscosity

Thermal properties :
- DSC

Morphological Analysis of Nanofibers :
- SEM

Conclusion

The results showed that poly(ε-caprolactone) was successfully synthesized. The inherent viscosity (ηinh) analysis indicated that the obtained polymer had an appropriate molecular weight, suggesting that the polymerization process occurred effectively. Thermal analysis using Differential Scanning Calorimetry (DSC) revealed a melting temperature and thermal behavior consistent with the typical properties of poly(ε-caprolactone), indicating the presence of crystalline regions in the polymer structure. Furthermore, the morphological study using Scanning Electron Microscopy (SEM) at magnifications of 1000x and 4000x showed that the fibers were continuous and had relatively smooth surfaces, indicating that the polymer could be successfully processed into fibers.

Result & Discussion

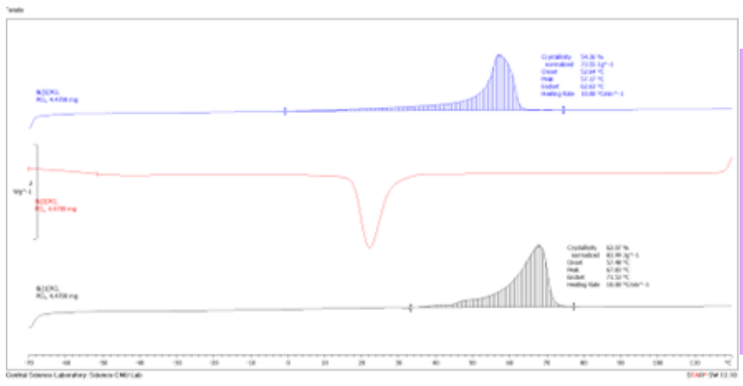
Mechanical Properties of Polymer

Table 1 : Inherent viscosity (η_{inh}) of poly(ε-caprolactone).

Polymer	Weight (g)	Concentration (g/dl)	η_{inh} (g/dl)	Average η_{inh} (g/dl)	SD
PCL	0.0255	0.1020	1.5920	1.5615	0.0266
	0.0251	0.1004	1.5433		
	0.0259	0.1036	1.5491		

The viscosity analysis of Polycaprolactone showed that the average inherent viscosity obtained from the measurements was approximately 1.56 g/dL, with a relatively low standard deviation (SD).

Thermal Properties of Polymer



The thermal properties of the nanofibers were analyzed using Differential Scanning Calorimetry. The DSC thermogram of Polycaprolactone showed an endothermic peak at approximately 58–65 °C, which corresponds to the melting temperature (Tm) of PCL and is consistent with values reported in the literature. This result indicates that the crystalline structure of PCL was maintained.

Figure 1 DSC thermograms of PCL

Morphological Analysis of Nanofibers

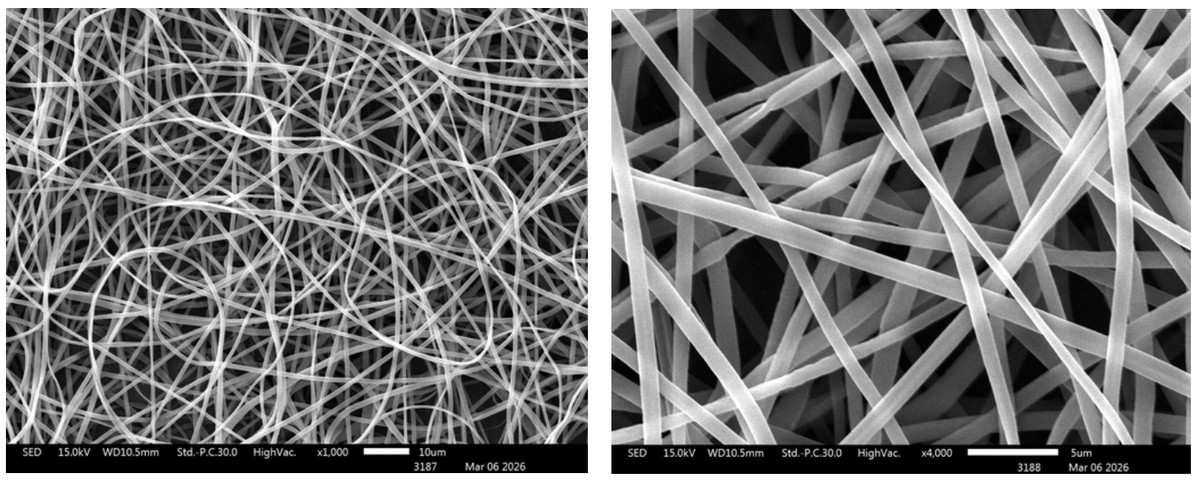


Figure 2 Morphology of electrospun fibers observed by Scanning Electron Microscopy at magnifications of 1000× and 4000×.

The results showed that fibers fabricated from pure PCL exhibited an average diameter of 0.535 ± 0.32 µm. When the herbal extract was incorporated at a concentration of 1% v/v, the average fiber diameter slightly increased to 0.592 ± 0.20 µm. However, increasing the extract concentration to 3% v/v and 5% v/v significantly reduced the average fiber diameter to 0.247 ± 0.16 µm and 0.228 ± 0.063 µm, respectively. Comparison of the obtained fiber morphologies indicated that fibers containing 5% v/v of the extract exhibited the smallest diameter and the most uniform fiber structure. Such smaller fiber diameters are advantageous for wound dressing applications because nanofibers with smaller diameters provide a higher specific surface area, which can enhance cell adhesion and improve the release efficiency of bioactive compounds from the incorporated herbal extract.

Acknowledgement

CHIANG MAI UNIVERSITY
CHEMISTRY
Bioplasorb BPLCMU

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