Campus Teltow

Understanding Degradation and Mechanical Performance of Hyper-elastic Polylactide Copolymers through Bulk and Ultrathin Film Analysis Correlation

Hanin Alkhamis[1], Shivam Saretia[1], Rainhard Machatschek[1], Sahar Salehi-Müller[2], Axel T. Neffe[1], Katarzyna Polak-Krasna[1]

[1] Institute of Active Polymers, Helmholtz-Zentrum Hereon, Kantstrasse 55, 14513 Teltow, Germany
[2] Department of Biomaterials, University of Bayreuth, Prof.-Rüdiger-Bormann-Straße 1, 95447 Bayreuth, 95447 Bayreuth, Germany

Introduction

- Degradable polyesters (e.g. polyglycolide, polylactide, and poly(ε-caprolactone)) have been extensively used in biomedicine[1]
- Understanding their properties is critical for good clinical outcomes
- **However**, several aspects are not fully understood especially for novel materials; their molecular processes need to be better understood
- Recently, hyperelasticity was shown in **novel-in house developed system** composed of Poly[(L-lactic acid)-*co*-caprolactone] (PLLAcoCL), blended with Poly(D-lactic acid) (PDLA)[2]
- **Here**, we investigate the degradation behavior of the polymer system (in bulk films, electrospun meshes, and ultrathin films), exploring its applicability as a covering material for cardiovascular implants (i.e. cardiac occluders; example shown in Figure 1)

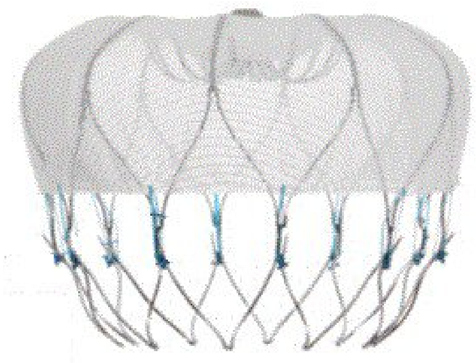

Figure 1: Boston Scientific's Left Atrial Appendage Occluder[3]

Methodology

Bulk Degradation

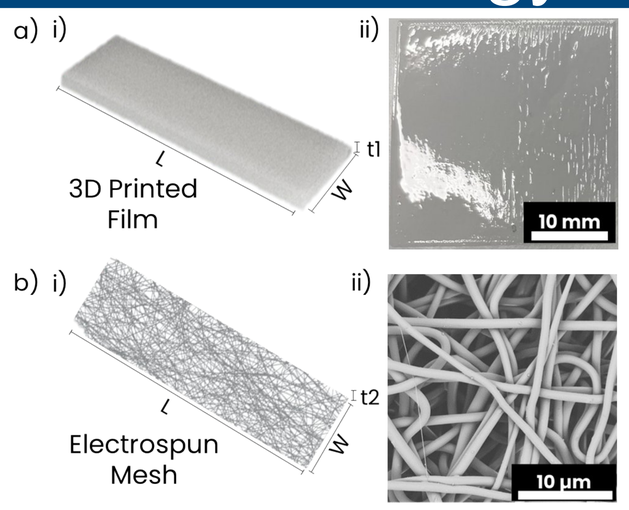

Figure 2: Structure and dimensions of samples prepared for bulk degradation experiments ai) 3D printed film, aii) macroscopic image, bi) electrospun mesh, iv) SEM image prepared by blending 95:5 PLLAcoCL203:PDLA20. *L=30mm, W=10mm, t1=5mm , t2=0.5mm*

Degradation Conditions: in PBS, 37 °C

Results

➢ **Increase in crystallinity during degradation leads to changes in mechanical properties**

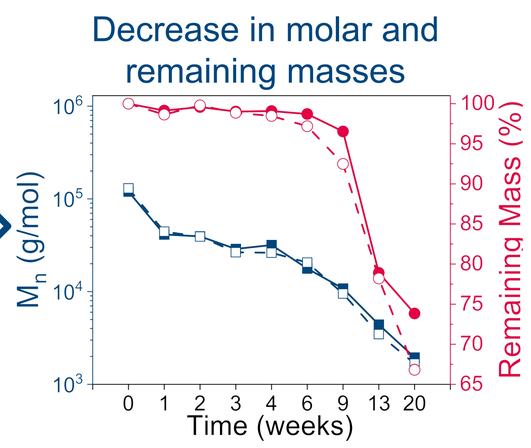

Figure 3: Reduction of both Molar (black) and remaining mass (red) over 20 weeks

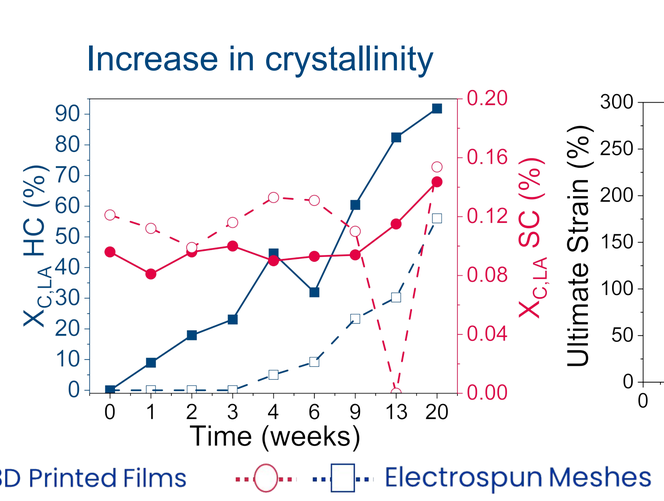

Figure 4: Increase in relative crystallinity of homocrystallites (HC) and stereocrystallites (SC) over time due to the increased movement of chains

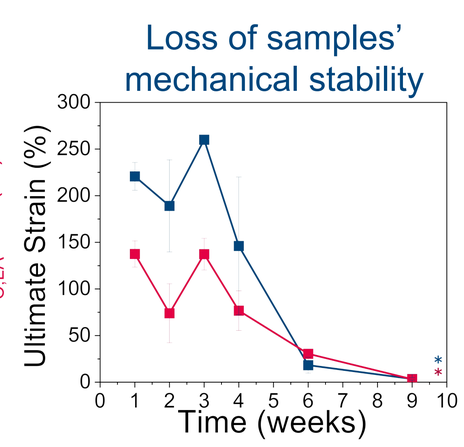

Figure 5: Decrease in ultimate strain over time

Ultrathin Films Degradation

➢ Via the Langmuir Technique[4,5]

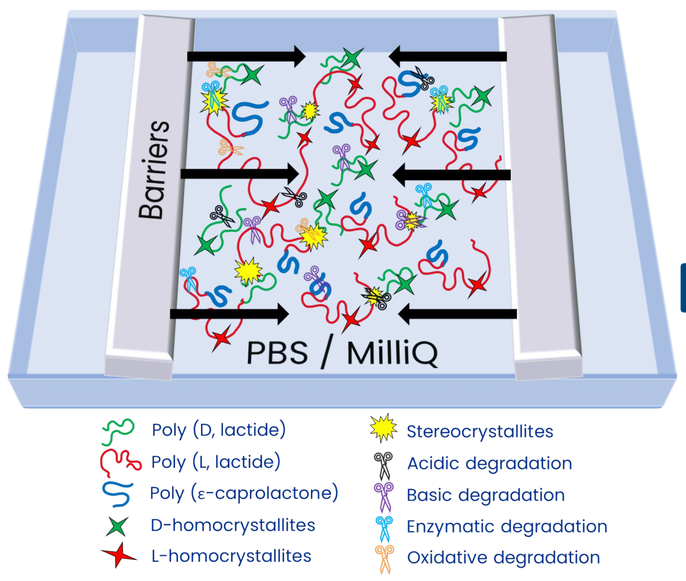

Figure 6: Schematic representation of the Langmuir degradation setup for PLLAcoCL, PDLA and blends

Formation of a monolayer of amphiphilic molecules over a liquid surface

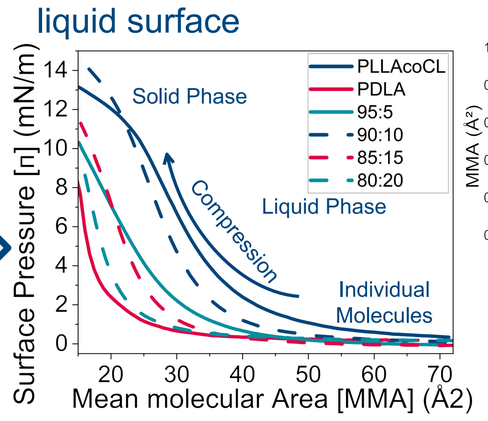

Figure 7: Increase in surface pressure upon compression, molecules change from individual molecules state to solid phase

Degradation or formation of crystals upon compression

Confirmed by

➢ **Degradation was observed under basic conditions but not in acidic, oxidative or enzymatic conditions**

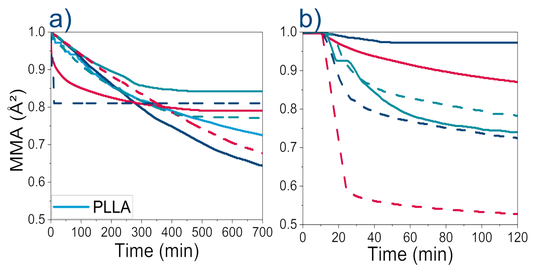

Figure 8: Surface pressure decreases over time in a) enzymatic and b) basic conditions

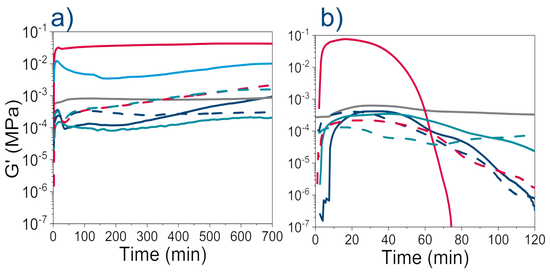

Figure 9: **Interfacial rheology** results; an increase in G' correlates to crystallization of films in enzymatic conditions (a), decrease in G' correlates to degradation under basic conditions (b)

Conclusion and Outlook

- Sample composition (i.e. blending ratios) influences both degradation rate and mechanism, this can be tailored to the intended application
- The investigated degradation of the polymer system implies a promising potential of PLA-based materials being applied in cardiac implants and coverings
- Bulk degradation of different blends is in progress; allowing the ability to correlate thin film versus bulk degradation depending on the blend
- Data obtained will serve as input data for degradation material models to develop digital twins
- Applications as cardiac implants coverings will be further explored

References

1. Ikada, Y. et al, Macromolecular Rapid Com., 2000
2. Neffe, A.T., et al., *Nanomaterials*, 2021
3. Grygier, M., et al., *Short Communication*, 2020
4. Saretia, S.. et al, Biomed. Materials, 2019
5. Izraylit, V., et al., MRS Com., 2021

Helmholtz-Zentrum Hereon • Kantstraße 55 • 14513 Teltow I Germany • www.hereon.de/biomaterials
Contact: Hanin Alkhamis • T +49 3328 352-234 • **hanin.alkhamis@hereon.de**

BSRT Berlin School for Regenerative Therapies
Universität Potsdam
HELMHOLTZ GEMEINSCHAFT
Bundesministerium für Bildung und Forschung