

Inkjet 3D Printing

High Resolution
Multi-Material
Digital Additive Manufacturing

Dr. Marin Steenackers
ChemStream

ChemStream: The Independent Chemical R&D Company

Translating customized requirements into chemical formulations with dedicated functionality, from **design to prototyping and implementation**

❑ Core activities:

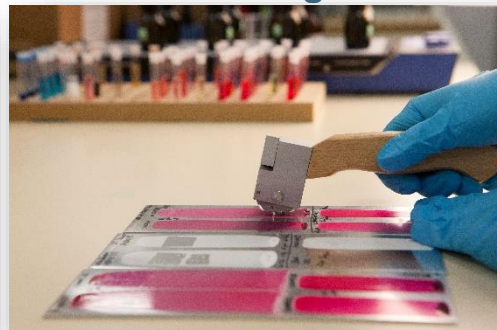
- ❑ Innovative contract research
- ❑ Customized product development
- ❑ Design and synthesis of functionalized (bio-based) polymers (dispersants, emulsifiers, surfactants...)

❑ Main deliverables:

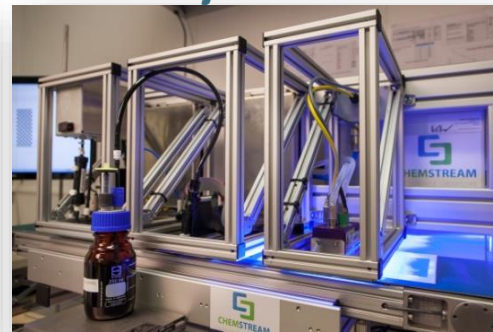
❑ Nano dispersions



❑ Coatings

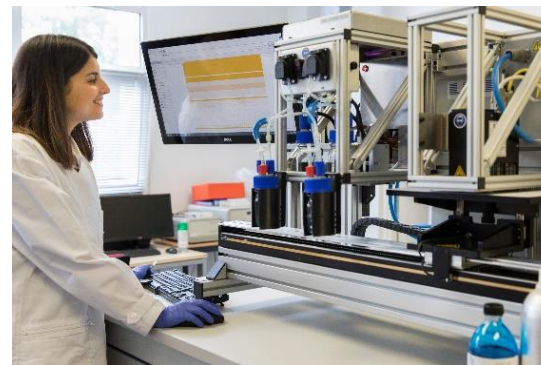


❑ Inkjet inks



ChemStream: The Independent Chemical R&D Company

- **Founded in April 2010**
- **Staff profile (14 FTE, 11 PhDs)**
 - Chemistry (12)
 - Material Science (1)
 - Bio Engineer (1)
- **Located near Antwerp – Belgium**
- **Lab-facilities (550 m²)**
 - Organic Synthesis
 - Chemical Formulation
 - Characterization
- **Prototype production facility**
 - Coatings: 250 L batches
 - Inkjet inks: 25 L batches



ChemStream: The Independent Chemical R&D Company

Expertises



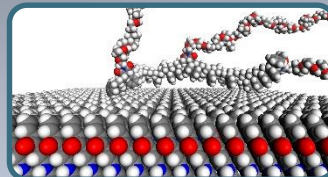
Organic Synthesis

- * Crystal, colorant and dispersant design
- * Photochemistry
- * Interfacial chemistry, wetting and adhesion
- * Superabsorbing polymers
- * Flow chemistry



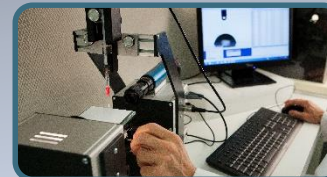
Technology

- * Dispersion technology
- * Coating, printing, jetting (Modular printing unit MPU)
- * Radiation curing (UV, UV-LED, e-Beam)
- * Atmospheric plasma



Methodology

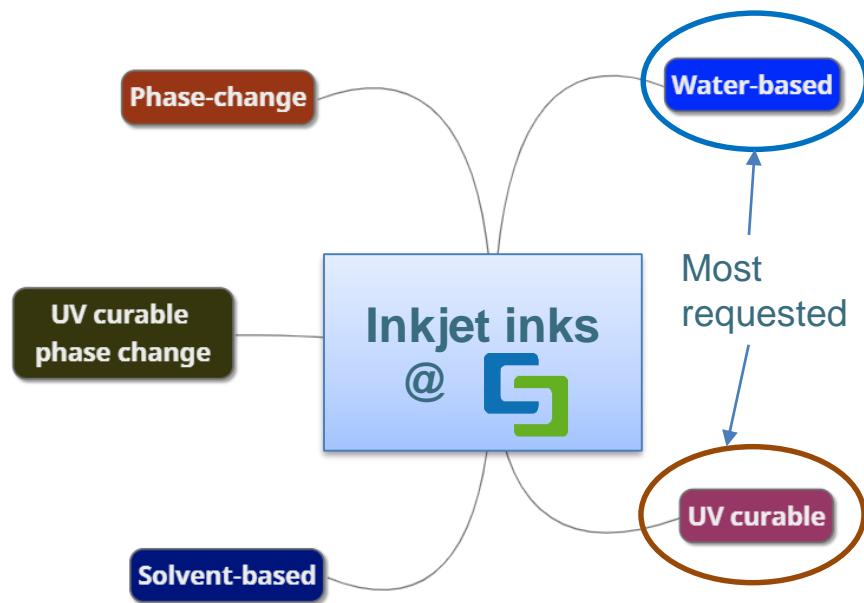
- * Molecular modeling
- * Design of Experiments (DoE)
- * Smart throughput screening
- * Hansen solubility parameters (HSP)



Analytical and physical chemical tools

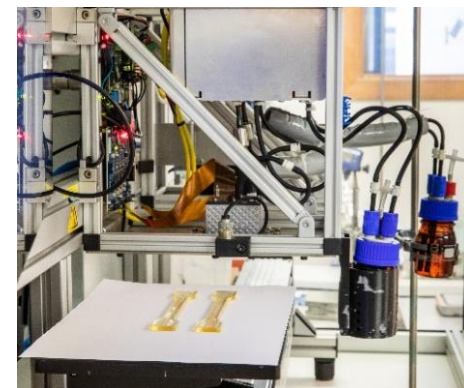
- * UVVIS, FTIR, GCMS, LCMS, GPC
- * Particle size distribution (PSD)
- * Contact angle, surface tension, viscosity

Inkjet @ ChemStream

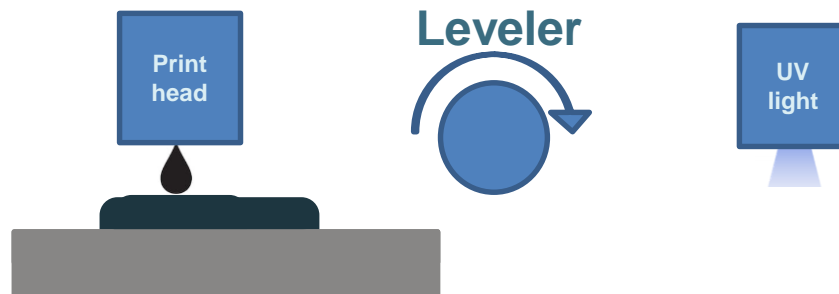


Modular Printing Units

- ❑ Mimic of an in-line printing process
- ❑ Fast iterations of ink prototypes
- ❑ Different inkjet printheads
- ❑ 3D printing



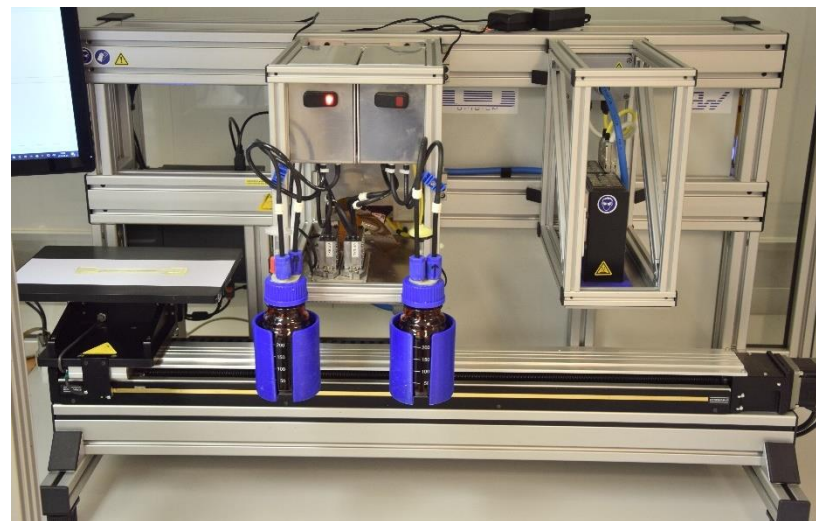
What is 3D inkjet printing



- UV-curable inkjet inks
- Phase change inkjet inks

What is 3D inkjet printing

- ❑ Printing with support ink
 - ❑ Allows complex geometries
 - ❑ Sharper structures



Modular 3D Printer

- ❑ Dissolve support ink after printing

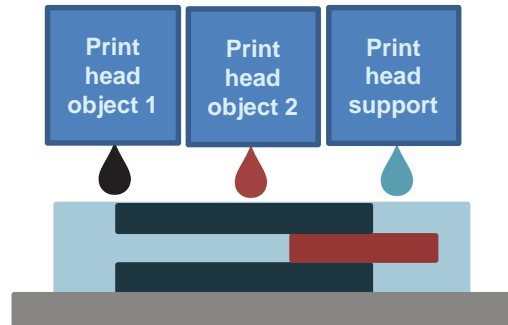


What is 3D inkjet printing



What is 3D inkjet printing

- Printing with different object inks
 - Allows multimaterial printing
 - Embedded functionality



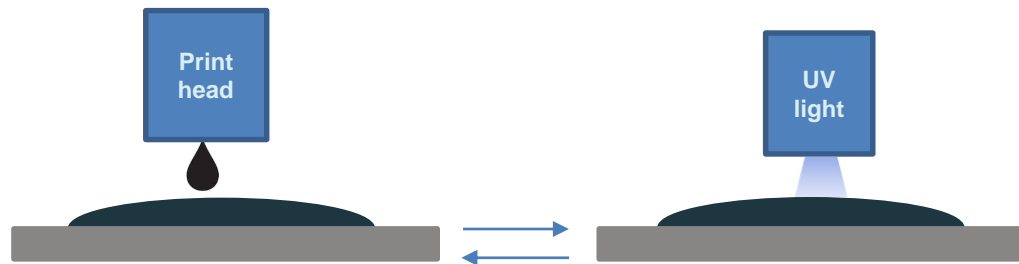
Why Inkjet 3D Printing?

- ❑ High resolution
- ❑ Optically smooth objects
- ❑ Multi-material
 - ❑ Different material properties
 - ❑ Embedded functionality
- ❑ High productivity

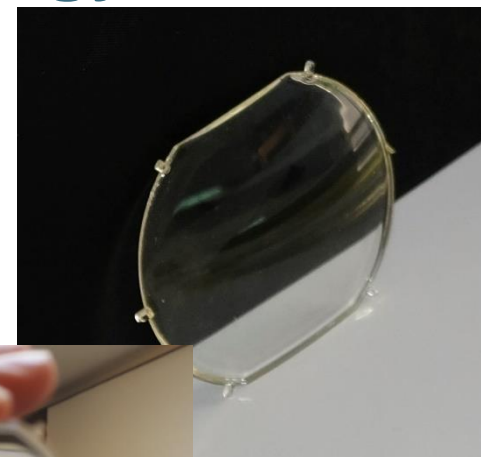


Focus on digital additive manufacturing

3D printing of lenses: a unique technology



- Printing without support ink
- Optically flat surface without post-polishing

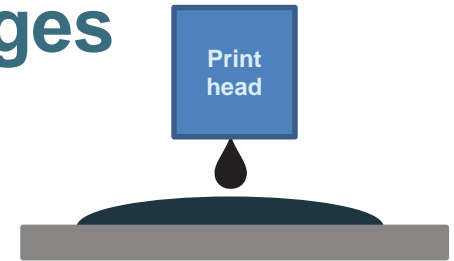


3D printing of lenses: material challenges

- High transparency and low yellowing
 - Photoinitiators
 - Stabilizers

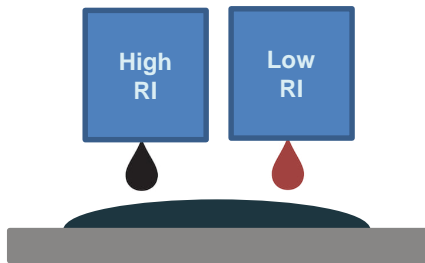
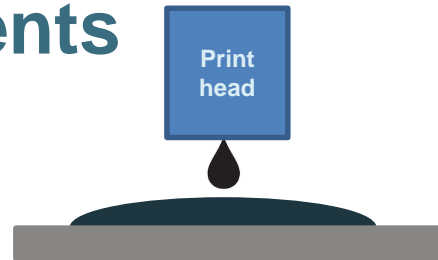
- Overprintability
 - Wetting agents
 - Balancing entire formula

- Material properties
 - Impact resistance
 - Hardness
 - Refractive index

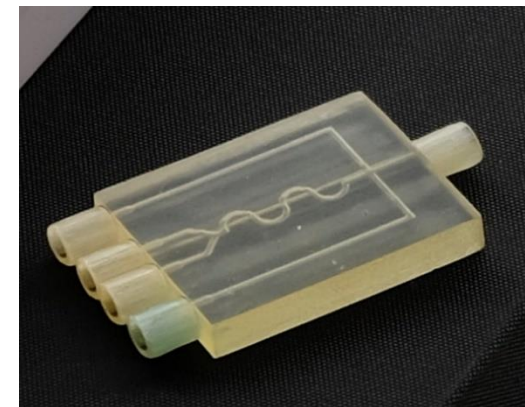
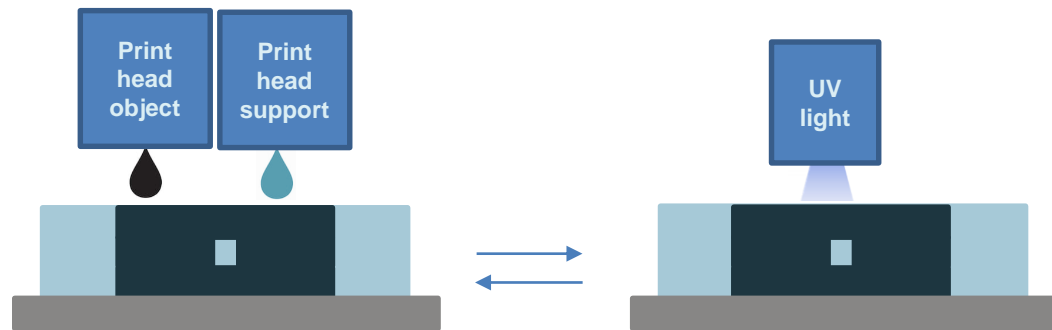


3D printing of lenses: future developments

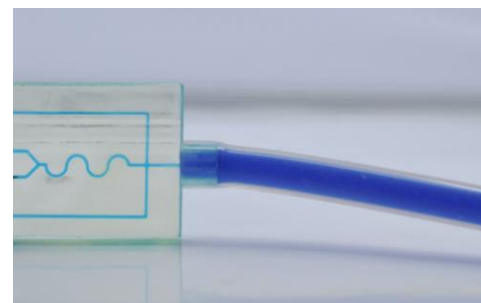
- ❑ Micro lenses
- ❑ High (>1.6) and low (<1.4) refractive index materials
 - ❑ Multimaterial 3D inkjet printing for Gradient-index lenses
 - ❑ Inks based on commercially available monomers as well as tailor made inhouse synthesized building blocks



3D printing of (bio) microreactors

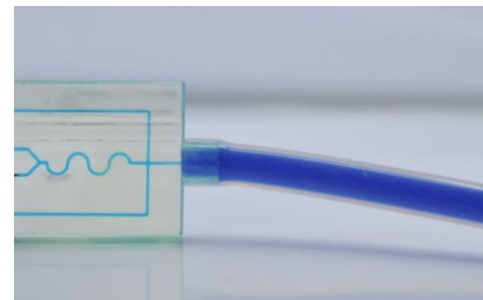
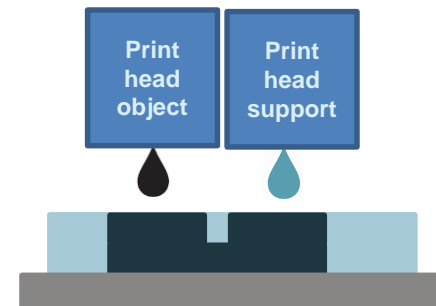


- ❑ High resolution 3D printing
 - ❑ XY resolution: 50 μm
 - ❑ Z-resolution: 3-30 μm
- ❑ Smooth surface morphology



3D printing of microreactors: material challenges

- ❑ Overprintability and co-printability
 - ❑ Finetuning dynamic surface tension (ink) and surface energy (pinned/cured ink)
 - ❑ Support on object + object on support printing
 - ❑ Wet-in-wet vs. wet-on-dry printing
- ❑ Fast (water) dissolving support material to create thin microfluidic channels
- ❑ Material properties
 - ❑ Hydrophilic / hydrophobic
 - ❑ Biocompatibility / cytotoxicity
 - ❑ Embedded functionality



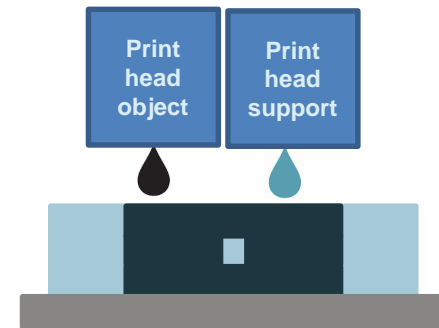
3D printing of microreactors: future developments

❑ Microreactors

- ❑ Further decrease channel width
- ❑ Controlled and tunable surface morphology
- ❑ New embedded (bio) functionalities

❑ Future and futuristic applications

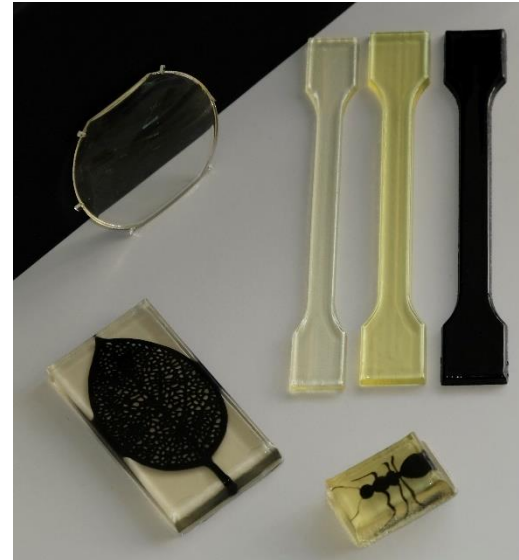
- ❑ Bio-scaffolds
- ❑ Bio-implants
- ❑ Tissue engineering
- ❑ 3D inkjet printing of organs



Multimaterial inkjet 3D printing

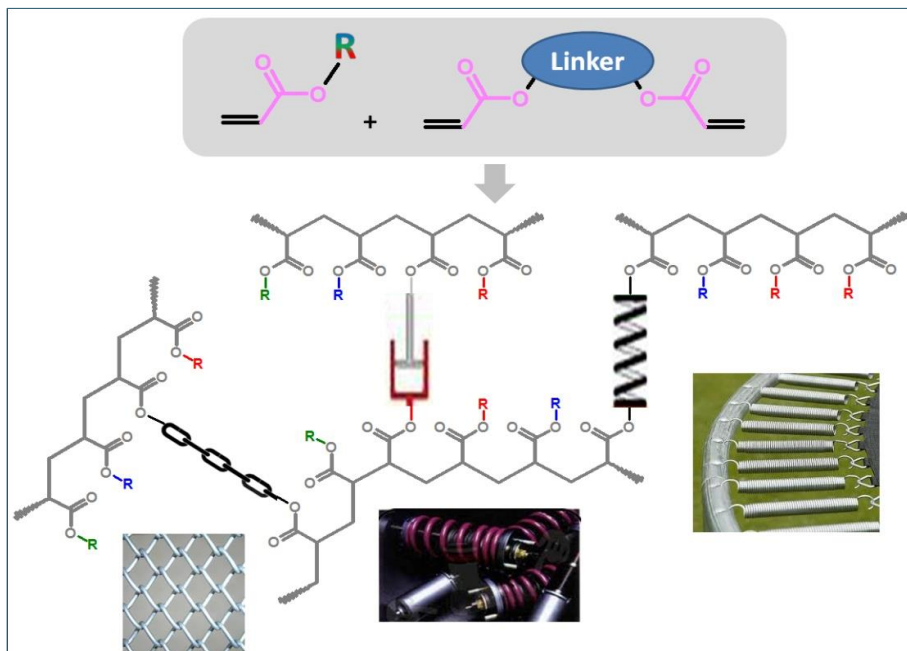
- ❑ Embedded functionality
 - ❑ Colors
 - ❑ Fluorescent
 - ❑ Ferromagnetic
 - ❑ Different refractive index
 - ❑ ...

- ❑ Different mechanical properties
 - ❑ Hard/soft
 - ❑ High/low T_g
 - ❑ ...

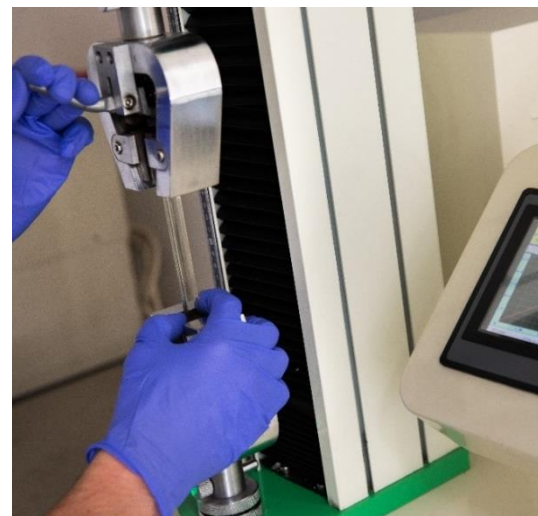


Mechanical properties

- Smart choice of building blocks



- Cross linking density
- Functionality side chain
- Functionality linker
- Intramolecular interactions

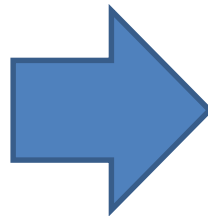


Mechanical properties

- ❑ Smart choice of building blocks

Molecular design toolbox

- ❑ Cross linking density
- ❑ Functionality side chain
- ❑ Functionality linker
- ❑ Intramolecular interactions



Mechanical properties

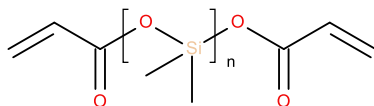
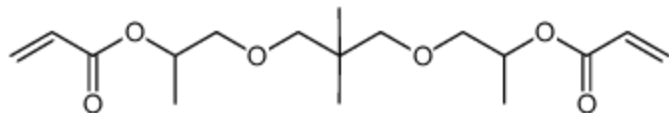
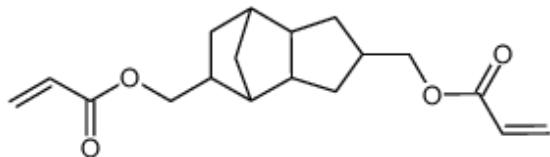
- ❑ Heat deflection temperature
- ❑ Young modulus
- ❑ Elongation at break
- ❑ Tensile strength
- ❑ Impact resistance
- ❑ Scratch resistance
- ❑ Tear resistance
- ❑ ...



Mechanical properties

□ Molecular design toolbox

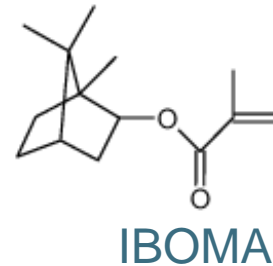
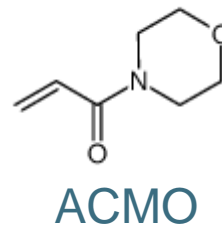
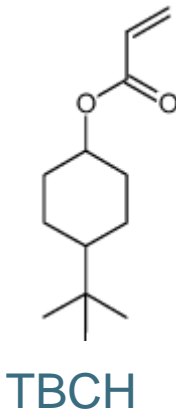
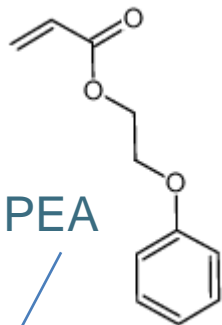
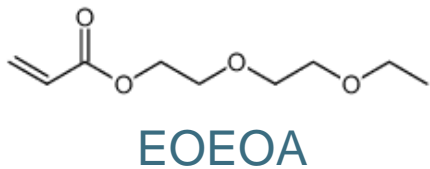
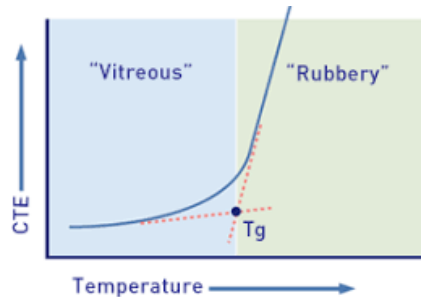
□ Bifunctional crosslinkers



Mechanical properties

□ Molecular design toolbox

□ Monofunctional monomers



Glass transition temperature (T_g) – Heat deflection temperature (HDT)

-50

0

50

100

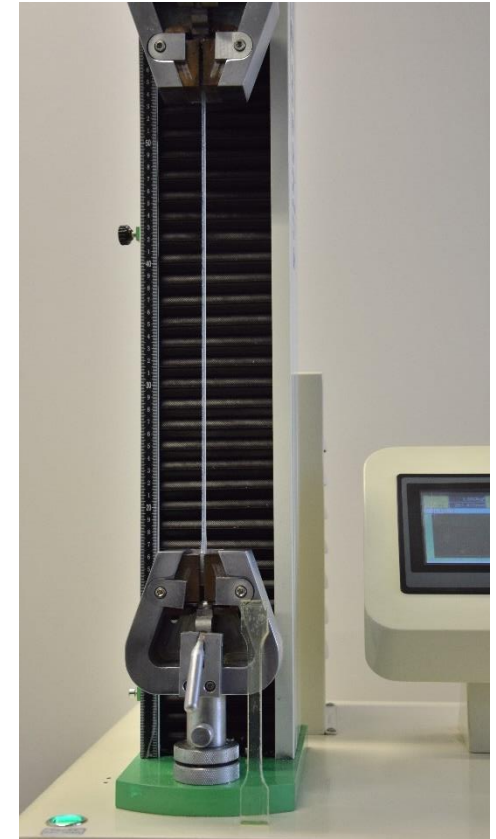
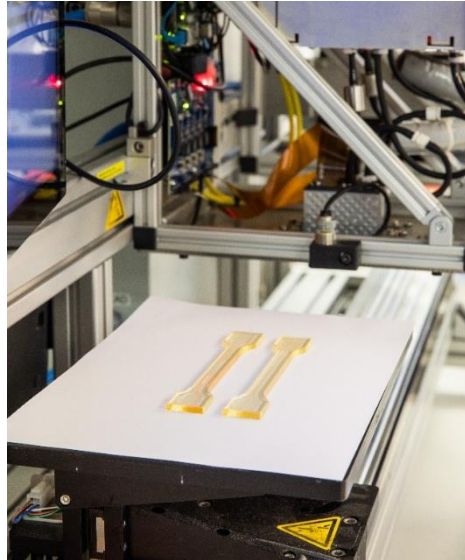
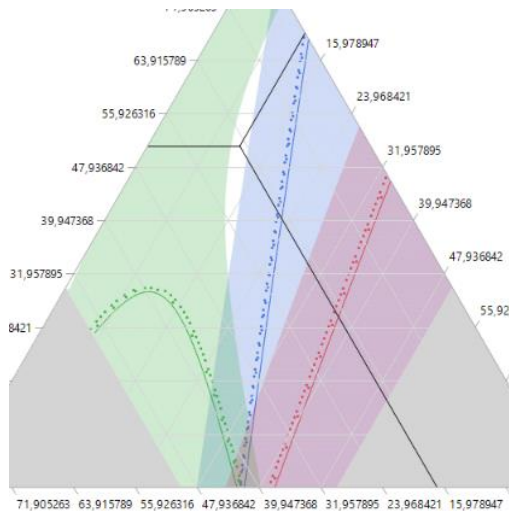
150

°C

Mechanical properties

- Smart choice building blocks + DoE for optimized compromise between different physical properties

Mixture profiler

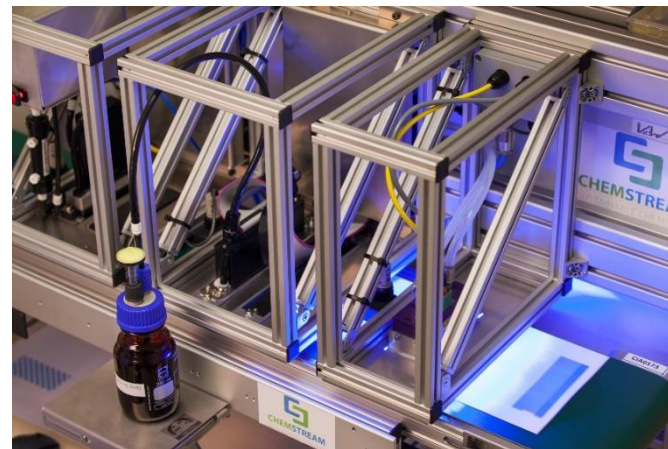


Thanks for your attention

You are invited at our booth A2

Not enough time during IJC 2019?

Visit our booth 430: Inks for the Future @ InPrint



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