Synthesis, Characterization and Processing of Novel Polymer Materials for Biomimetic Implants

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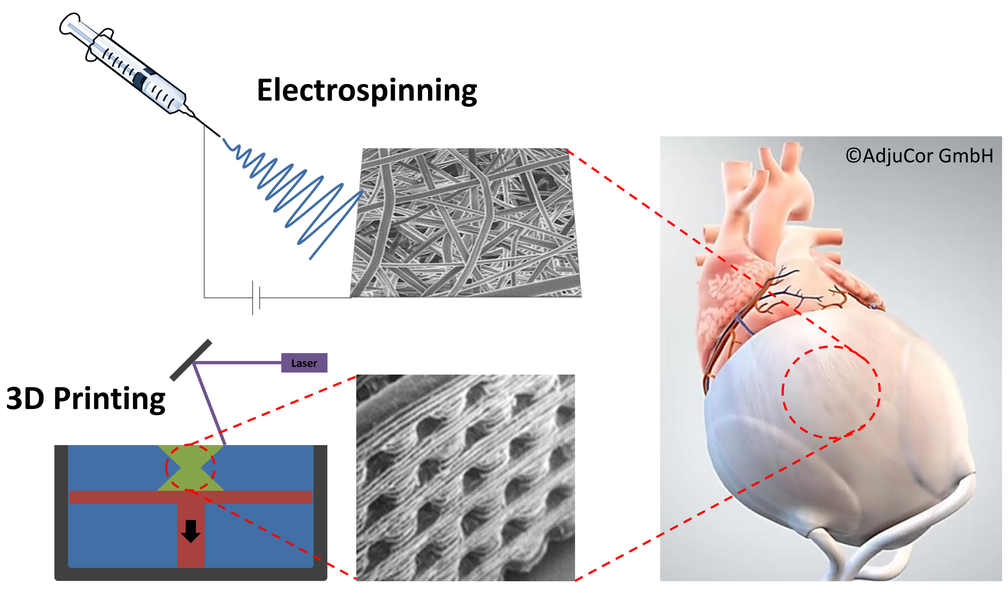
Aims of the PolyKARD Project

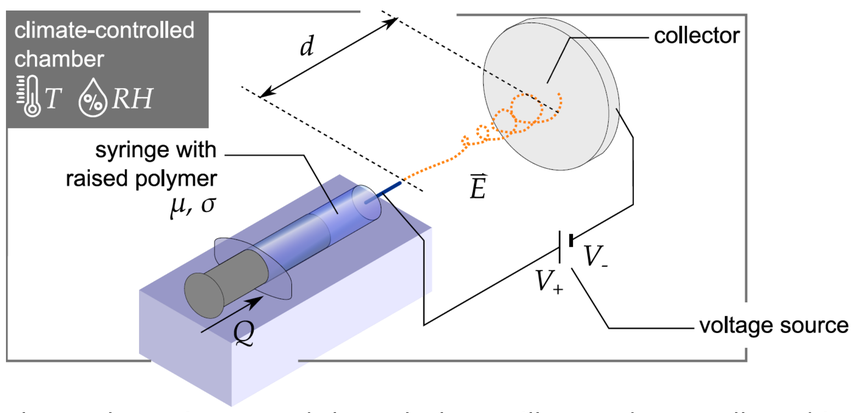
- Developing novel flexible polymers with mechanical properties corresponding to pericardium for fabricating a sleeve as a support system for the heart.



- Using non-isocyanate urethane (NIU) chemistry to synthesize monomers and polymers without using toxic isocyanates and tin compounds.
- Processing the monomers and polymers through digital light processing (DLP) and electrospinning to fabricate polymers with entangled and non-entangled segments or collagen hybrid systems, which mimic the non-linear properties of the pericardium.

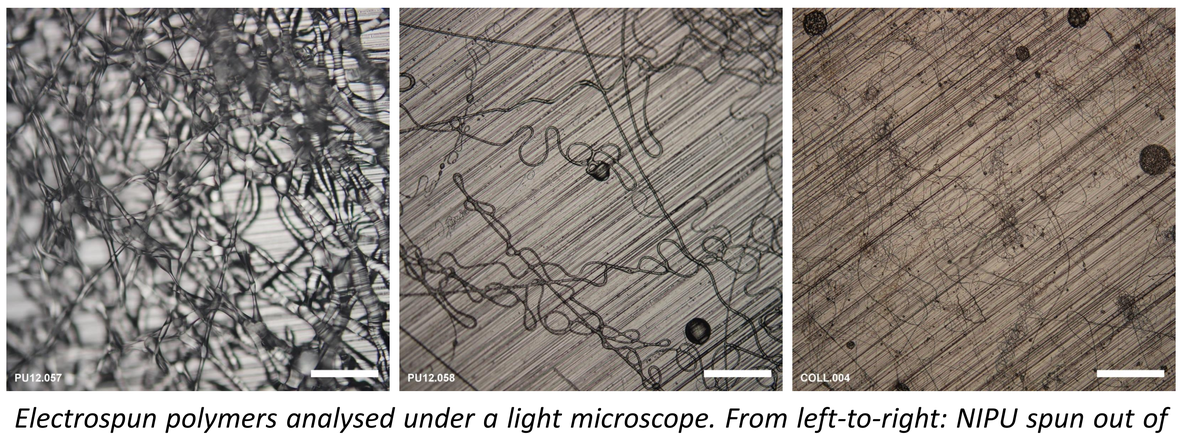
Electrospinning

- By means of electrospinning, polymer solutions are processed into porous, fibrous carrier substrates.



Process: Dissolved or molten polymer is pumped through the capillary and gets collected in a small conic-shaped droplet (Taylor cone) on the tip of the capillary, when high voltage is applied. When the electrical field is appropriately increased, a fibre is ejected from the Taylor cone and travels in spinning motion towards the collector, while the solvent evaporates.

- Polymers were spun using different solvents, which in turn thoroughly influence the microstructure of fibers.

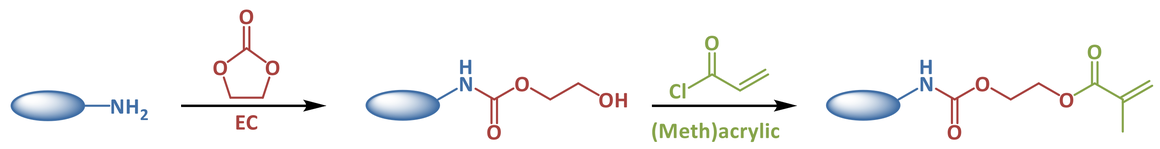


Electrospun polymers analysed under a light microscope. From left-to-right: NIPU spun out of 40% THF, NIPU spun out of 27% HFIP, and collagen spun out of an 8% PBS/ethanol mixture. Scale bar: 200 µm. All concentrations are given in (w/w).

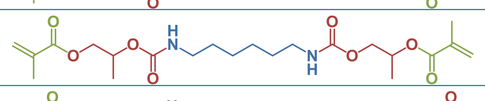
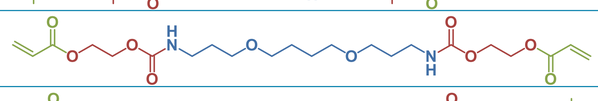
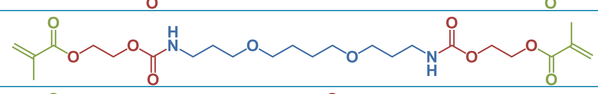
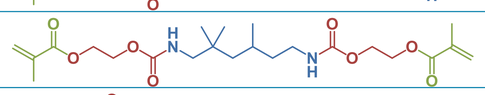
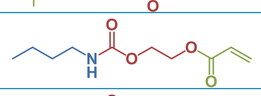
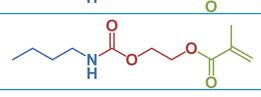
- NIPUs have the potential to fabricate fibrous microstructures by means of electrospinning, when dissolved in HFIP and THF.
- Collagen can be electrospun using a gentle PBS/ethanol mixture.

NIU Monomers

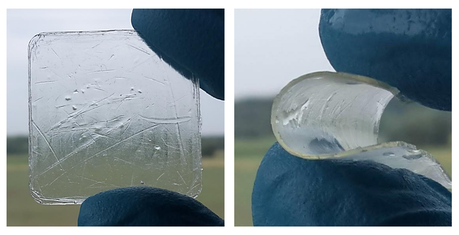
- A library of photo-active urethane-acrylate monomers was developed through NUI chemistry. Amine and diamine compounds were converted to hydroxylureathanes through the reaction with ethylene carbonate. Later, the hydroxyl groups of the hydroxylureathanes are converted to the (meth)acrylates through reaction with (meth)acryloyl chloride.



Synthesis route for NIU monomers

Name	Chemical Structure	Meting Point	Cured Sample
UrDMA1		76 °C	hard
UrDMA2		–	less flexible
UrDA1		31 °C	less flexible
UrDMA3		43 °C	flexible
UrDMA4		–	hard
UrA1		2 °C	very flexible
UrMA1		3 °C	hard

- The NIU monomers containing a photo-initiator cured instantly under UV light.

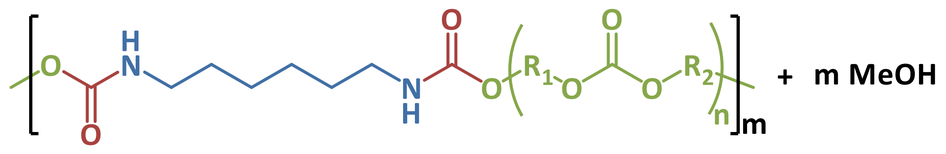


Photos of cured samples based on UrDMA1 (left) and UrDA1 (right)

Non-Isocyanate Polyurethanes (NIPUs)

- High-molecular non-isocyanate polyurethanes (NIPUs) were prepared through transurethanization reaction of dimethyl hexane-1,6-diyldicarbamateand polycarbonate diols.

Dimethyl hexane-1,6-diyldicarbamate **Polycarbonate diol**



NIPUs

Synthesis route for NIPUs

- The prepared NIPUs have molecular weights in the range of 14.000-26.000 g/mol and melting points of 44-108 °C.

Outlook

- Synthesis of high molecular weight NIPUs for more elastic high performance materials
- SEM imaging of electrospun scaffolds to assess fiber size and porosity
- Functionalization of collagen to develop of reactive fibrous hybrid systems based on combination of NIPUs and collagen.

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