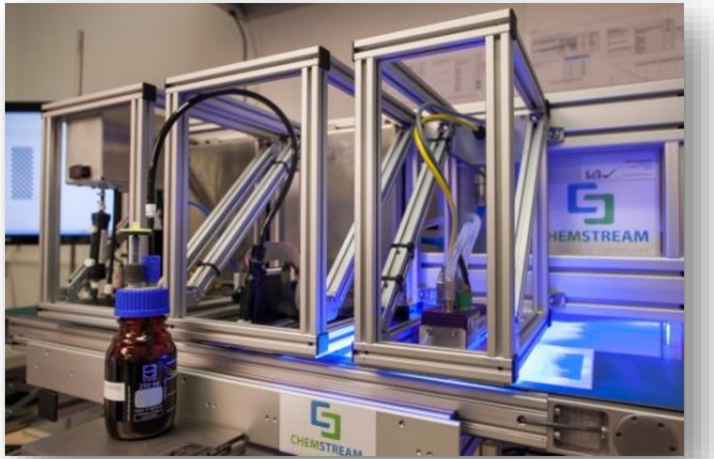
The importance of ingredient quality in printing inks for demanding applications

Wim Van Beek

CHEMSTREAM
SUSTAINABLE CHEMISTRY

INDUSTRIALPRINTINTEGRATION



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,

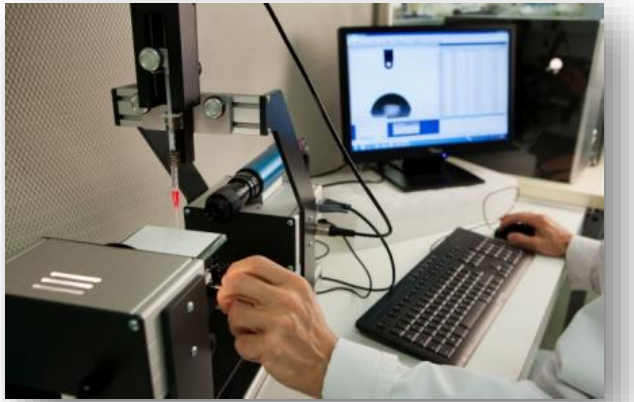
- Site for SMEs near Antwerp University

Lab-facilities (500 m^2):

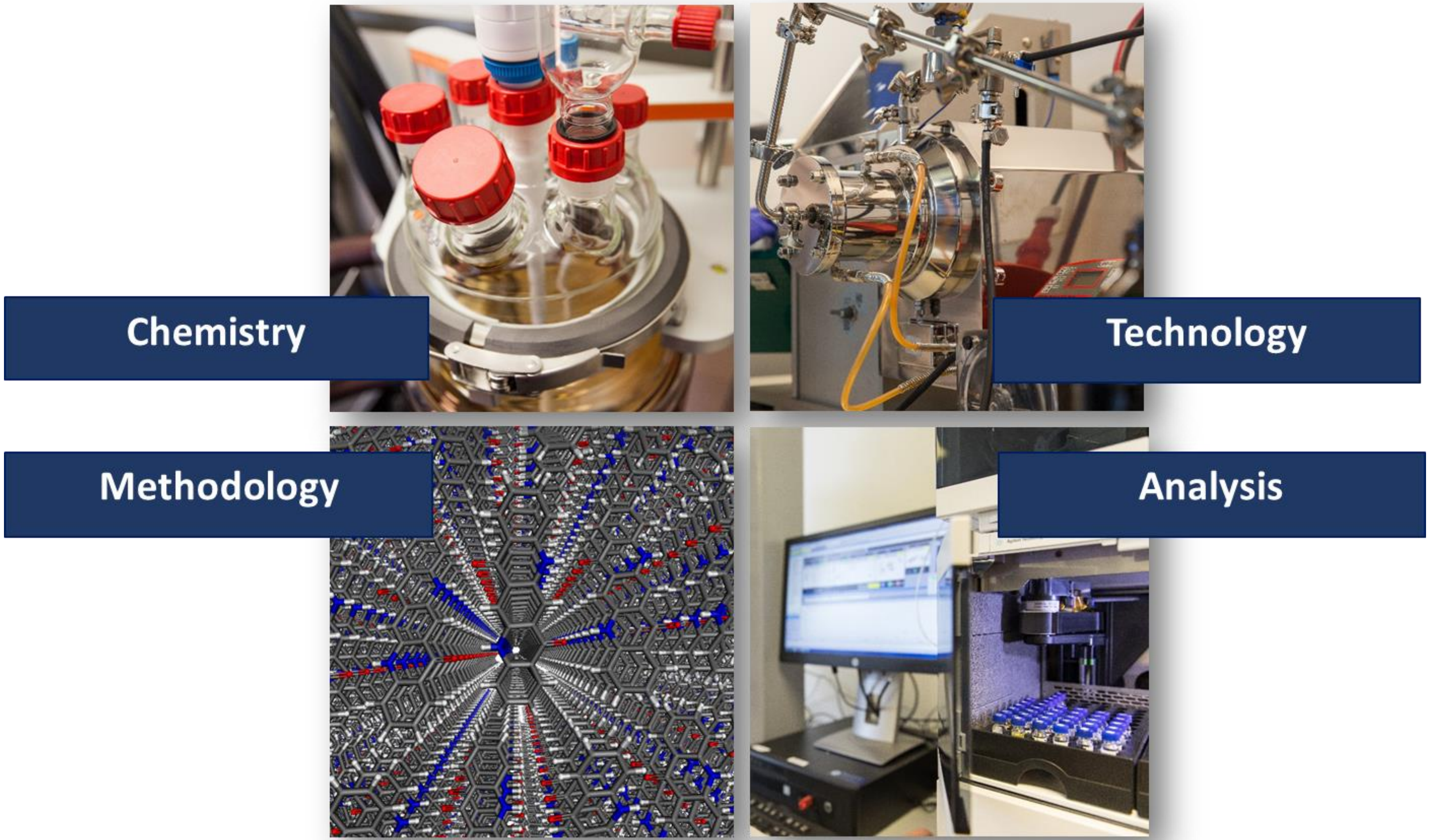
- Organic synthesis
- Chemical formulation
- Characterization

Pilot scale facilities

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



ChemStream's expertise



ChemStream's expertise

Independent chemical R&D company:

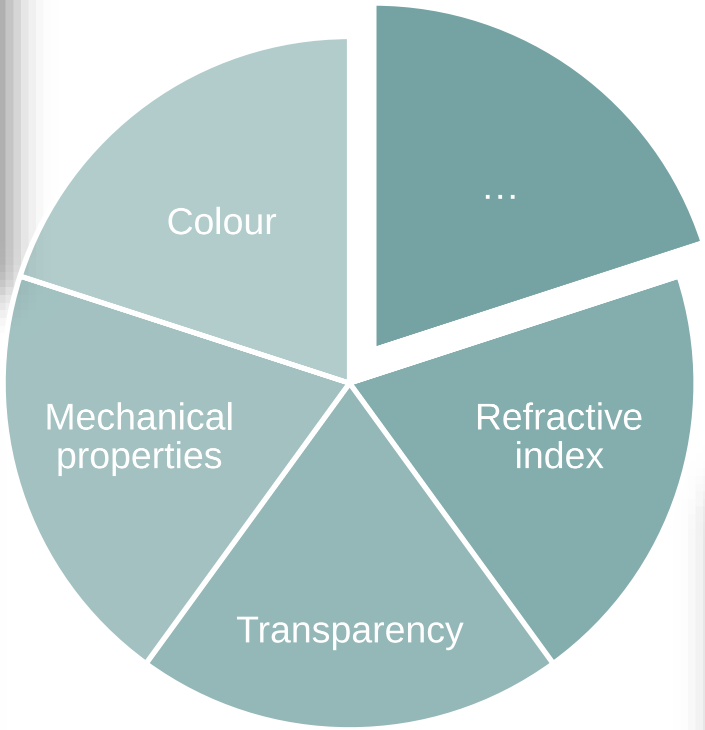
- Translating customized requirements into chemical formulations with dedicated functionality, from design to prototyping
- Core activities:
  - Innovative contract research
  - Partner in several funded R&D projects
  - Customized product development
  - Design and synthesis of functionalized (bio based)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

- Nano dispersions

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

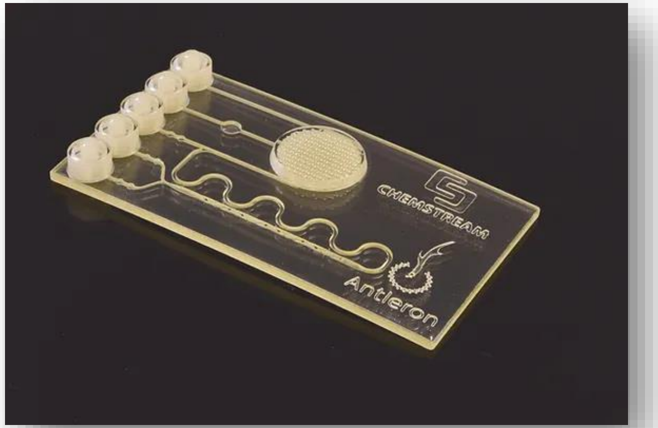
- Inkjet Inks

Demanding applications in 3D UV inks?



Demanding applications in 3D UV inks?

- Lab-on-a-chip



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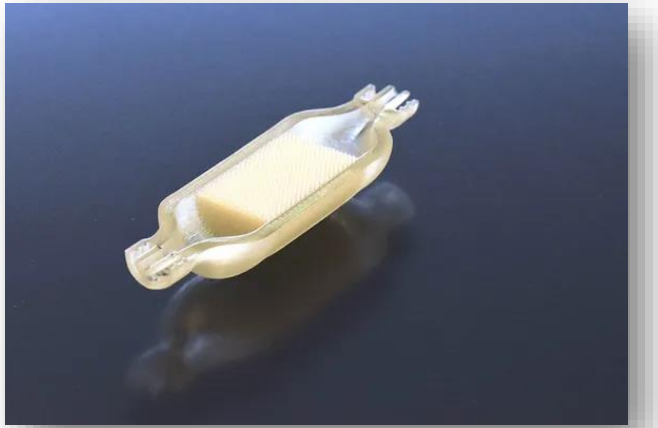
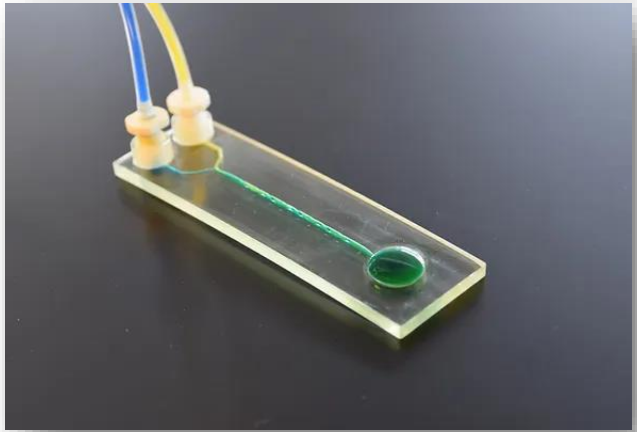
Antleron
Engineering life

LifeFab.eu

- 3D cell cultivation



- 3D microfluidics



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

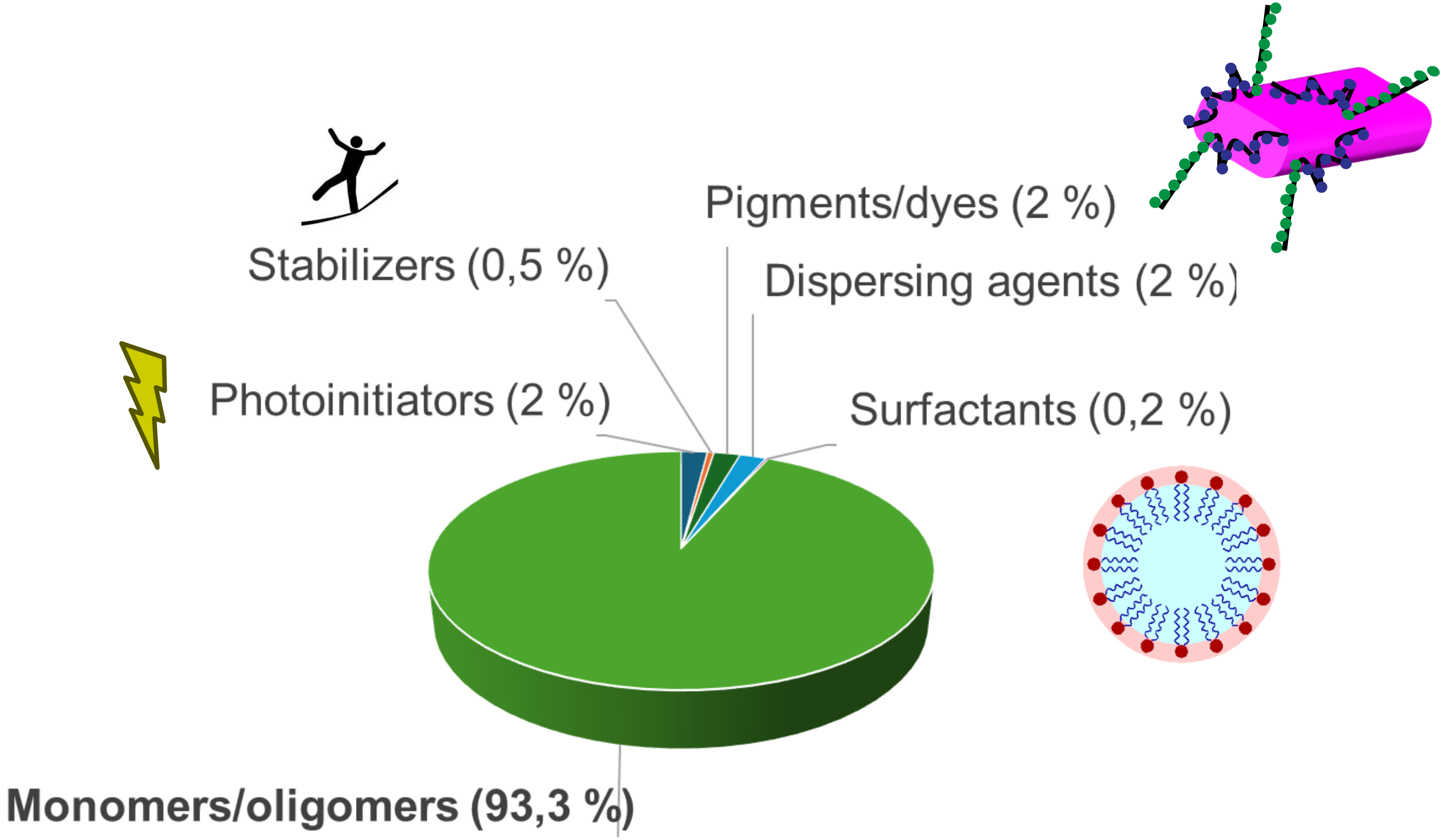
It all starts with the ink…

- Avoid addition of **known problematic** substances to your formulation

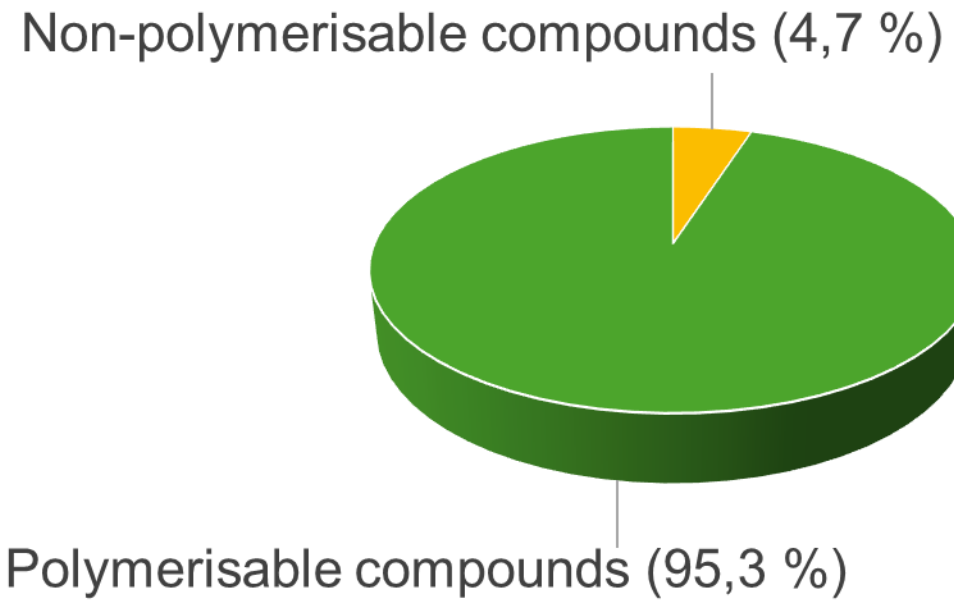
- But be careful with labels…

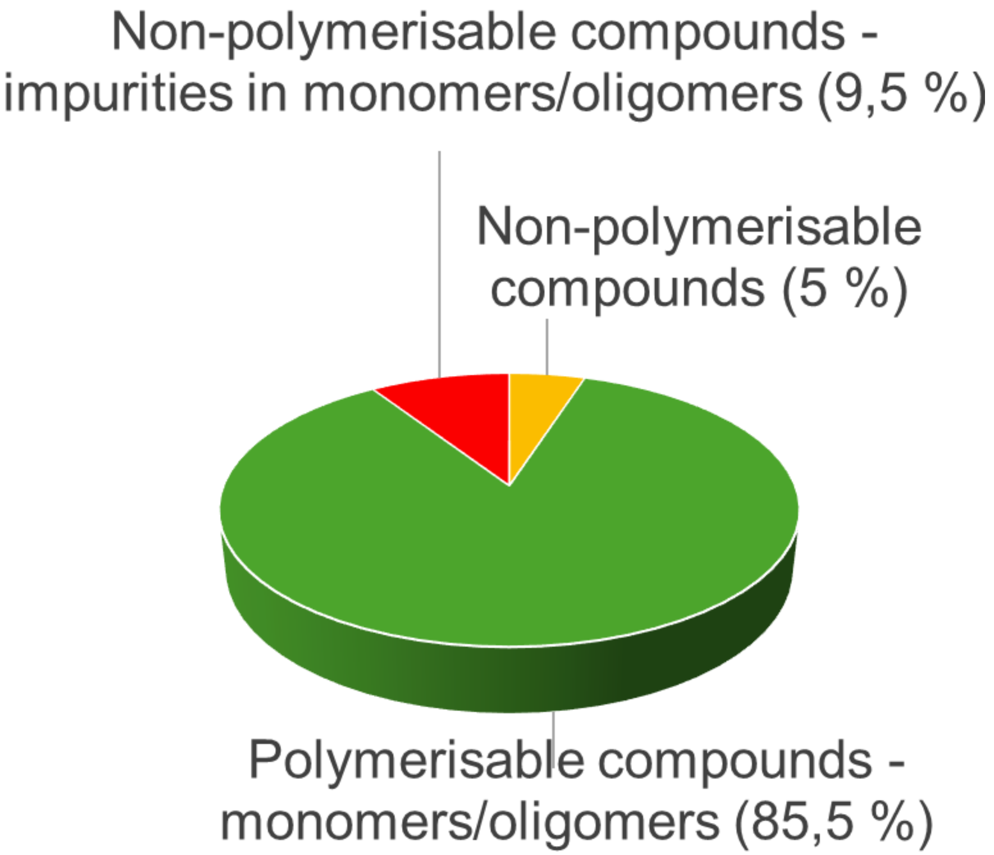
- EU prepares ban on Bisphenol A in food packaging applications (2024)

3D UV printing inks: composition

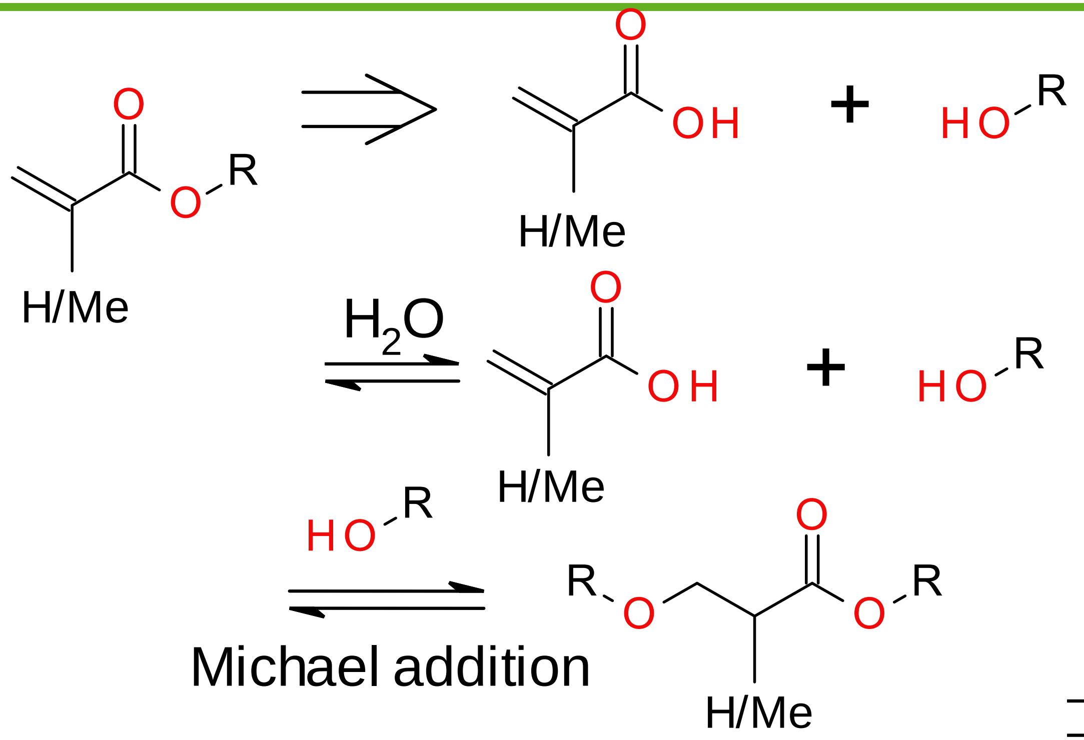


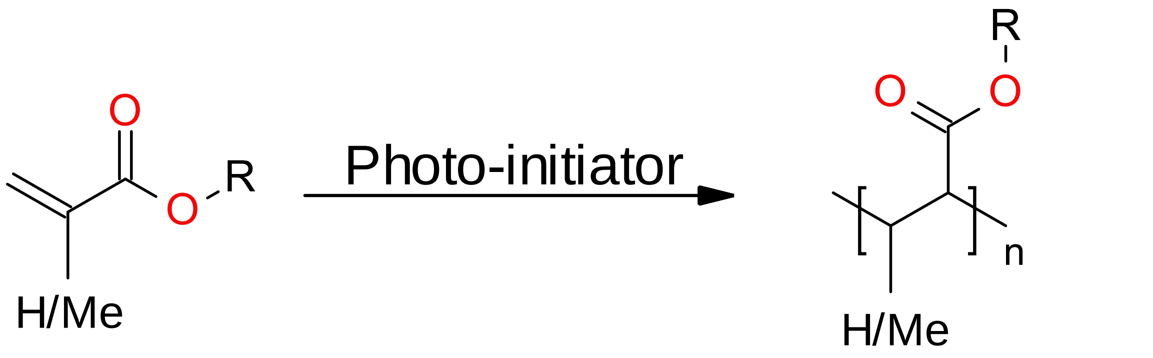
3D UV printing inks: composition





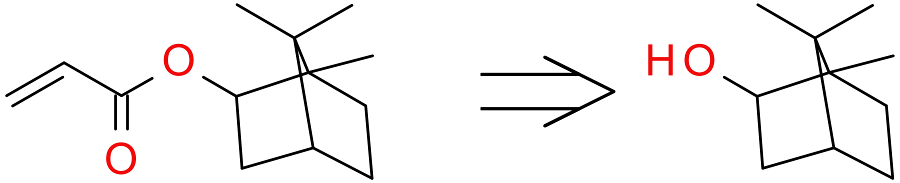
Chemistry of (meth)acrylates





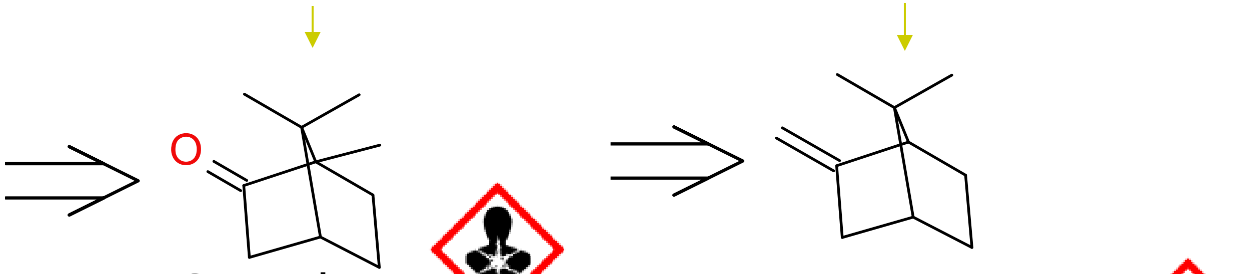
Not indicated on MSDS

Indicated on MSDS, Concentration < 0,5 %



Isobornyl acrylate (IBOA)

Isoborneol



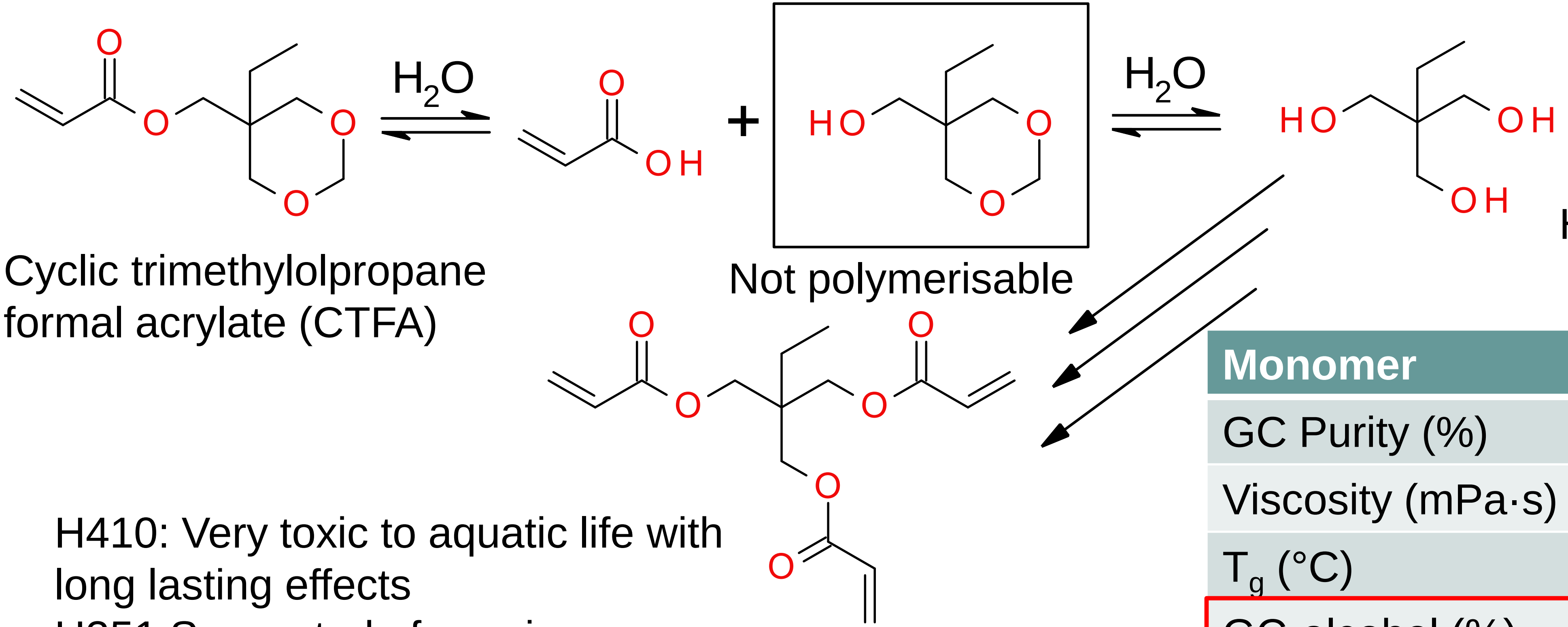
Camphor, known plasticizer

Camphene

H302 Harmful if swallowed
H332 Harmful if inhaled
H371 May cause damage to organs

H410: Very toxic to aquatic life with long lasting effects

Different purity… different properties!



Cyclic trimethylolpropane formal acrylate (CTFA)

Not polymerisable

H301: Toxic if swallowed

Trimethylolpropane triacrylate (TMPTA)

H410: Very toxic to aquatic life with long lasting effects
H351 Suspected of causing cancer

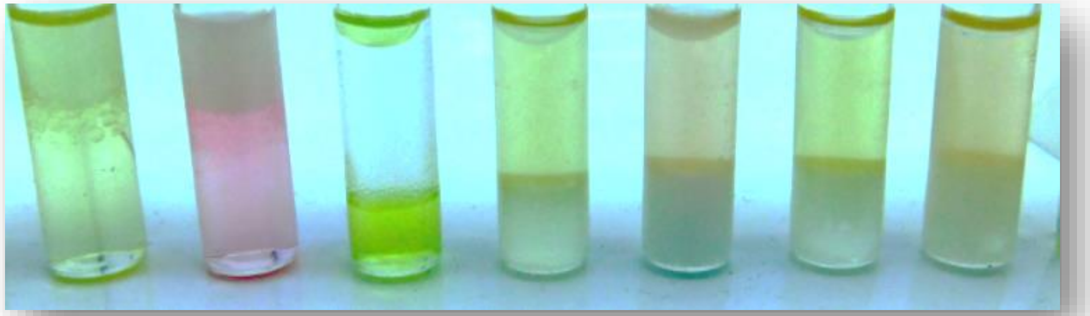
Can act as plasticizer

Monomer	CTFA-HP	CTFA
GC Purity (%)	99,6	84,0
Viscosity (mPa·s)	10	13
T_g (°C)	27	15
GC-alcohol (%)	0,1	3,4
Water (%)	0,03	0,24
Color (APHA)	5	45 (Light yellow)

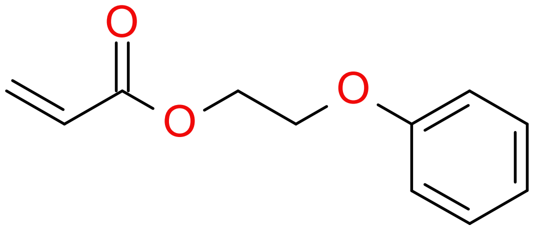
Monomer purity check – Acidity

- ChemStream uses a **quick test** to determine the acidity of a monomer/oligomer
- Visual inspection of a mixture of monomer/oligomer, water and **pH indicator** gives an idea about acidity
- The presence of acid often creates **stability problems** in IJ inks

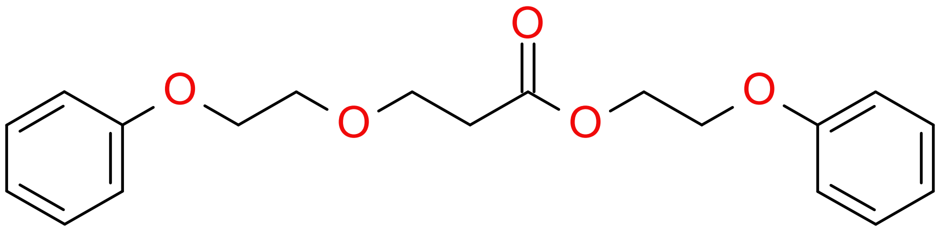
pH < 3,1
3,1 < pH < 4,4
pH > 4,4



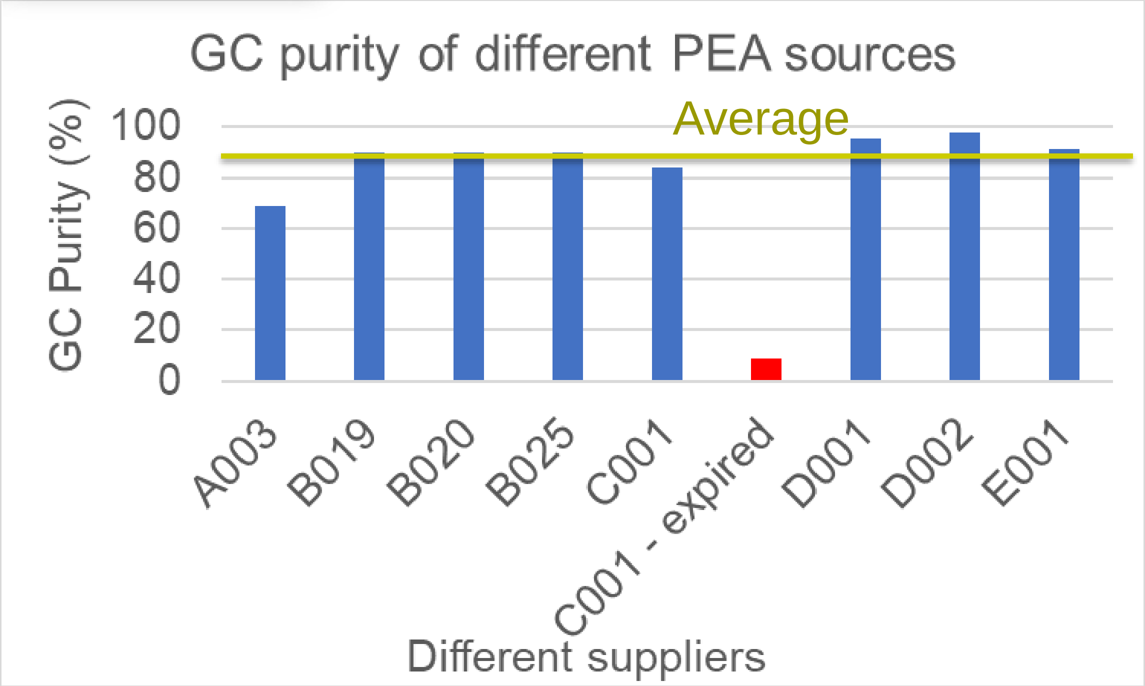
Monomer purity check – GC/LC-MS

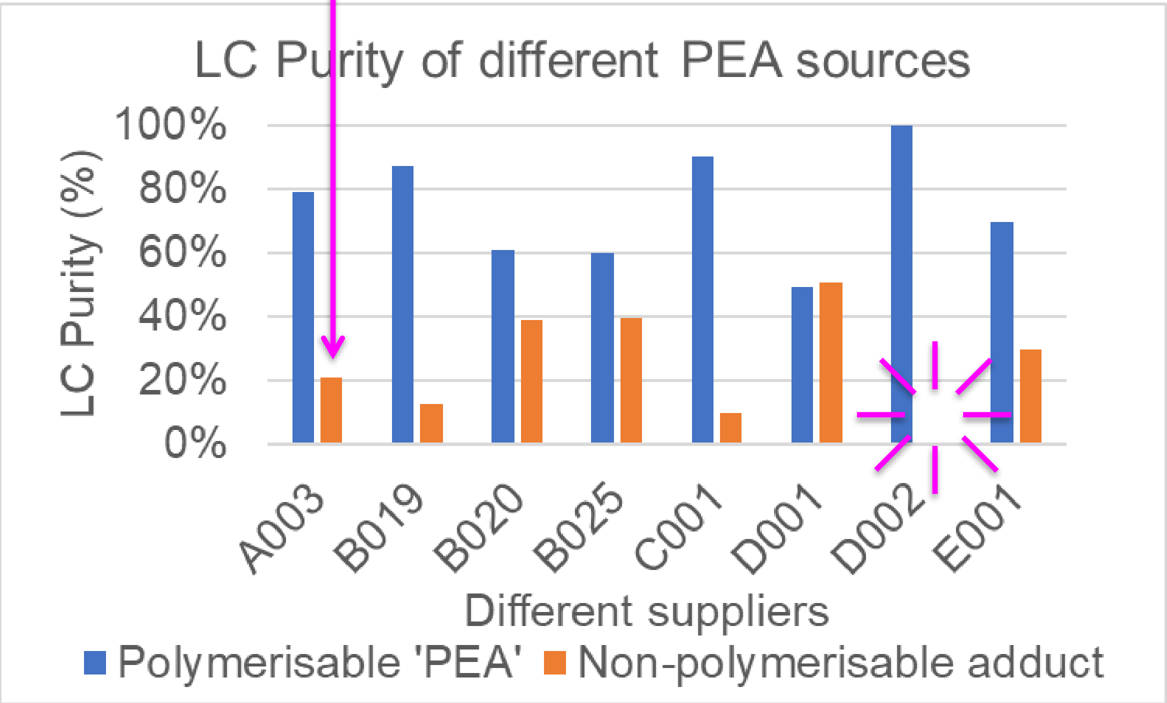


Phenoxy ethyl acrylate (PEA)



Michael addition product of PEA and phenoxy ethanol



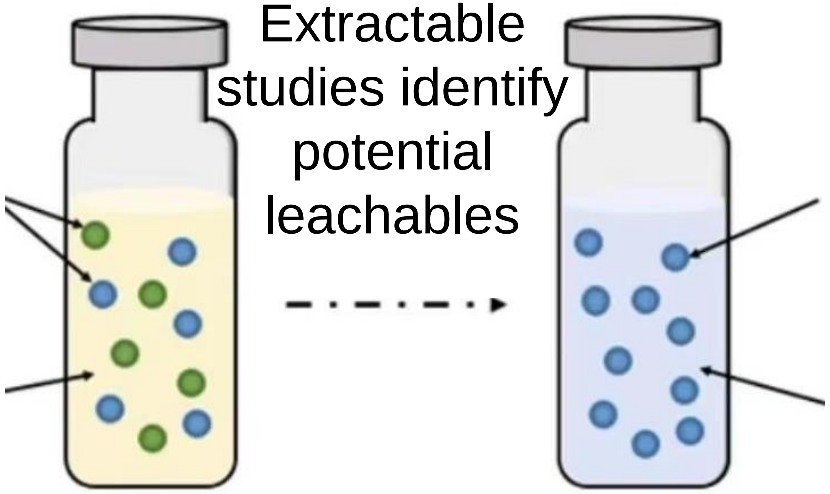


Very low leaching required?

- **Extraction test**

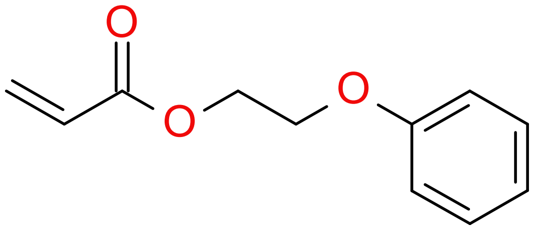
= quick test to assess which chemical compounds can be **extracted** (worst-case scenario – with an organic solvent)

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



“Worst-case scenario”

Extraction test



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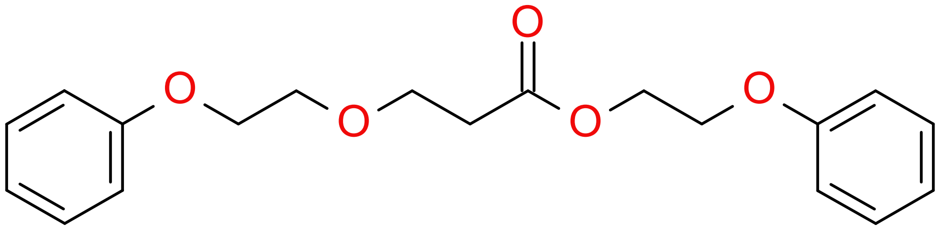

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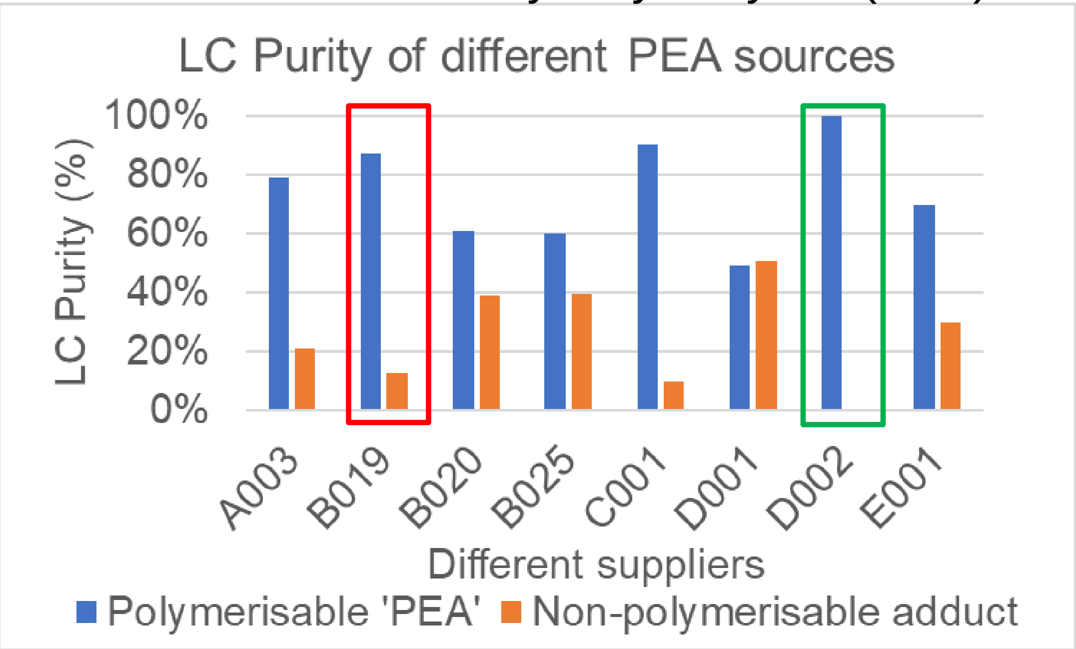
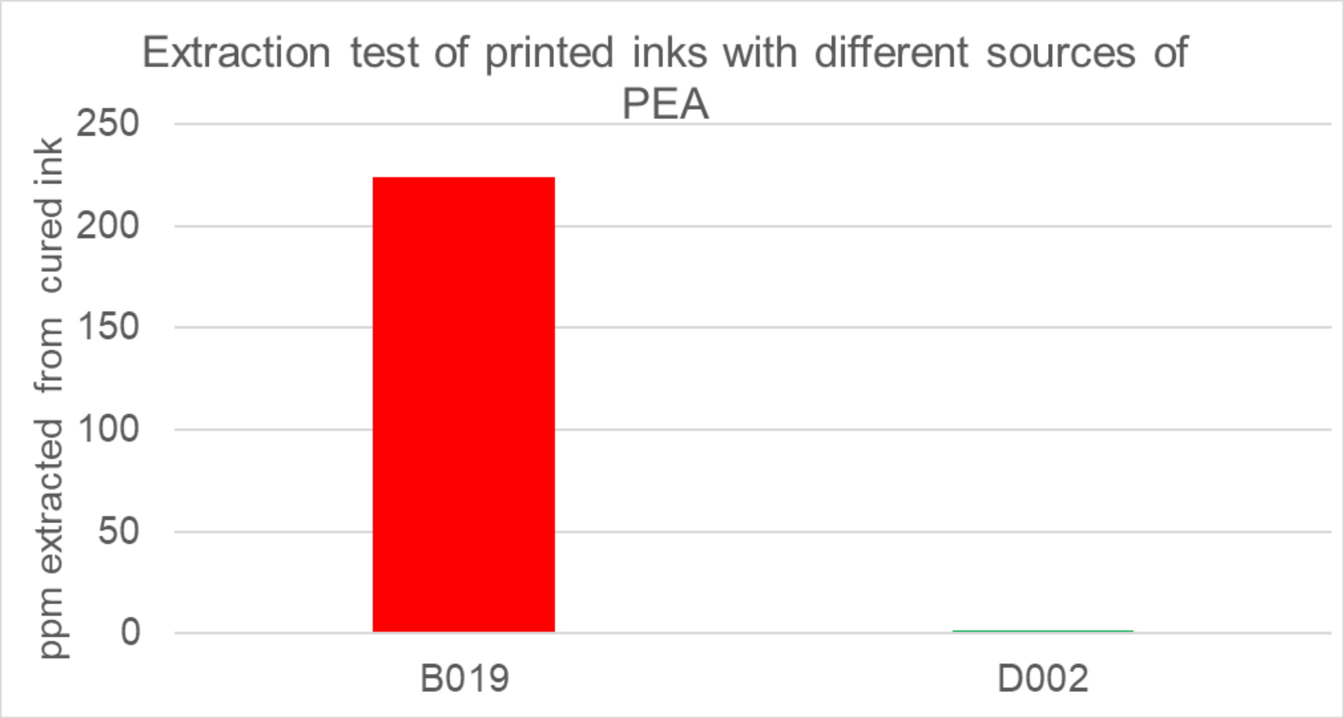
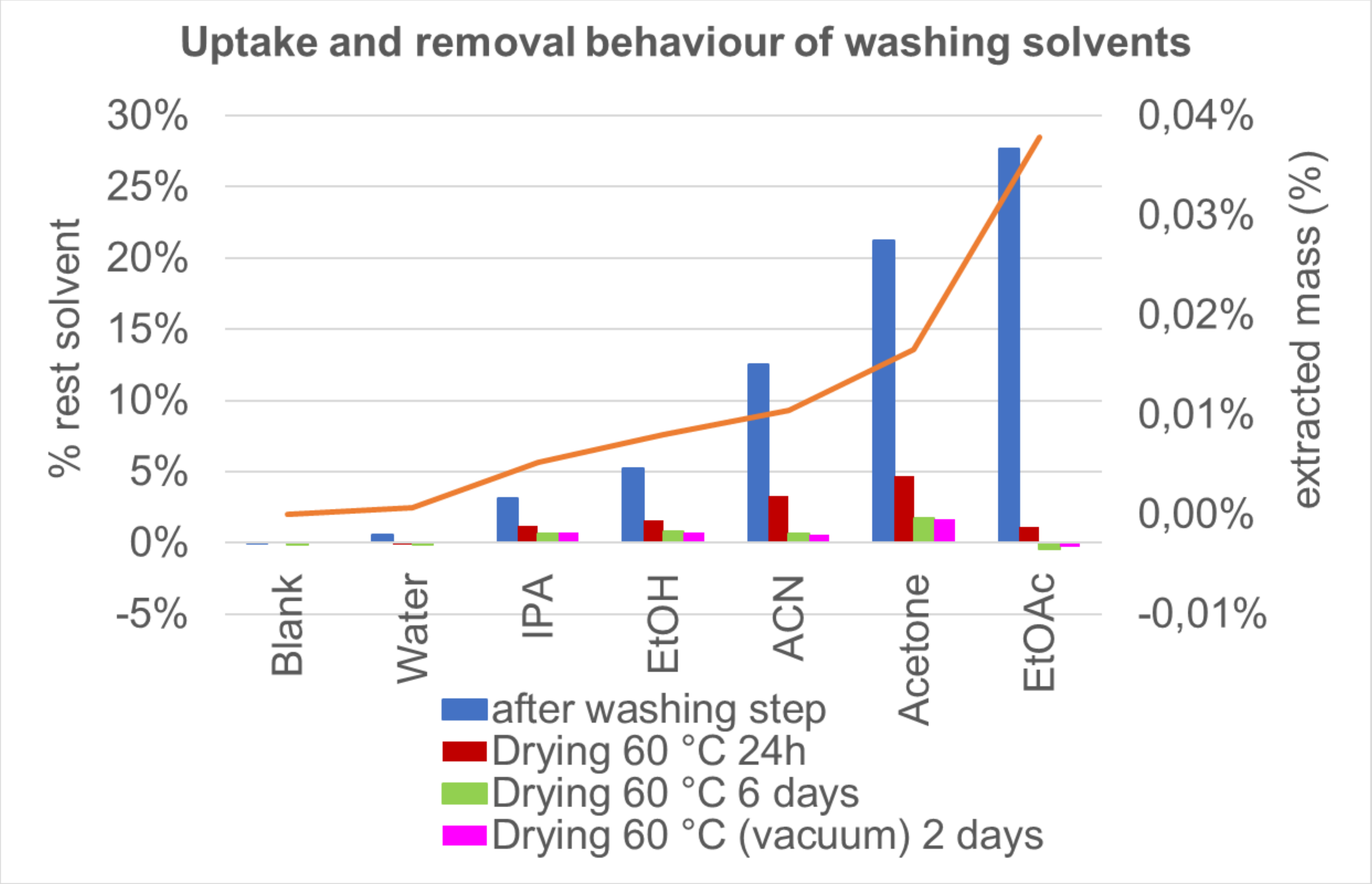




The importance of post-treatment

- 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 (~~oxygen inhibition~~)
  - Vacuum (possible VOC removal)
  - Nitrogen
  - Glycerin (or water)
- Consider E-Beam curing
- Not good enough? => extra **washing** step

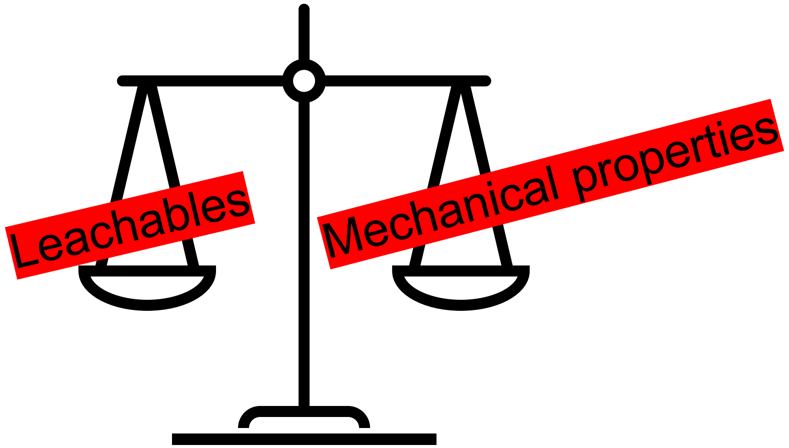
Washing step: Pre-extraction



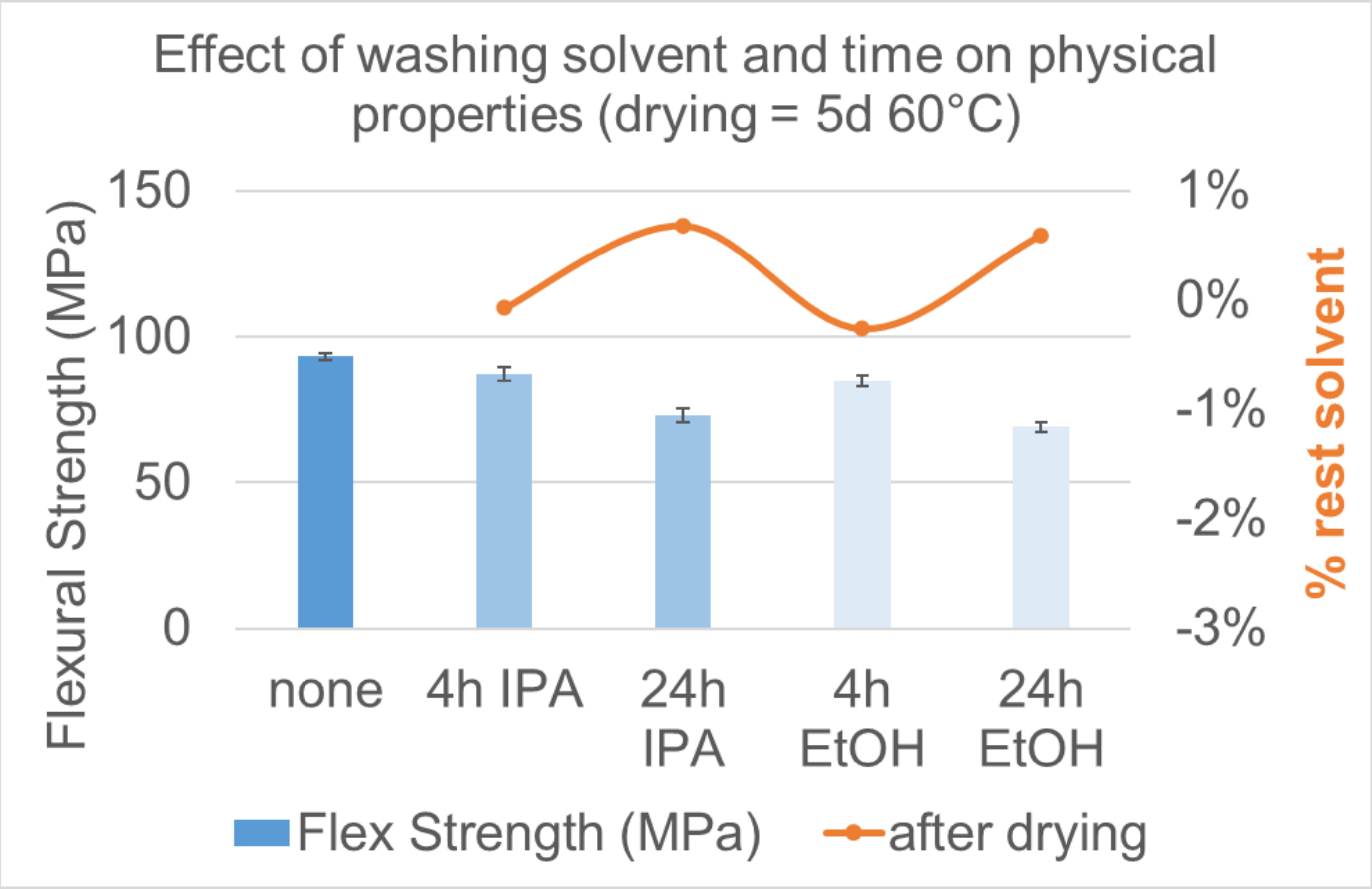
- Different solvents can penetrate different objects easier or more difficult
- “**Smaller molecules/solvents**” can penetrate an object better
- Be careful! Solvents that have entered an object are **notoriously difficult to remove** again and can act as plasticizer!
- If an object swells **too much**, 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 extracted to have a non-cytotoxic material



Conclusions

- 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

Thank you…

… for your attention!

Find us at our booth (A3) for further questions and discussion

www.chemstream.be

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