

## Introduction

New function-integrative material solutions which offer significant added value in terms of resource efficiency with a simultaneous increase in functionality are necessary. Also the increasing demand for individualization and small batch sizes requires highly flexible, cost-effective and reliable manufacturing technologies.

The main objective of the project was to develop an individually heatable TPU molded part that can be produced by automatized highly flexible thermofforming processes from a flat, electrically conductive TPU composite, as well as the necessary control and regulation technology.

for more information:



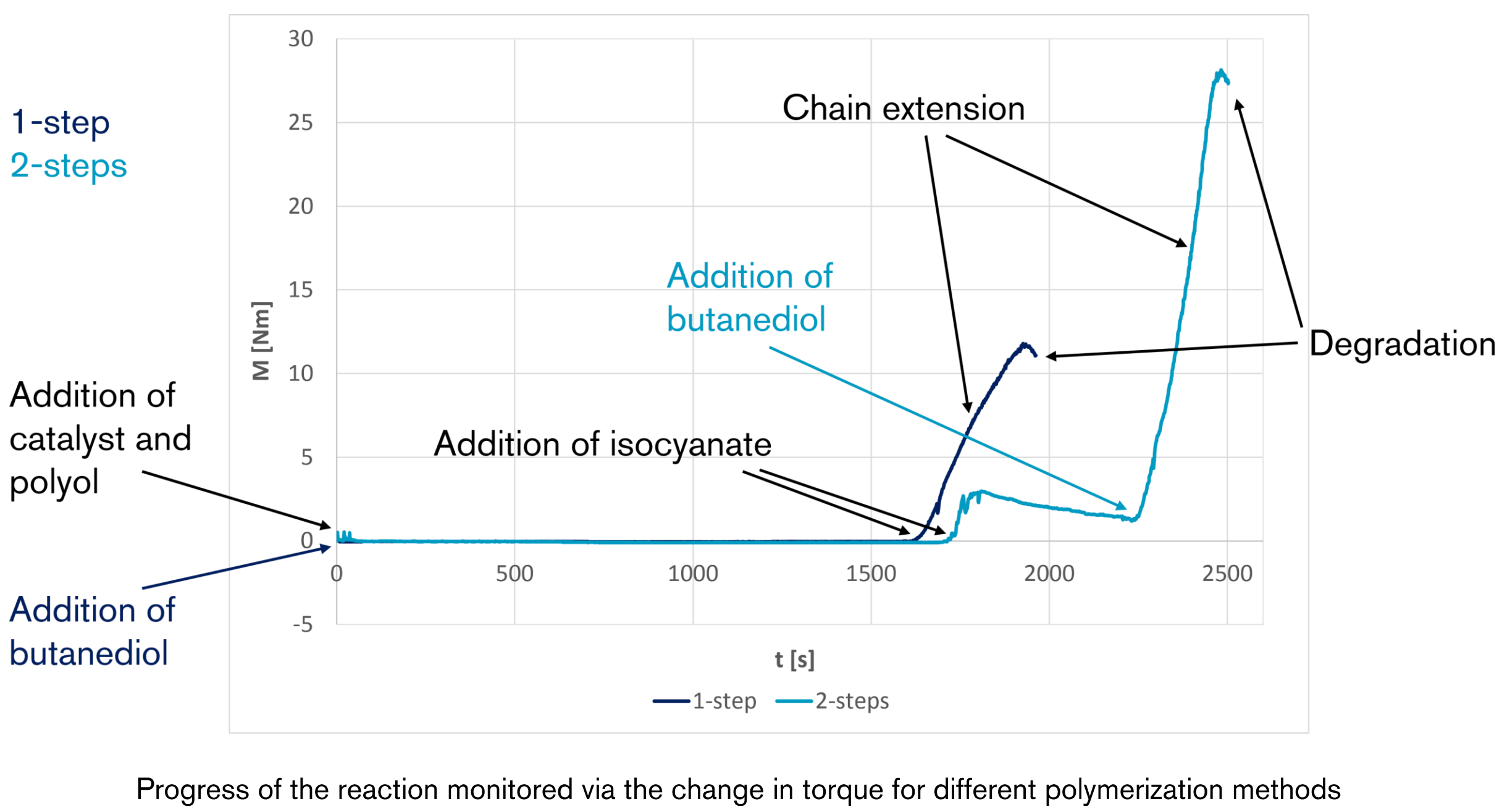
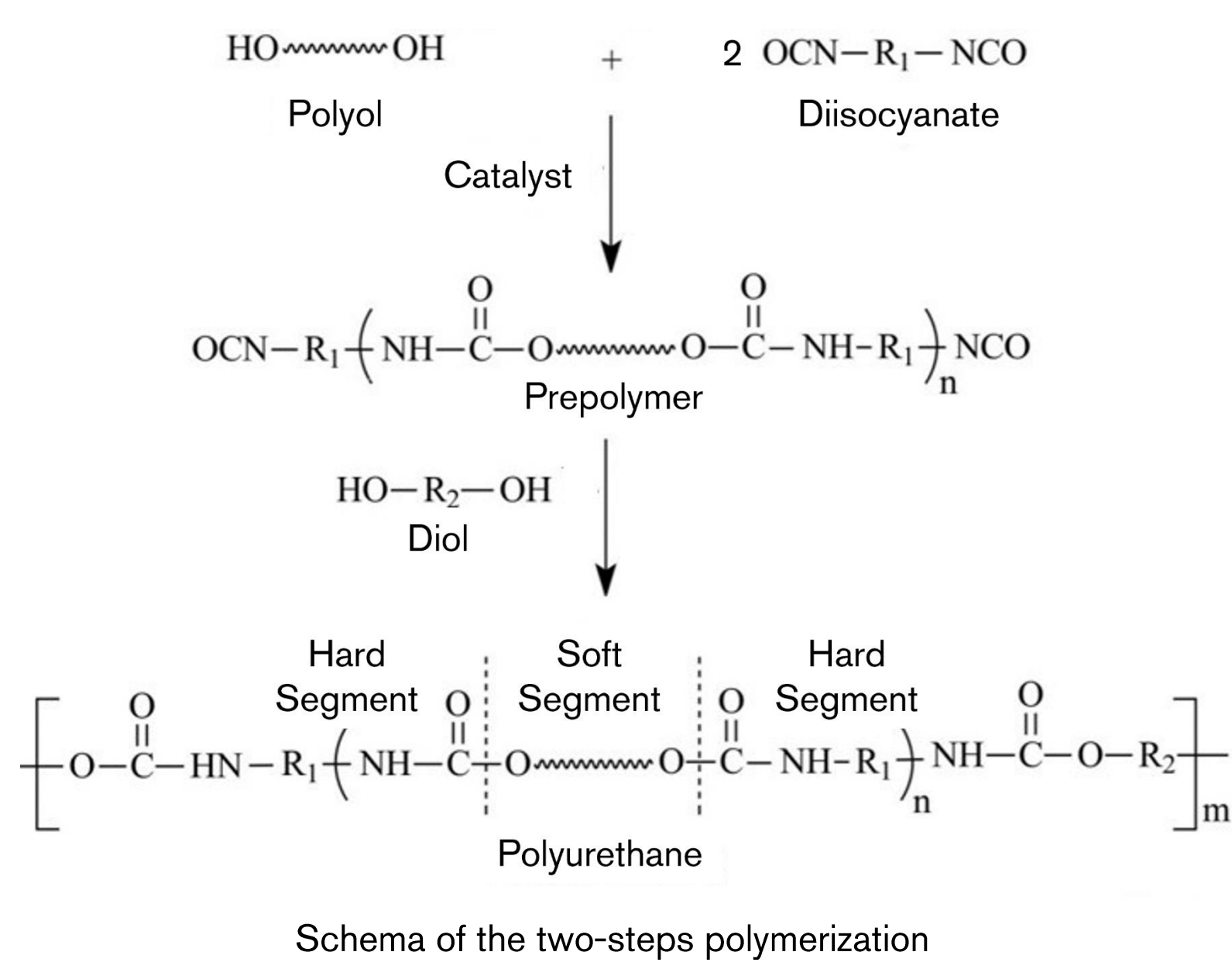
SCAN ME!

## Preliminary studies in a kneader

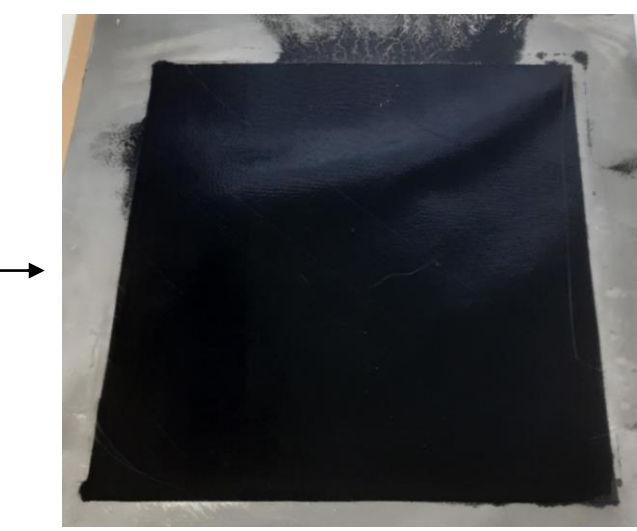
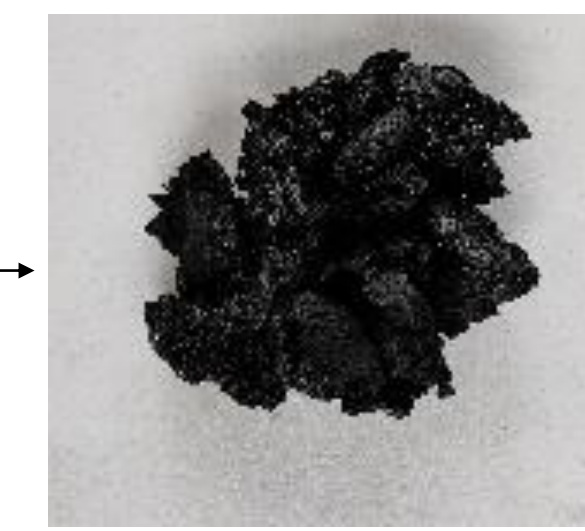
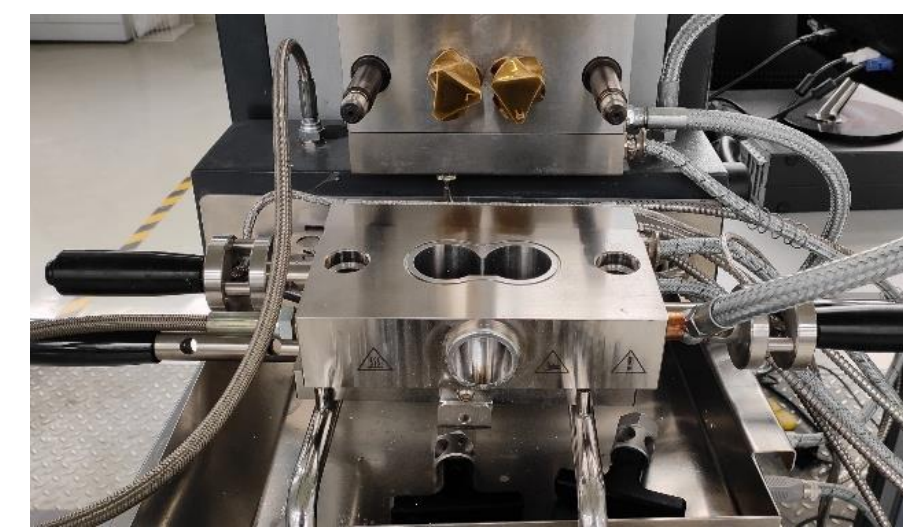
synthesis of TPU via one-step and two-steps polymerization

varied parameters:

biobased isocyanates  
biobased polyols  
temperature  
catalyst type  
catalyst concentration  
kneading elements

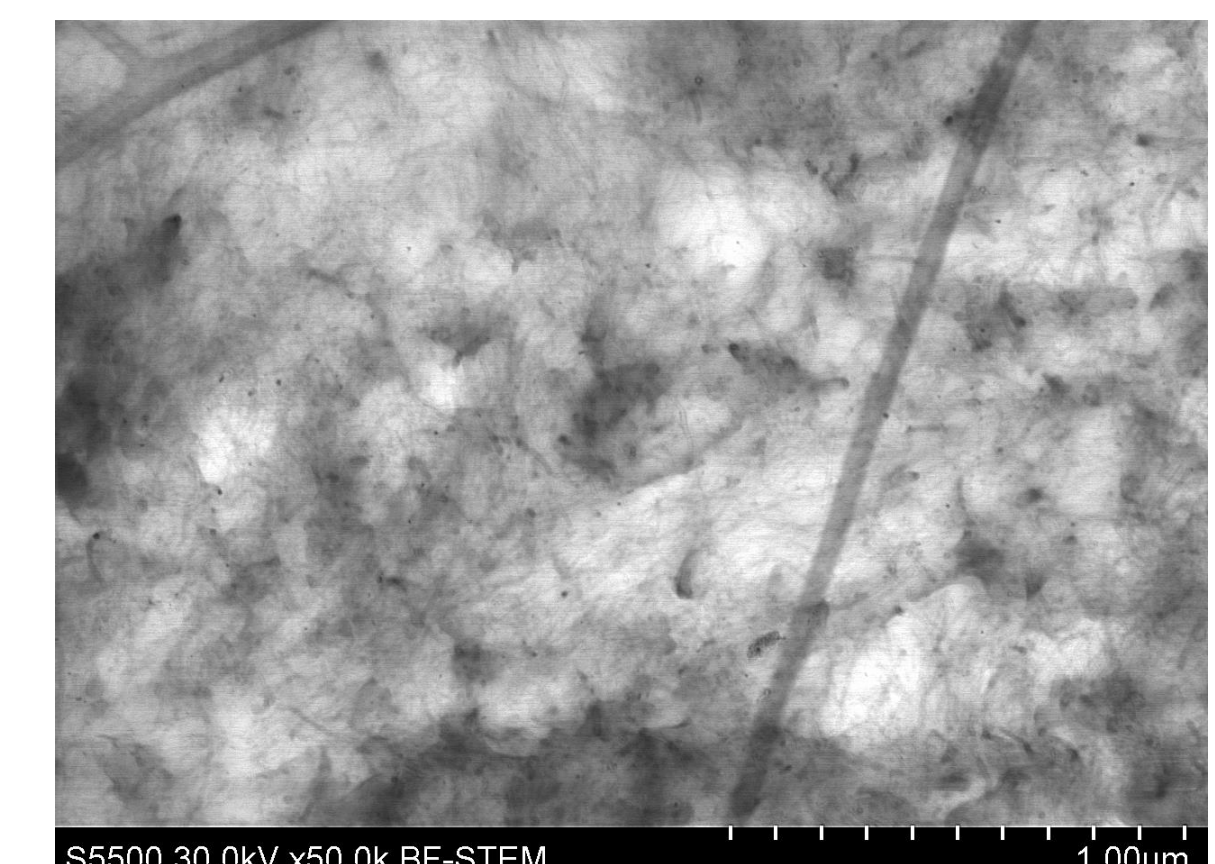
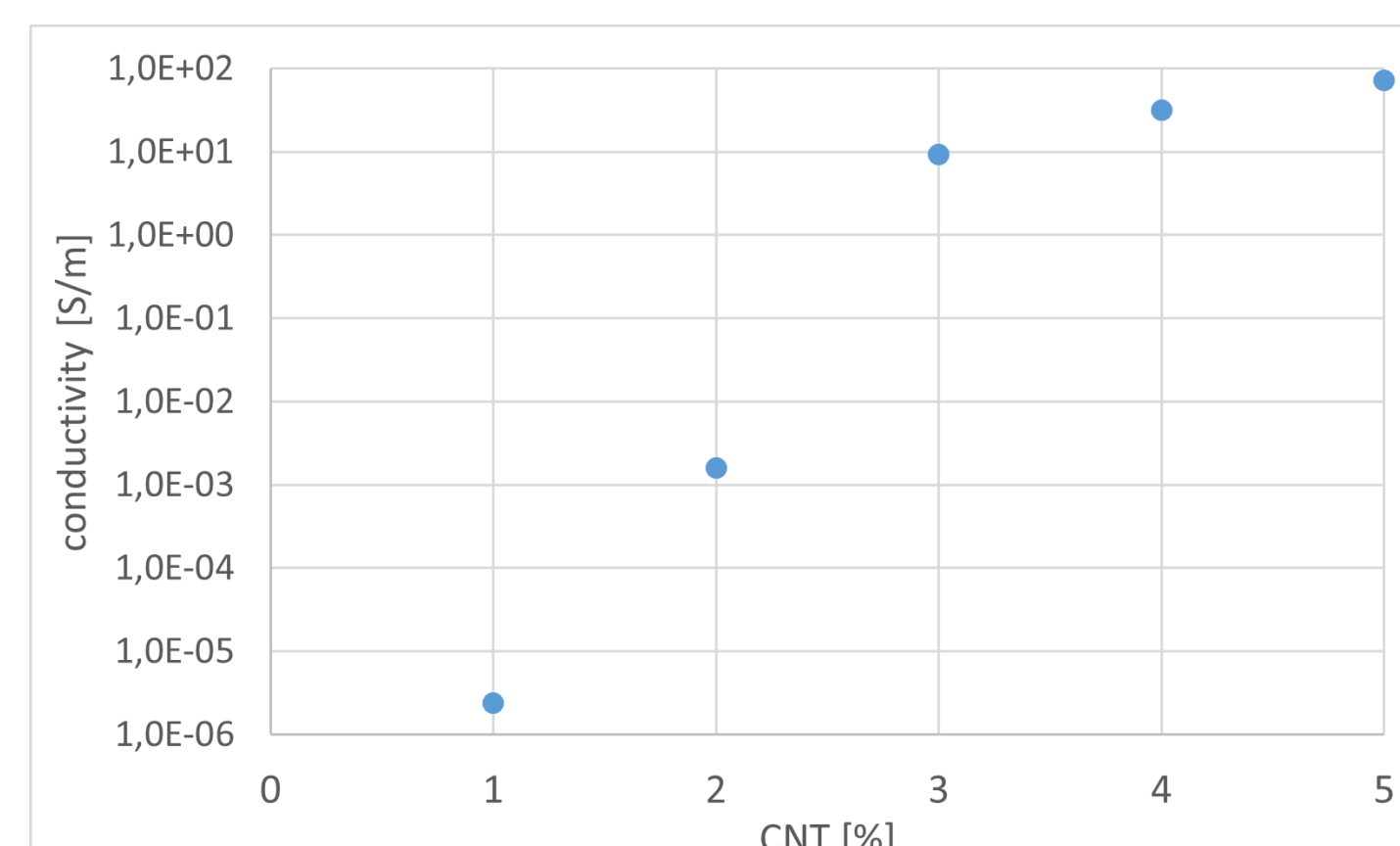


## Electrically conductivity and heating characteristics

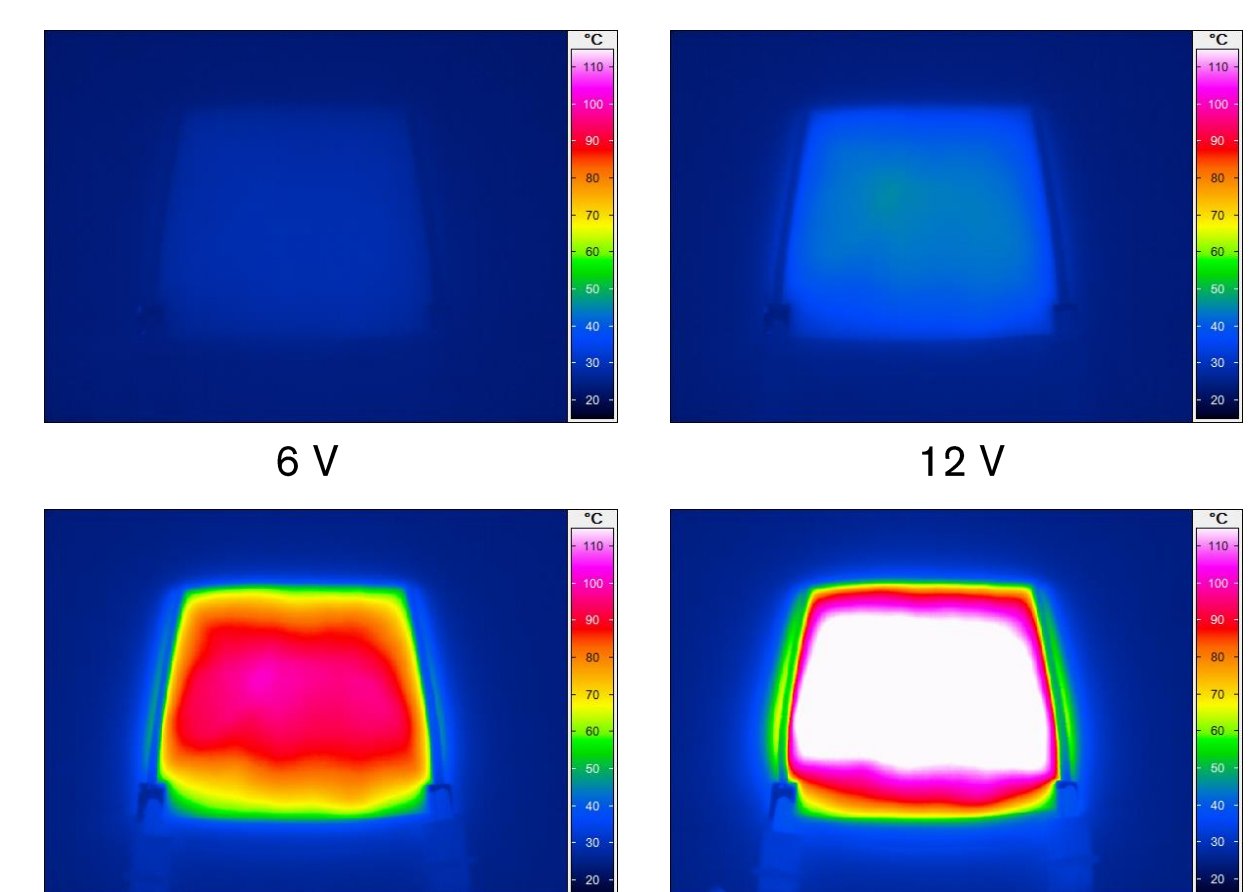
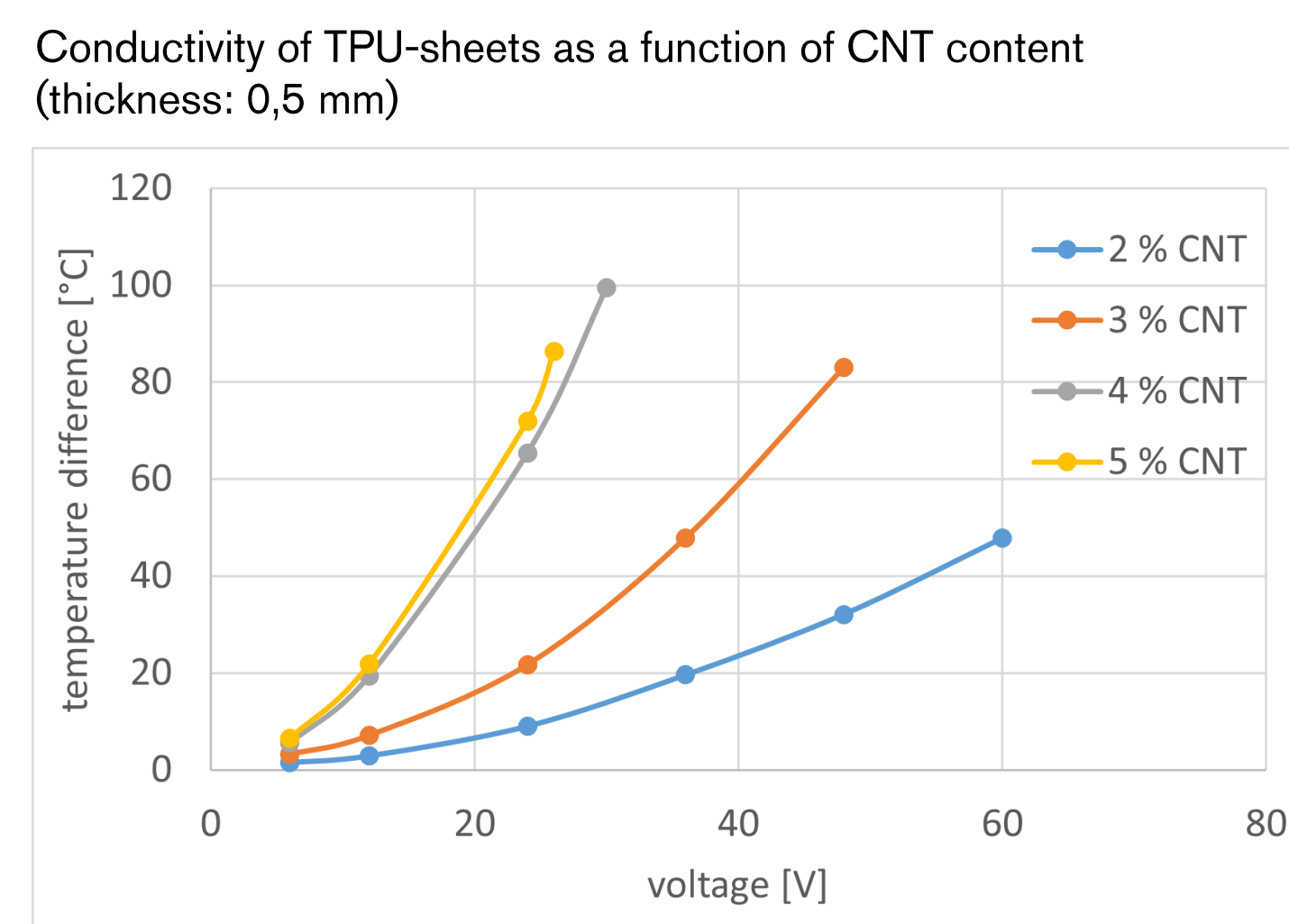


analysis:

- electrically conductivity
- heating behavior
- TEM
- mechanical properties



CNTs form a electrically conductive network



even distribution of CNTs leads to uniform heating behavior

## Reactive extrusion process

1. step: working CNTs in polyol in a kneader grinding of polyol-CNT lumps

advantages:

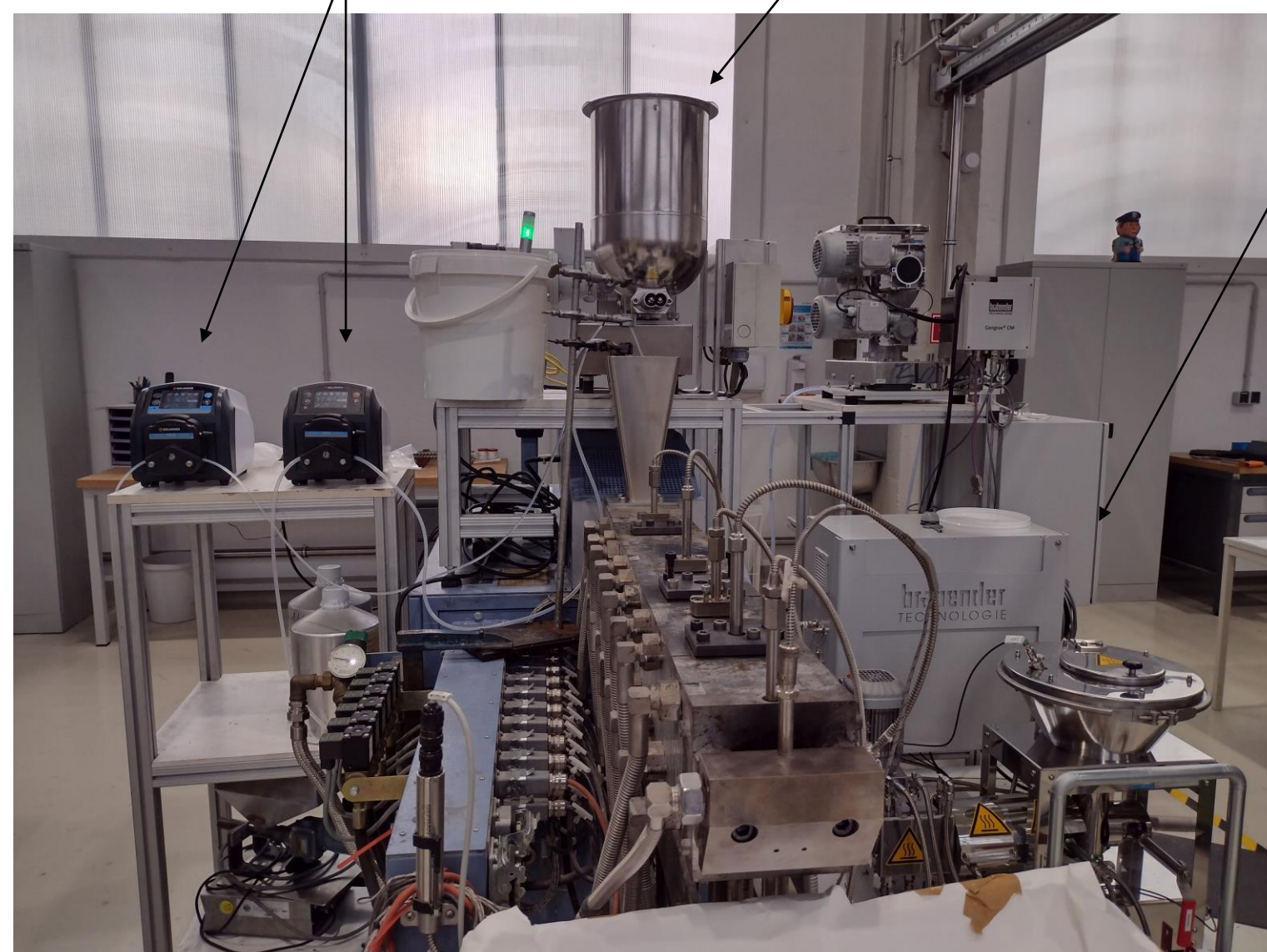
breaking CNT-agglomerates, separation of CNTs easier dosing to extruder



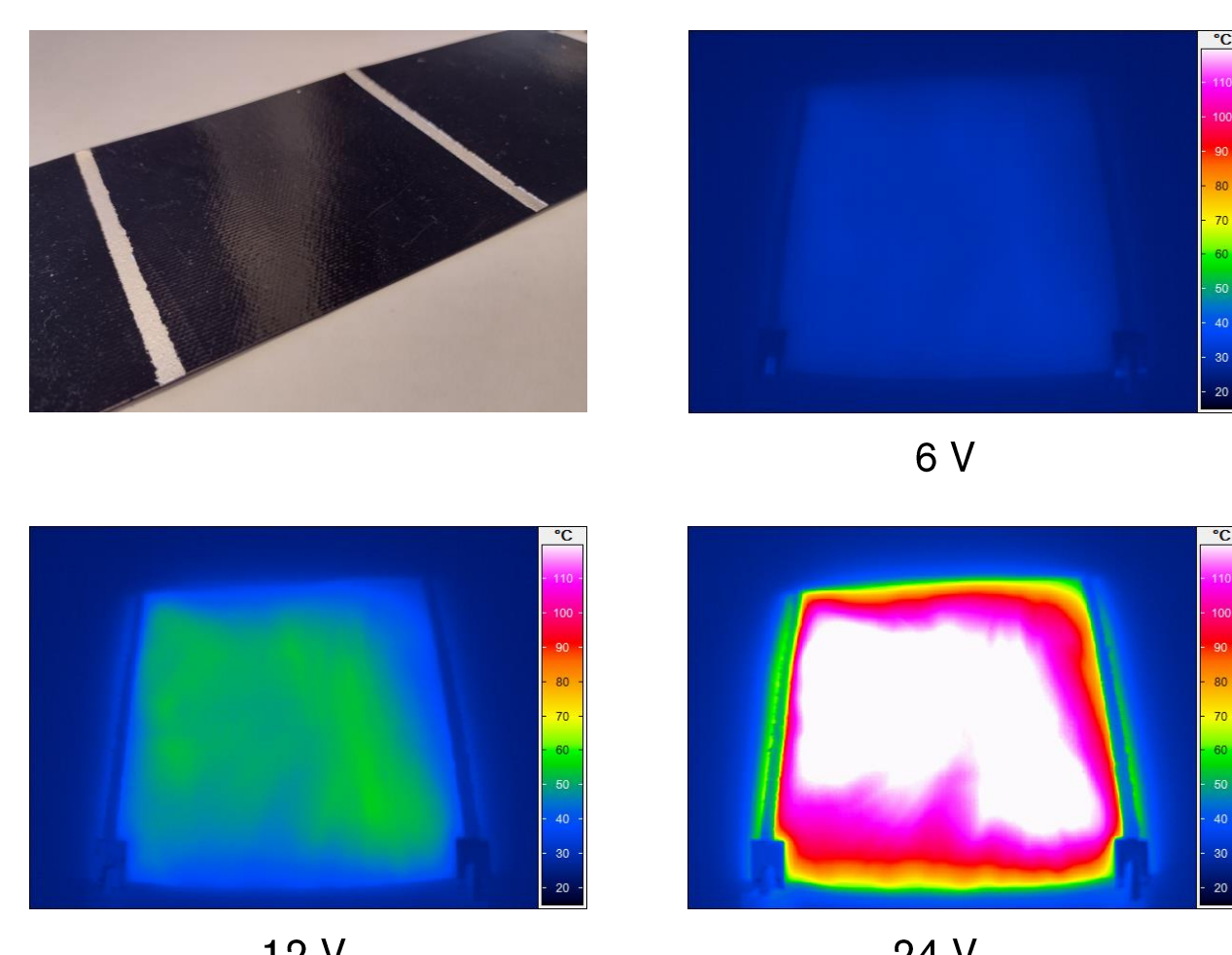
butanediol and isocyanate volumetric dosing

polyol with CNT gravimetric dosing (solid)

polyol with catalyst gravimetric dosing (liquid)



TPU-CNT sheet 5 % CNT	electrical conductivity [S/m]
kneader	71,3
reactive extrusion	63,1



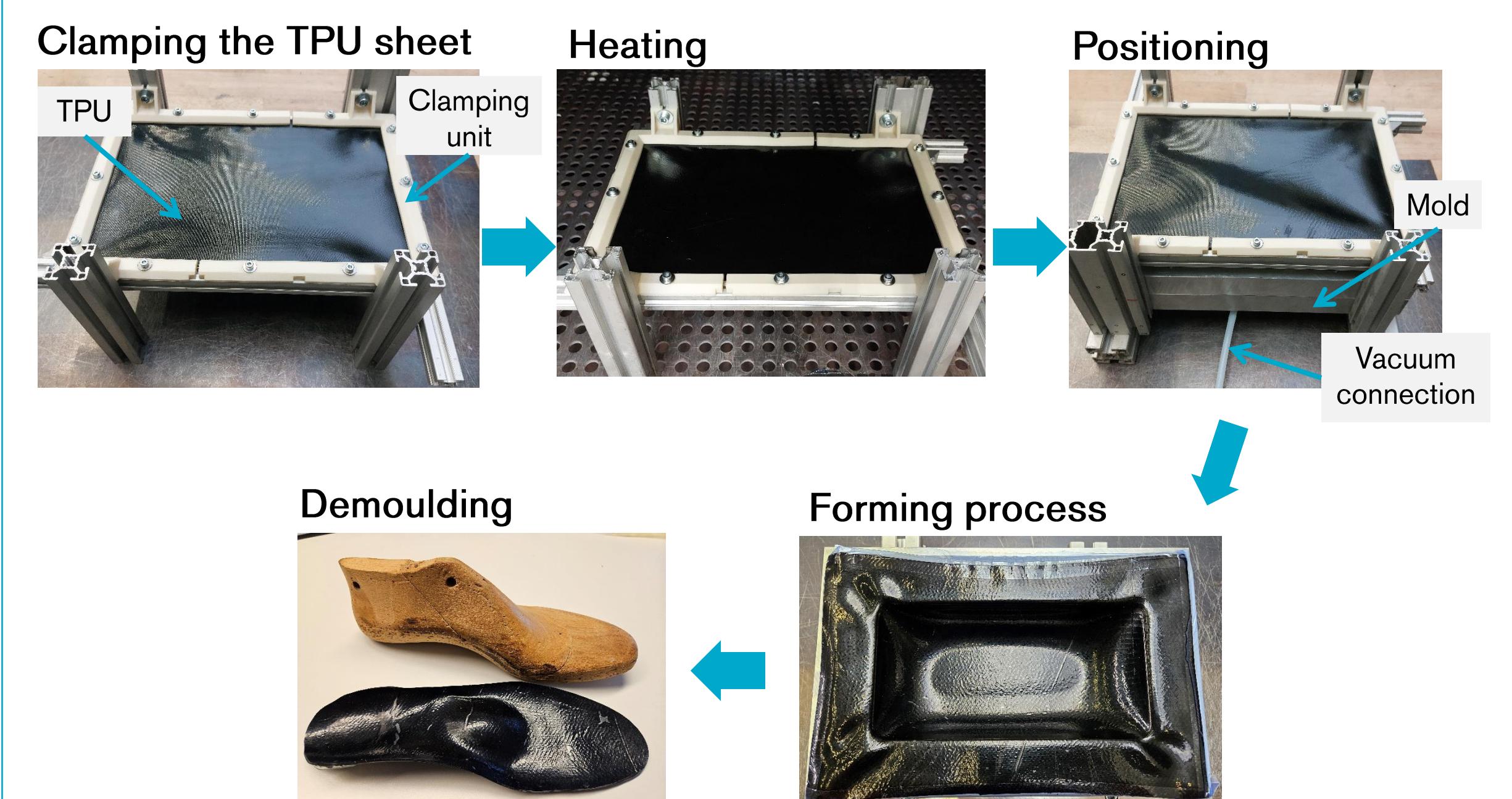
## Thermofforming process

Thermofforming is a generic term for a group of processes that include vacuum forming, drape forming, blow forming, mechanical bending, molding with adapted molds and the newer processes of pressure forming and double-plate forming.

Advantages:

- Very efficient process sequences due to flexible design of the molds
- Energy-efficient heating of the semi-finished products
- Possibility of model-based process simulation

### Process chain



### Demonstrators

- Medical Technology
  - Orthopaedic inlays (Figure above)
  - Maximum heating temperature of 35 °C
- Railway industry
  - Interior seat (Figure right)
  - Maximum heating temperature of 50 °C



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