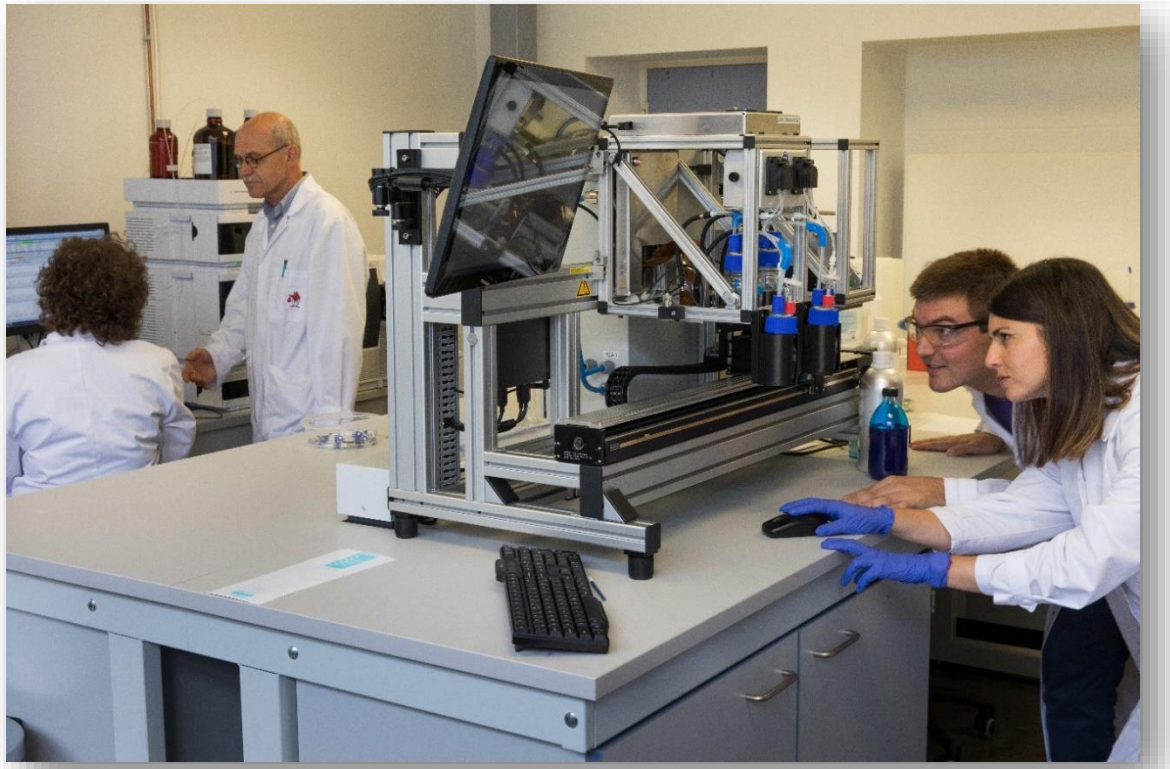
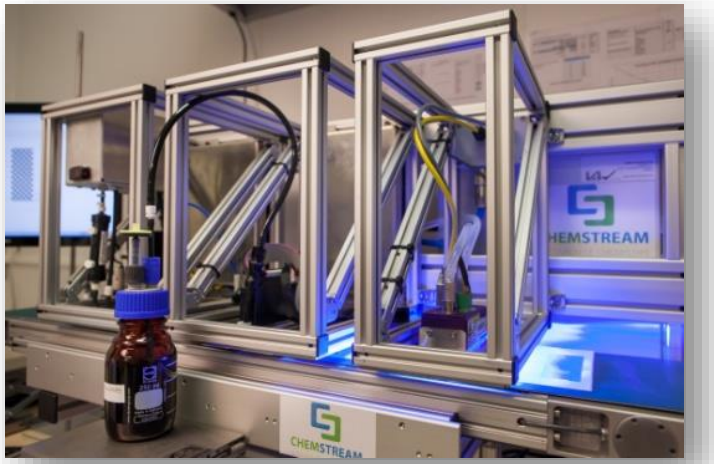
CHEMSTREAM
SUSTAINABLE CHEMISTRY

A comparison of UV curable inks in DLP and Inkjet printing for applications requiring low leachables/extractables





Wim Van Beek, ChemStream
Leuven Additive Manufacturing Conference, 28/05/2025

ChemStream: who are we?

Founded in April 2010

Staff profile: 12 Chemists (mainly PhD's)

- Chemistry (10)
- Material Science (1)
- Bio Engineer (1)

Located at 3Oaks,

- Site for SMEs near Antwerp University

Lab-facilities (500 m^2):

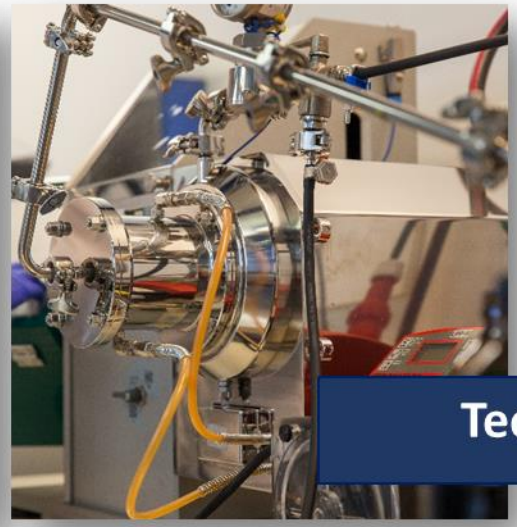
- Organic synthesis
- Chemical formulation
- Characterization

Pilot scale facilities

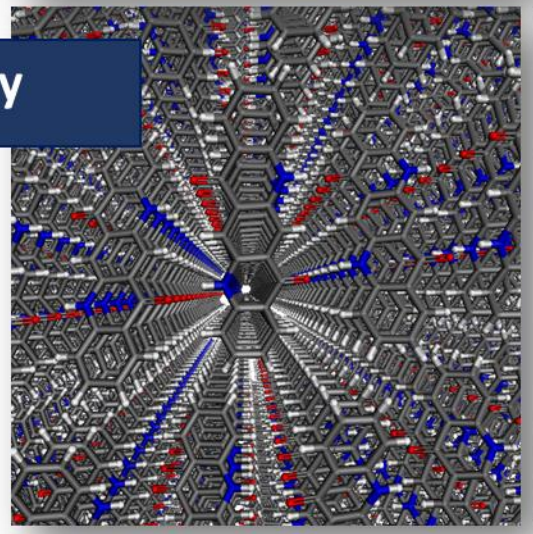
- 20 kg for organic synthesis
- 25 kg for nano-dispersions
- 100 – 200 kg for formulations

ChemStream's expertise

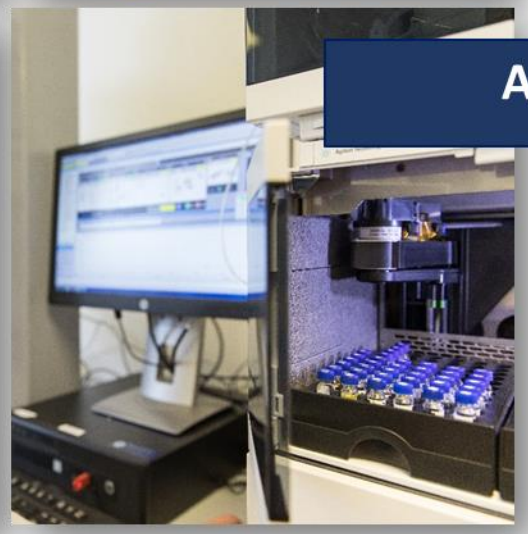
Chemistry



Technology



Methodology



Analysis

ChemStream's expertise

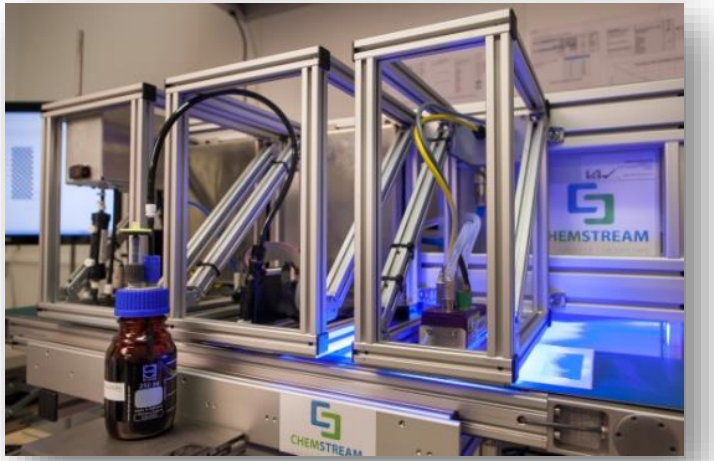
Independent chemical R&D company:

- Translating customized requirements into chemical formulations with dedicated functionality, from design to prototyping
- Core activities:
  - Innovative contract research
  - Partner in several funded R&D projects
  - Customized product development
  - Design and synthesis of functionalized (bio based) polymers (dispersants, emulsifiers, surfactants...)

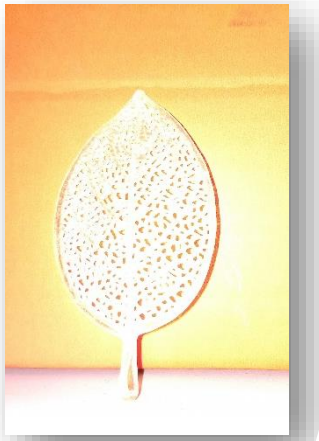
- Own brand of dispersing agents **Dispersense©**

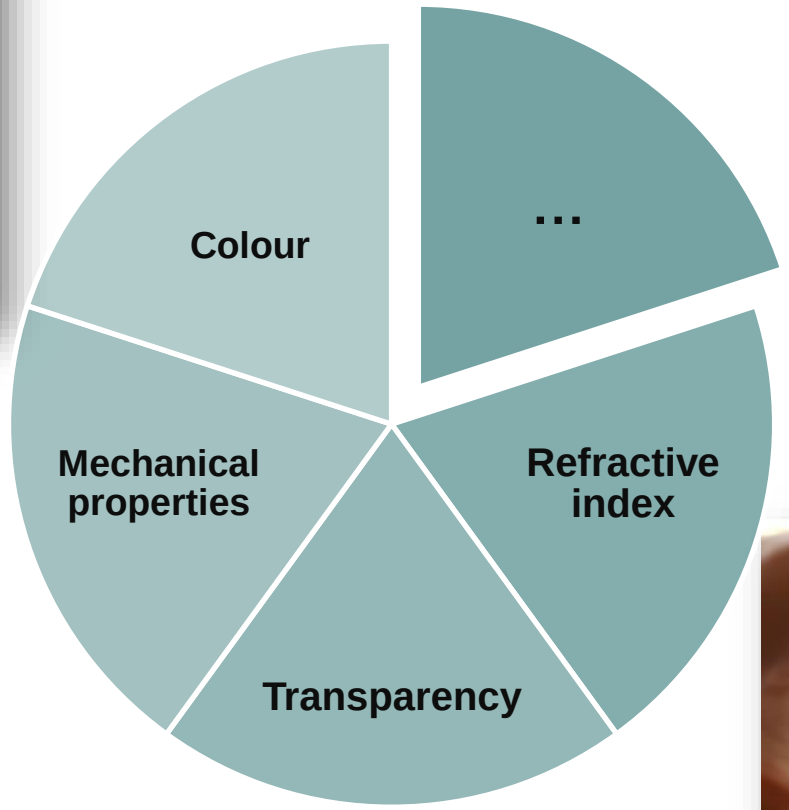
- Nano dispersions

- Inkjet Inks
- 2D → 3D



Demanding applications in 3D UV inks?

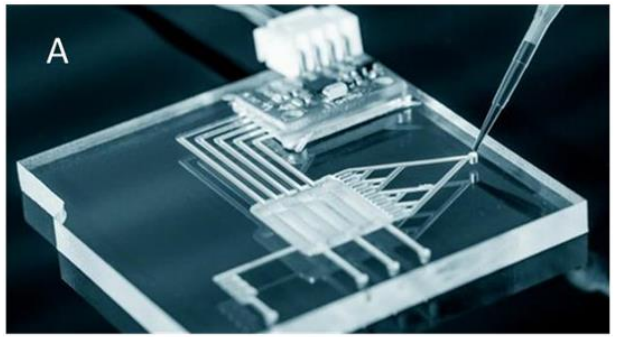


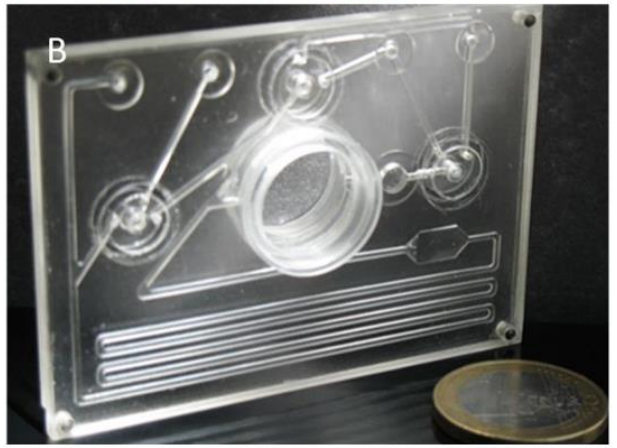


LifeFab

CHEMSTREAM
SUSTAINABLE CHEMISTRY

Antleron
Engineering life



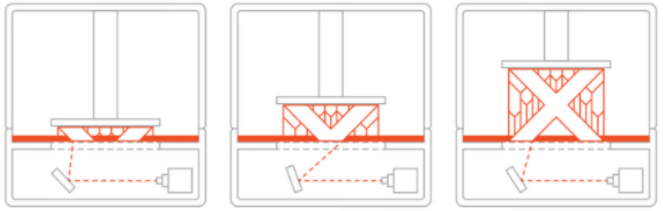


- VLAIO supported research project (2020-2024)
- Goal: create a platform to 3D IJ print micro-reaction technology features
- Typical channel width < 1 mm → fast dissolving support ink
- Transparency, controlled hydrophilicity, controlled hardness, surface functionalizable
- Bio-compatible with living cells (low migration)

VLAIO
Vlaanderen
is ondernemen

DLP vs IJ in additive manufacturing

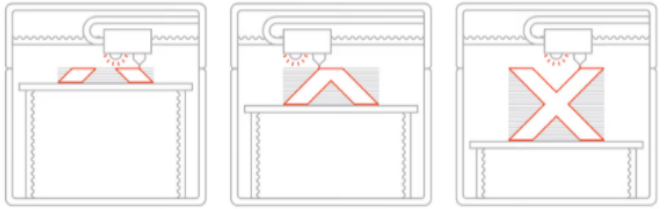
VAT (photo)polymerisation



SLA
DLP

Photopolymer resin(s)

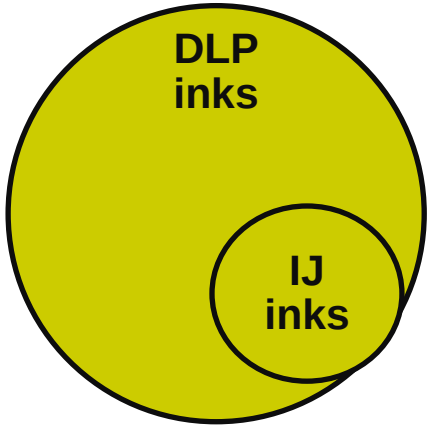
Material jetting = Ink jetting



DOD
PolyJet
NPJ

- Easily 1000 mPa·s at VAT temperature
- More formulational freedom to use polymeric/oligomeric building blocks
- Easier to achieve certain mechanical properties

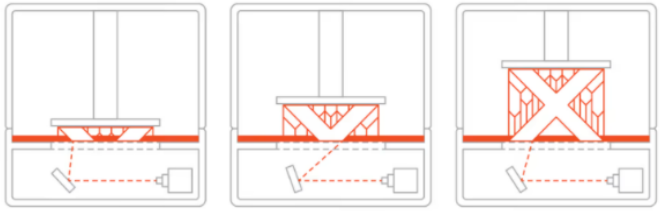
Viscosity range



- Limited to around 10 mPa·s at jetting temperature
- Limited choice of low viscous building blocks
- More difficult to achieve certain mechanical properties

DLP vs IJ in additive manufacturing

VAT (photo)polymerisation



SLA
DLP

Photopolymer resin(s)

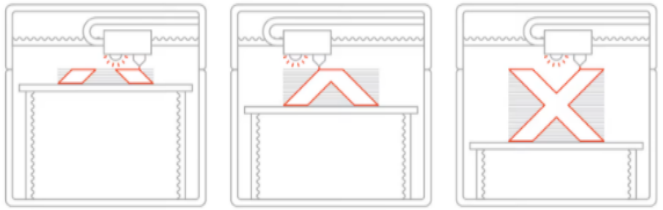
Curing

- Within the resin
- Oxygen free environment
- Lower dose of UV light

Post-processing

- Remove excess resin
  - By centrifuging/washing with solvent
  - Breaking support off + polishing (=labour intensive!)
- Post-curing

Material jetting



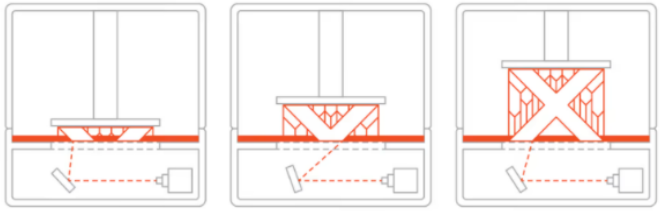
DOD
PolyJet
NPJ

- Under ambient atmosphere
- Oxygen inhibition
- Higher dose of UV light

- “What you jet is what you get” minus support
- Removal of support (melting/water dissolving)
- Post-curing

DLP vs IJ in additive manufacturing

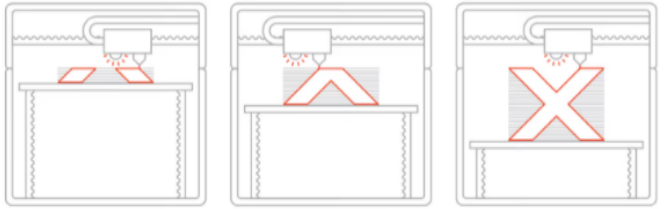
VAT (photo)polymerisation



SLA
DLP

Photopolymer resin(s)

Material jetting



DOD
PolyJet
NPJ

- Determined by resolution of projection (generally high)
- €
- Robust

Accuracy

Cost

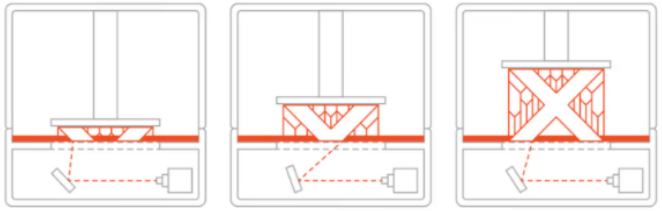
Robustness

- Determined by nozzle resolution of printhead
- €€€
- Less robust

DLP used @ ChemStream for printing dogbones or flexural strength test specimen

DLP vs IJ in additive manufacturing

VAT (photo)polymerisation

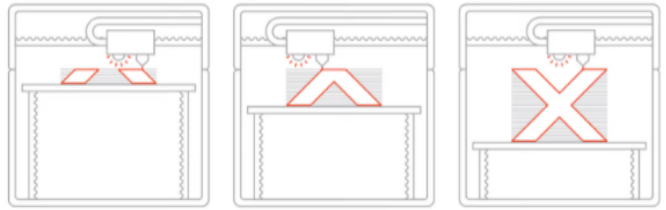


SLA
DLP

Photopolymer resin(s)

Single material

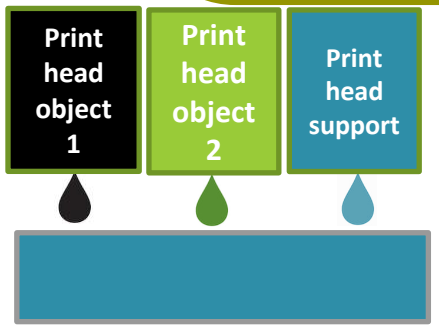
Material jetting



DOD
PolyJet
NPJ

Multi-material

- Academic examples of multi-material DLP
- Multiple VAT: avoid cross contamination via air-jet cleaning, centrifuging, …
- Curing at different wavelengths



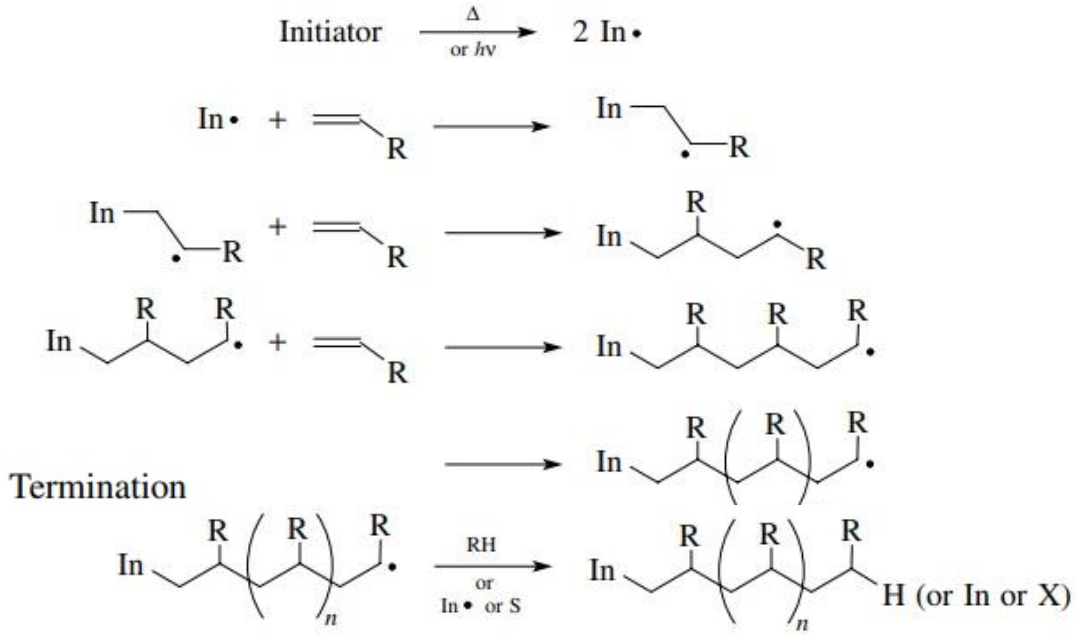
=>

Support ink gets washed away after printing

Kowsari, K.; Akbari, S.; Wang, D.; Fang, N. X.; Ge, Q., High-Efficiency High-Resolution Multimaterial Fabrication for Digital Light Processing-Based Three-Dimensional Printing. *3D Printing and Additive Manufacturing* **2018,** *5* (3), 185-193.
Bergoglio, M.; Rossegger, E.; Schlögl, S.; Griesser, T.; Waly, C.; Arbeiter, F.; Sangermano, M., Multi-Material 3D Printing of Biobased Epoxy Resins. *Polymers* **2024,** *16* (11), 1510.
Chin, K.; Ovsepyan, G.; Boydston, A., Multi-color dual wavelength vat photopolymerization 3D printing via spatially controlled acidity. *Nature Communications* **2024,** *15,* 3867.

Bio-compatible IJ ink development

- Photopolymerization process is **never 100% complete** – thus parts of the ink remain unreacted
- Smaller fragments can leach out of the 3D network
- Avoid addition of **known problematic** substances to your formulation
- Quality control: avoid addition of **low purity** (meth)acrylates: non-polymerisable compounds = source of leachables/extractables



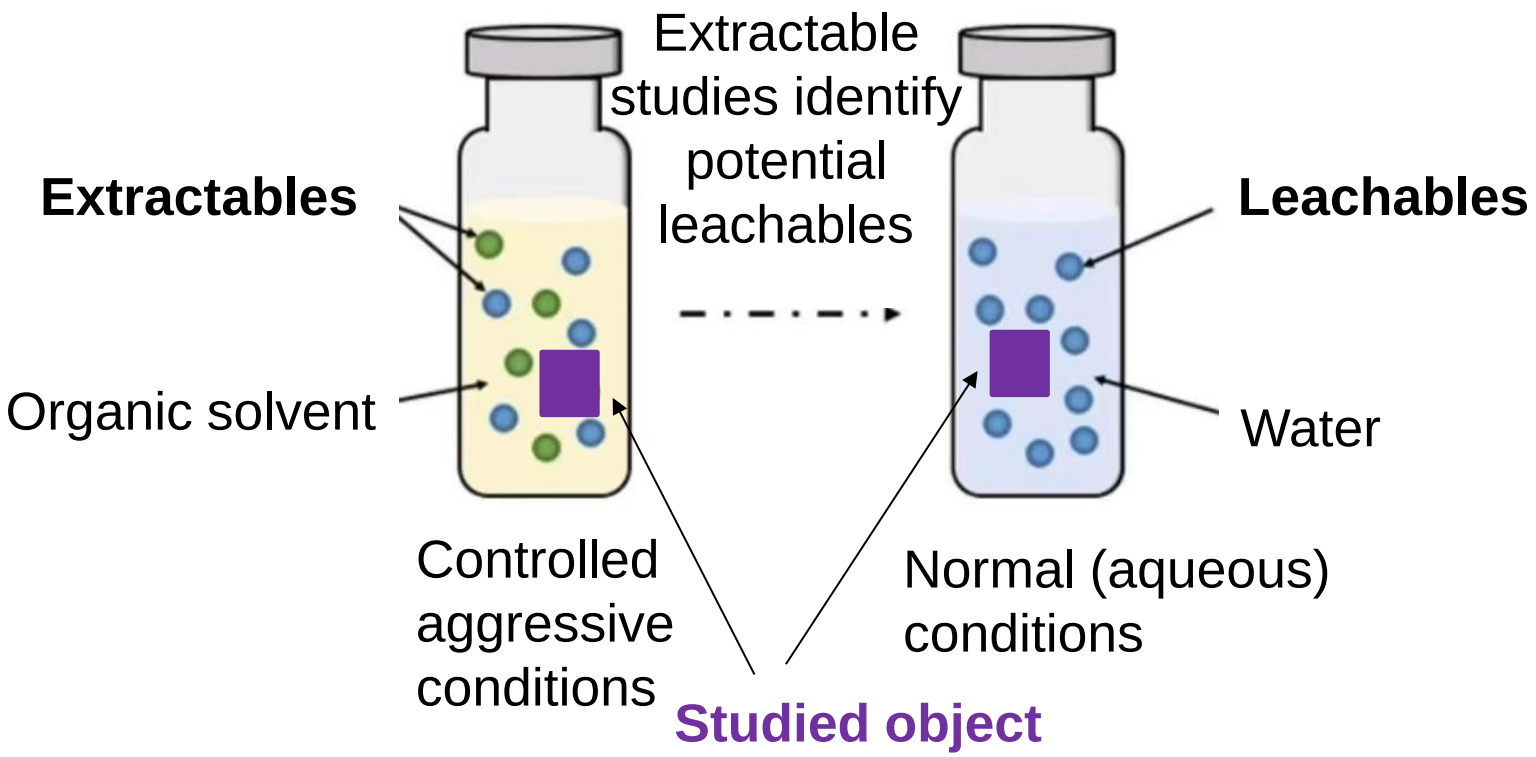
Very low leaching required?

- **Extraction test**

= quick test to assess which and how much chemical compounds can be **extracted** (worst-case scenario – with an organic solvent)

to study potential **leachables** (leaching under normal conditions) from printed objects

=> Leachable levels for same ink in DLP and IJ are comparable

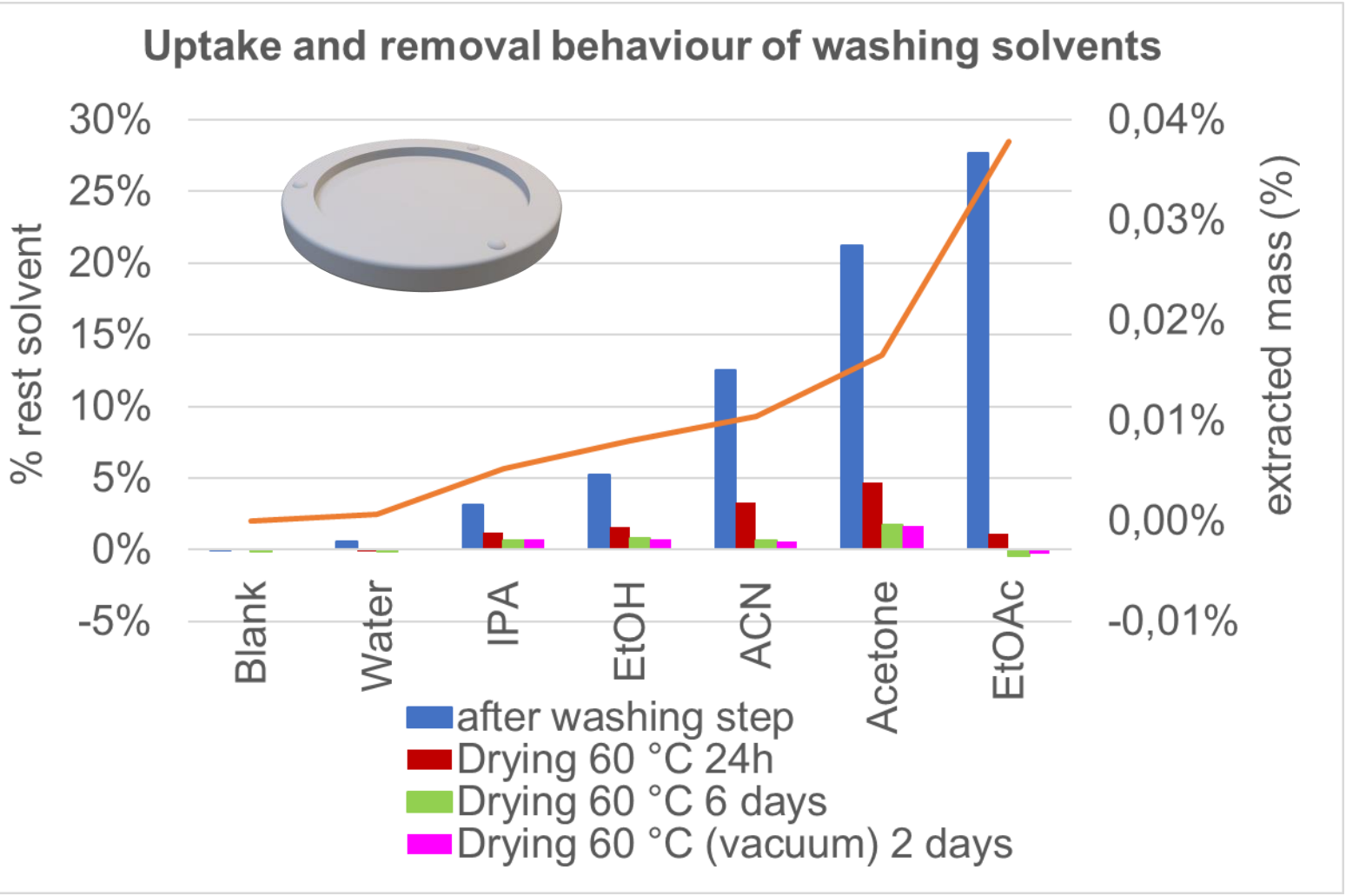


“Worst-case scenario”

The importance of post-treatment

- Reaching the **lowest amounts** of unreacted (meth)acrylates
- Via post-curing = supplemental UV treatment
- If possible: **heating** above T_g of object
- Under inert atmosphere to avoid oxygen inhibition
  - Vacuum; additional VOC removal
  - Nitrogen
  - In glycerin- (or waterbath)
- Consider E-Beam curing
  - Not generally applicable
- Not good enough? => extra **washing** step

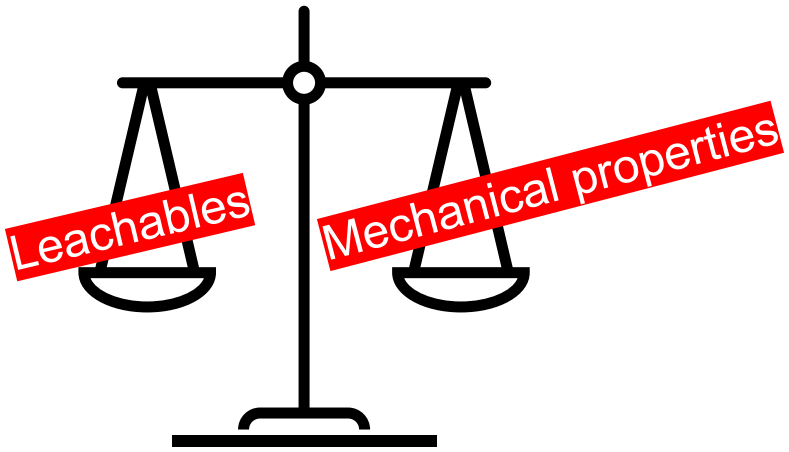
Washing step: Pre-extraction



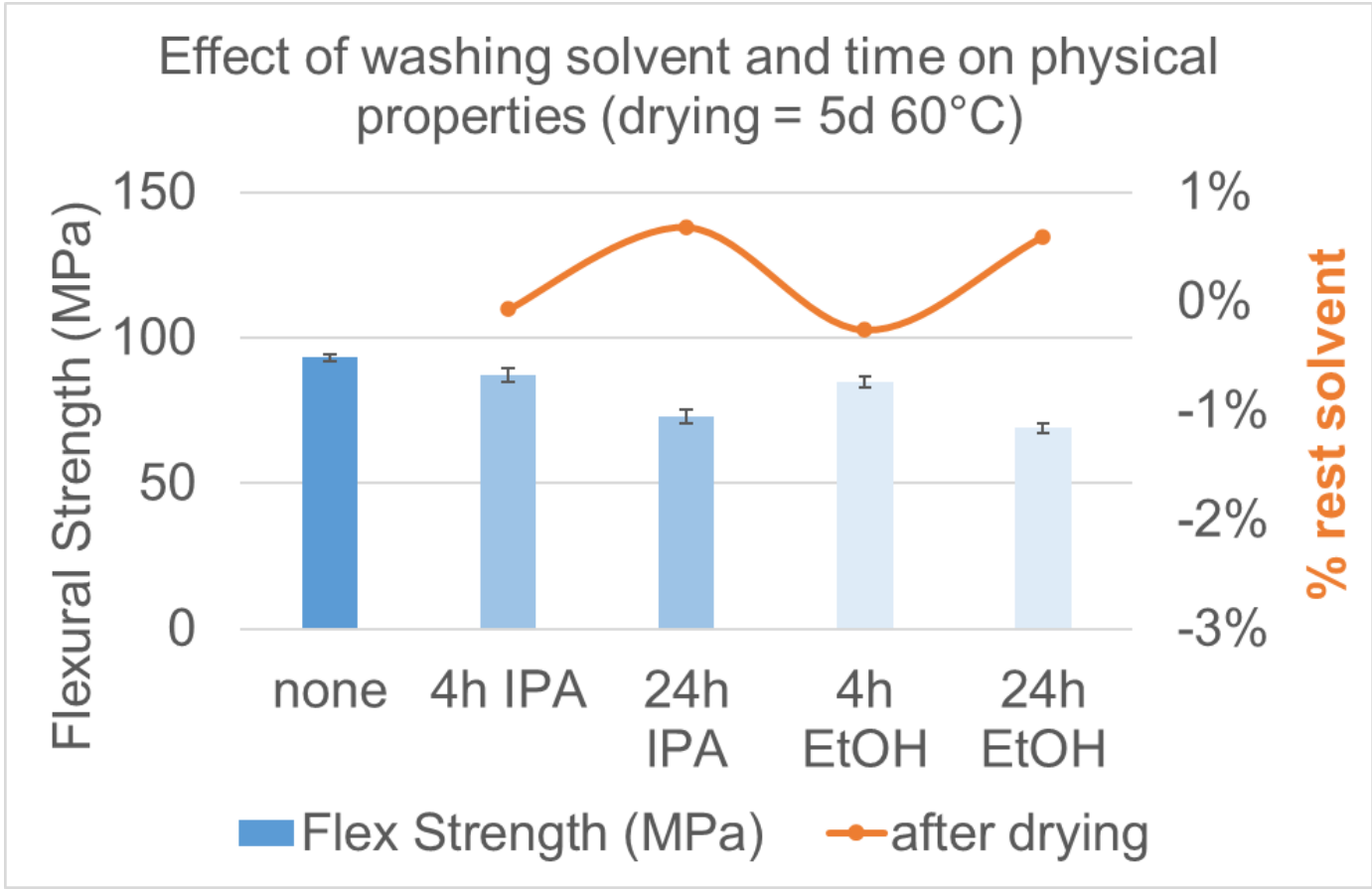
- Different solvents can penetrate different objects easier or more difficult
- "**Smaller molecules/solvents**" can penetrate an object better
- Be careful! Solvents that have entered an object are **notoriously difficult to remove** again and can act as **plasticizer**!
- If an object swells **too much**, internal stress can lead to **cracks**

Finding the balance…

- … between **removal of leachables** and retaining **decent mechanical properties**



- For this application **4h IPA** was selected as post-treatment: enough extractables removed to have a non-cytotoxic material

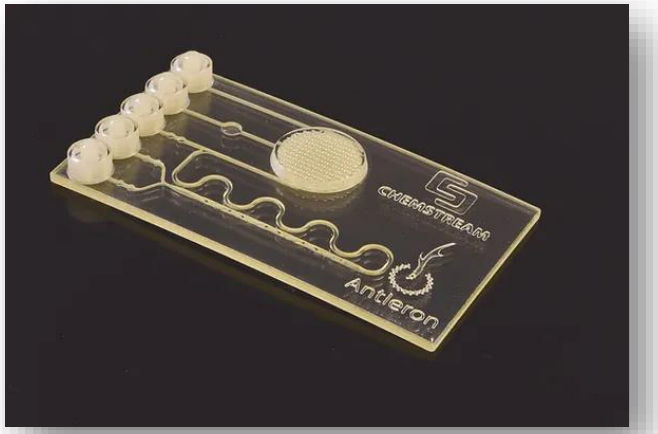


LifeFab

- Lab-on-a-chip

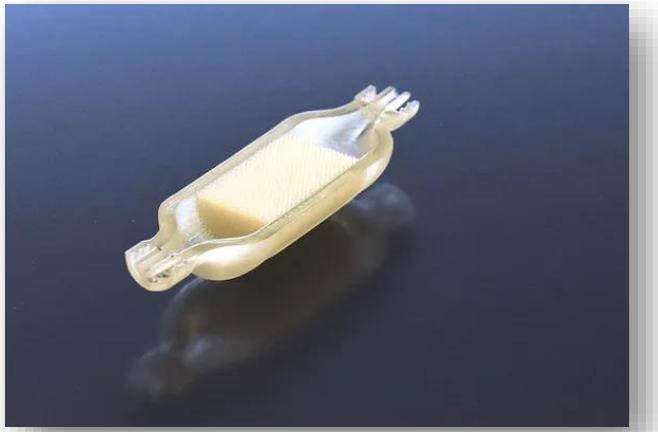
CHEMSTREAM
SUSTAINABLE CHEMISTRY

Antleron
Engineering life

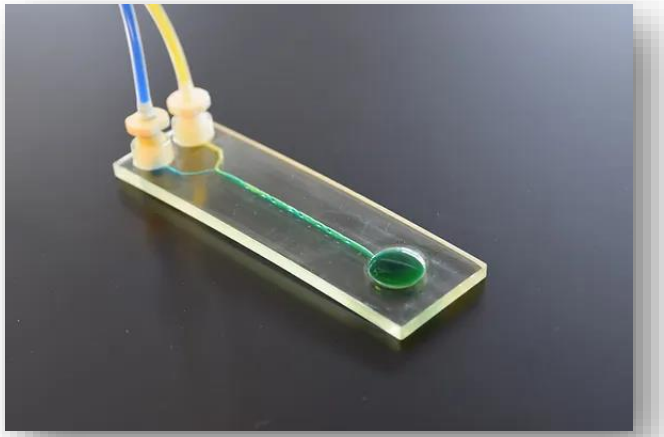


LifeFab.eu

- 3D cell cultivation



- 3D microfluidics

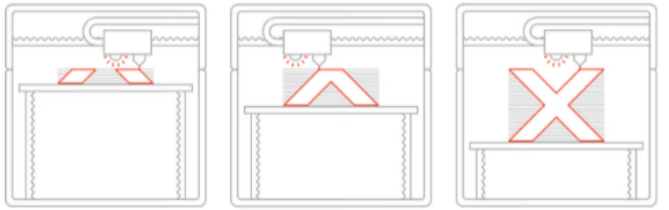


- ChemStream developed:
  - Biocompatible object inks
  - Water-soluble support ink

Conclusions

- For multi-material printing **3D Inkjet** is the only real solution for our application, DLP can be used for ink screening
- Choice of formulation ingredient: choose the **less dangerous ingredients**
- Use ingredients with lowest amounts of **non-polymerizable impurities**
- **Quality control** of formulation ingredients, fresh = safest
- Combination of **washing** and **post-curing** conditions as severe as possible **without compromise** of other important properties

Material jetting



DOD
PolyJet
NPJ

Thank you…

… for your attention!

wim.vanbeek@chemstream.be

www.chemstream.be

CHEMSTREAM
SUSTAINABLE CHEMISTRY

Antleron
Engineering life

Matthias Ceulemans

Els Mannekens