Poly(hydroxy-oxazolidone) Thermoplastic Elastomers for Safer and 3D Printable Blood-Contacting Medical Devices

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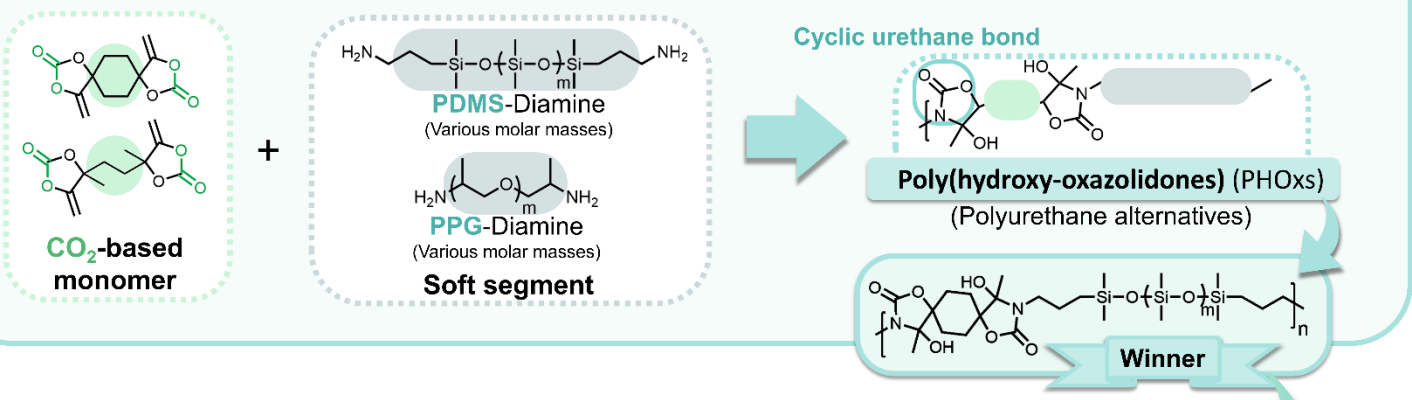
1 INTRODUCTION

Polyurethanes are among the most produced families of polymer in the world and are used in many applications, including in the biomedical field, such as in catheters, cardiac-assist devices and various implants. Unfortunately, they are produced from highly toxic reagents (isocyanates), responsible for environmental and health issues. The aim of this work was therefore to develop a **new alternative biomaterial** by using a **greener and safer synthetic route**. A poly(hydroxy-oxazolidone) (**PHOx**), containing cyclic urethane linkages, exhibiting remarkable thermoplastic elastomer properties and **suitable** for various processing technologies, including **3D-printing** and **electrospinning** was thereby obtained by reaction between precisely chosen **CO_2-sourced** cyclic carbonate and diamine monomers.

2 SYNTHESIS

Different compositions were tested to obtain a material that has properties suitable for cardiovascular devices:



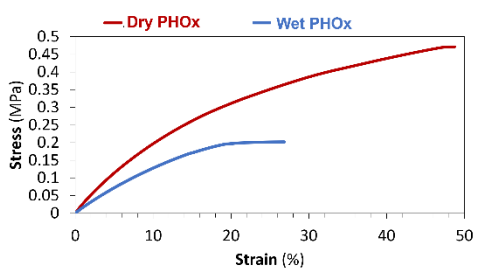
3 CHARACTERIZATION

Physico-Chemical Properties

	$T_{d,10\%}$ (°C)	EWA (%)	Contact Angle (°)	Mechanical Properties					
				E_{dry} (MPa)	E_{wet} (MPa)	σ_{dry} (MPa)	σ_{wet} (MPa)	ε_{dry} (%)	ε_{wet} (%)
PHOx	437	5.9 ±1.5	105 ±1	2.5 ±0.03	1.6 ±0.01	0.5 ±0.06	0.2 ±0.03	52.6 ±11.2	23.9 ±4.2

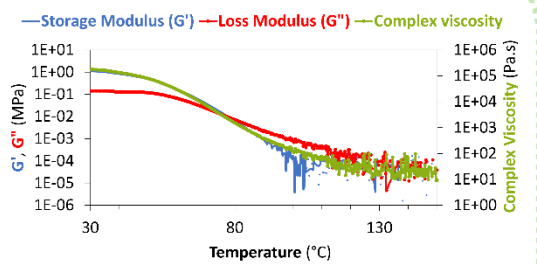
This **PHOx is a thermoplastic elastomer**, in addition to being hydrophobic and thermally stable

Mechanical Properties



✓ **Elastomeric behavior**, PHOx can be used for soft biomedical implants or catheters

Rheological Measurements



✓ **Thermoplastic,** can be easily (re)processed by thermal-based manufacturing techniques

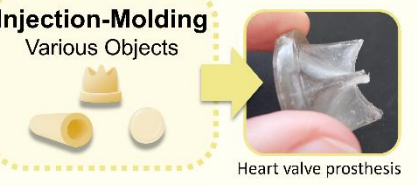
4 PROCESSING

✓ PHOx-based **objects of various architectures can be produced** by traditional industrial processes & innovative technologies

Hot press
Film

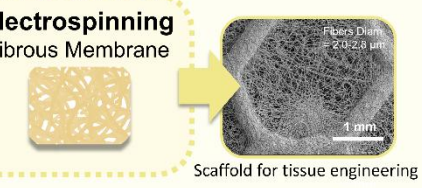
Extrusion
Filament

Injection-Molding
Various Objects



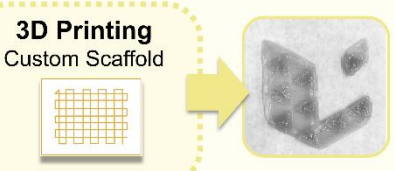
Heart valve prosthesis

Electrospinning
Fibrous Membrane

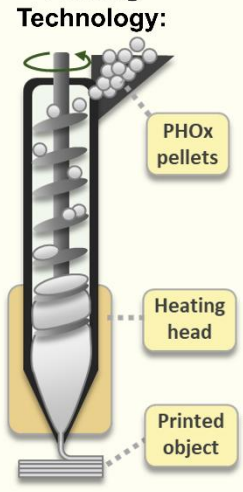


Scaffold for tissue engineering

3D Printing
Custom Scaffold



Printing Technology:

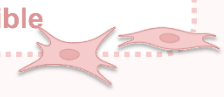


Next Step:
Custom Implants!

Biological Testing

Biocompatibility

✓ **Non-cytotoxic** with fibroblasts and HUVEC cells
➔ Biocompatible



Hemocompatibility

✓ Non-hemolytic
✓ Low platelet adhesion
✓ Long plasma clotting time
➔ Hemocompatible
➔ Low thrombogenicity

Antibacterial Assays

✓ **Antifouling properties** against *Staphilococcus Epidermidis*

***In vivo* Subcutaneous Implantation**

✓ **No inflammation** after 1 month in rabbits

This new, safer and greener biomaterial has better biological performance than medical-grade polyurethane!

5 CONCLUSION

- The analysis of the physicochemical properties and the *in vitro* and *in vivo* compatibility studies performed on this new highly promising biomaterial prove its **suitability for use in biomedical applications** (e.g., cardiovascular implants/devices).
- Its thermoplastic behavior allows its easy processing by various thermal-based techniques, including 3D-printing, which also shows the future **possibility of customizing parts for personalized devices/implants**.

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