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TheIJC.com

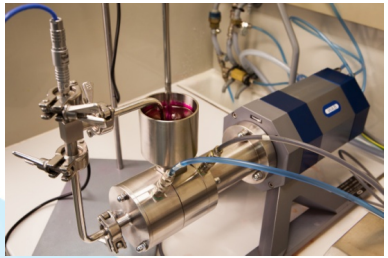
CHEMSTREAM
SUSTAINABLE CHEMISTRY

Optimizing ink formulations to meet customized end user requirements

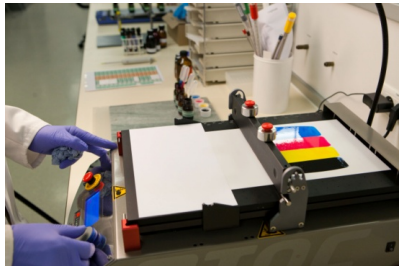
Frank De Voeght - ChemStream

ChemStream's profile: Chemical R&D Company

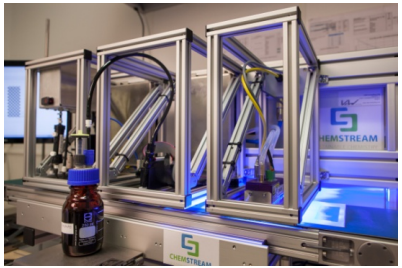
- Core activities:
  - Innovative contract research
  - Customized product development
- Translating customized requirements into chemical formulations with dedicated functionality, from design to prototyping:
  - Nano dispersions



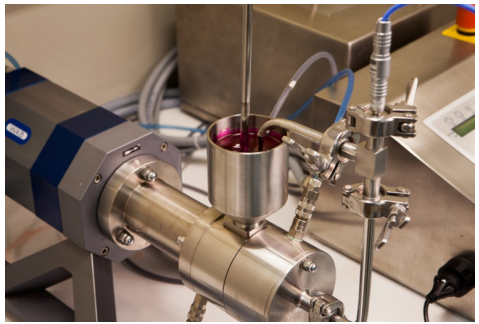
  - Coatings



  - Inkjet inks



Ink design: Helicopter point of view



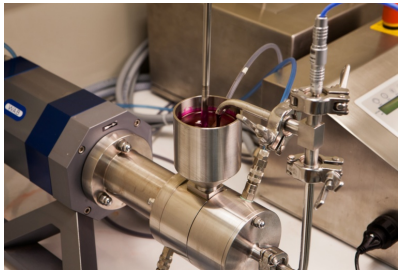
Functionality:
- Colorant
- Pigment nano dispersion
- Conductivity
- Hydrophobicity
- ….

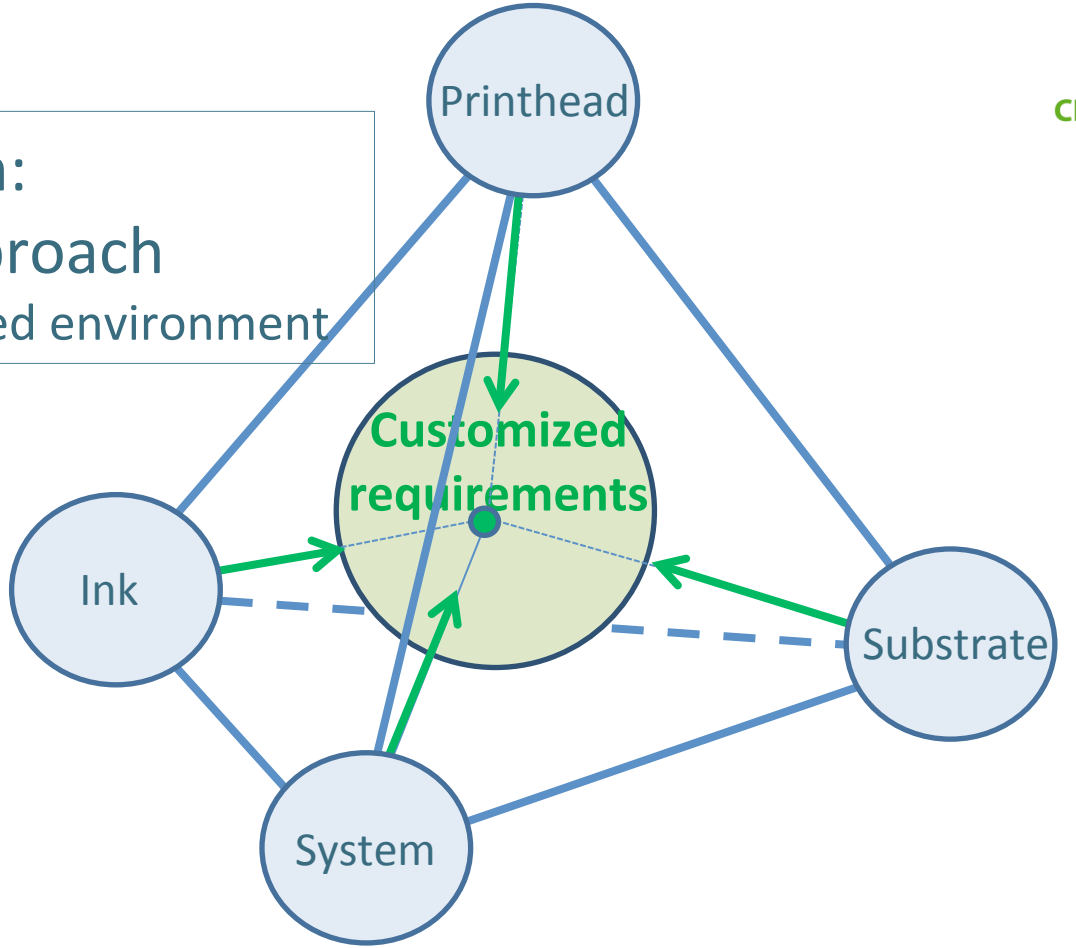
Carrier design:
- Process/application driven
- Rheology
- Ink/media interaction
- Ink/printhead interaction
- …

End user requirements

Jetting performance

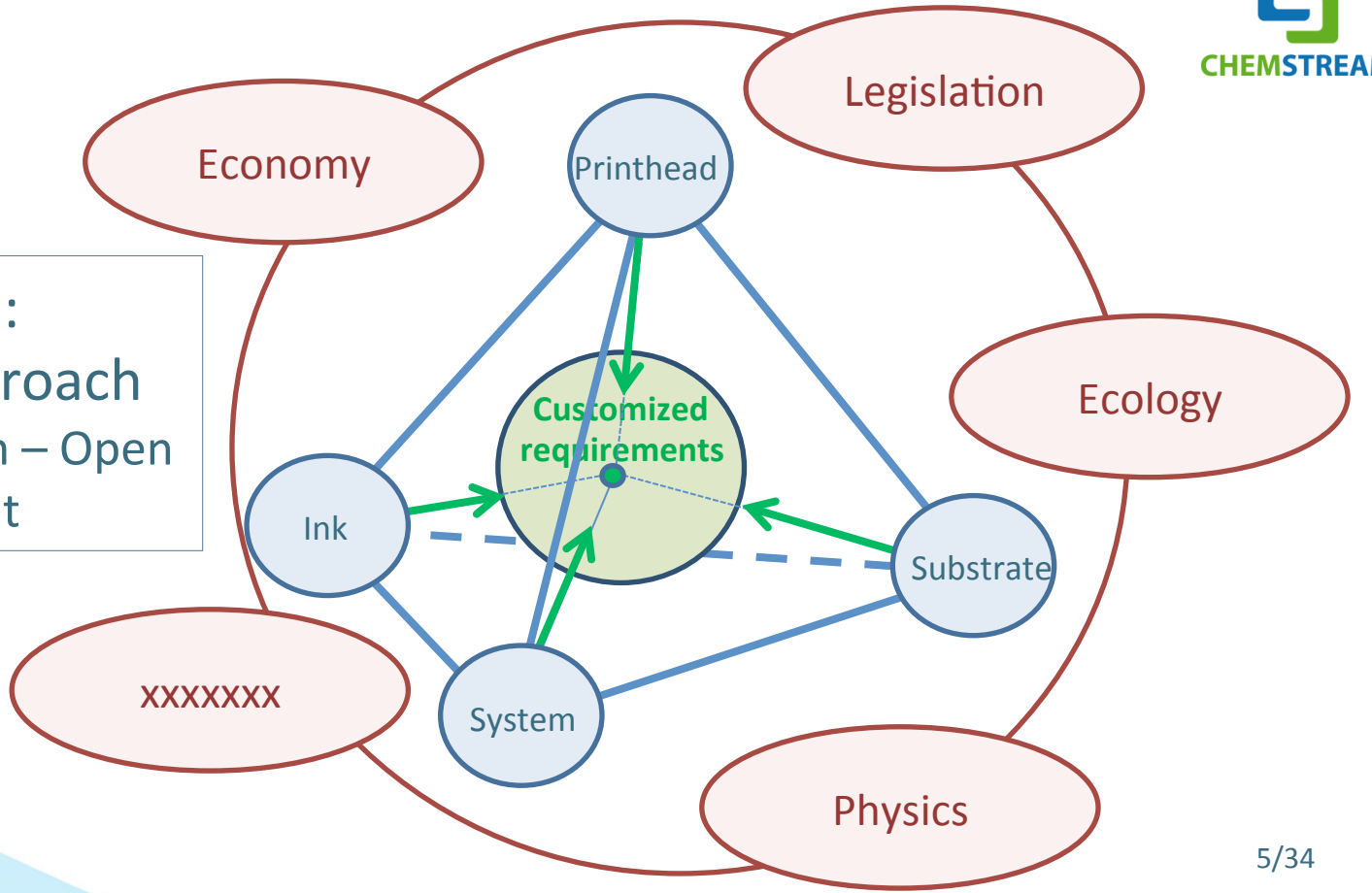
Ink design:
Integrated approach
Interaction diagram - Isolated environment





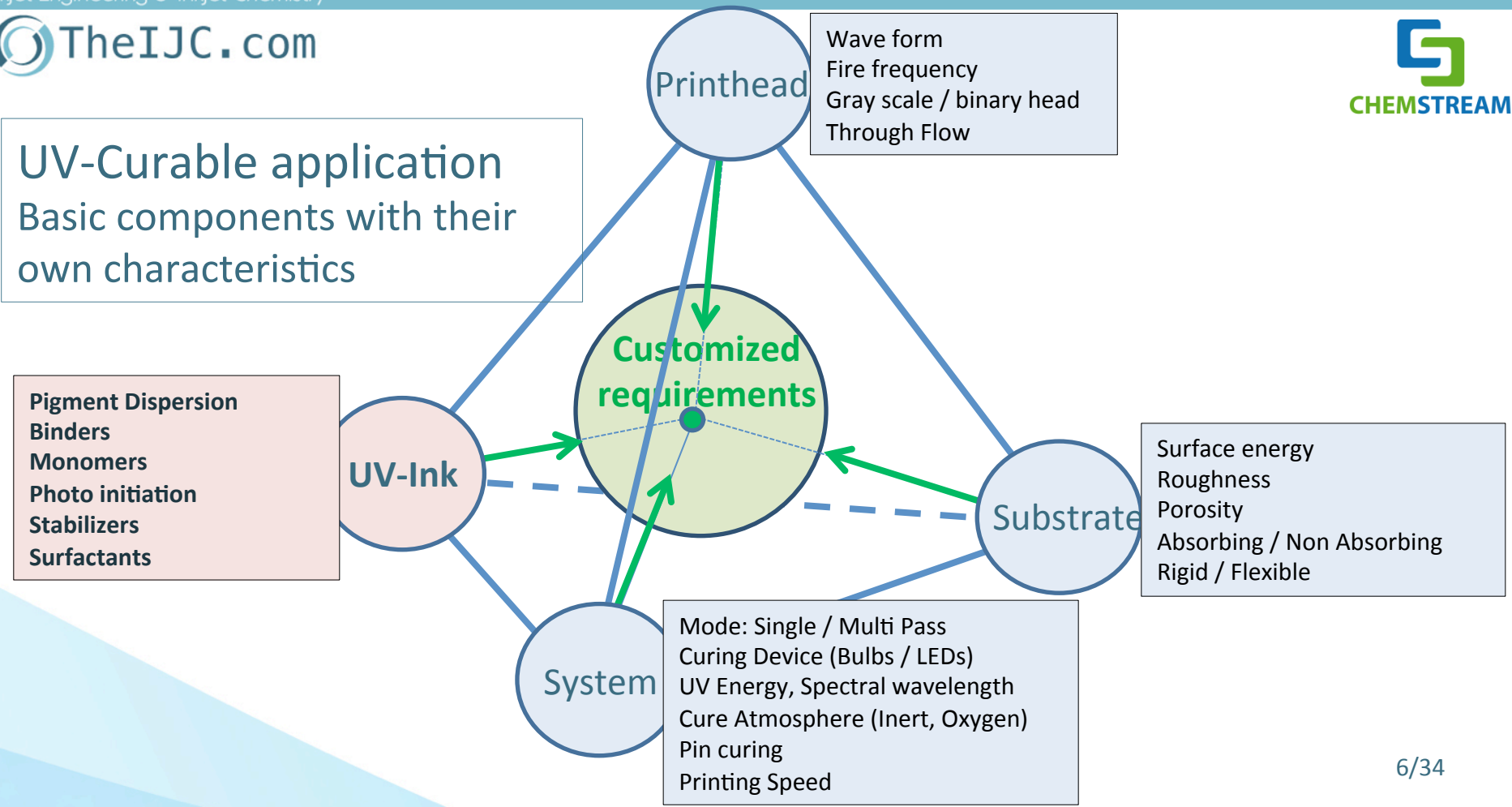
Ink design: Integrated approach

Interaction diagram – Open environment



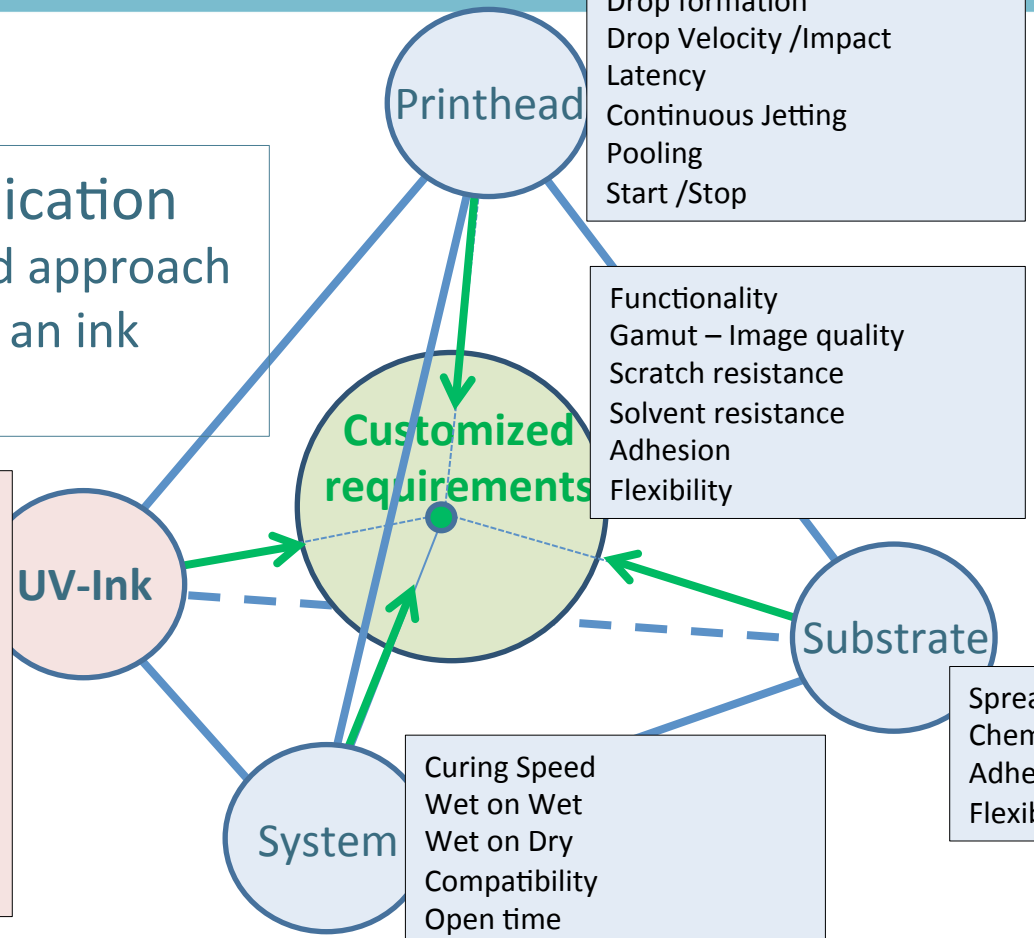
UV-Curable application

Basic components with their own characteristics



UV-Curable application

- System integrated approach
- Interactions from an ink point of view



Ink development: a dynamic iteration process between 3 sub processes

- Chemical formulation process
- System integrated process
- Customer driven interaction process in an open environment

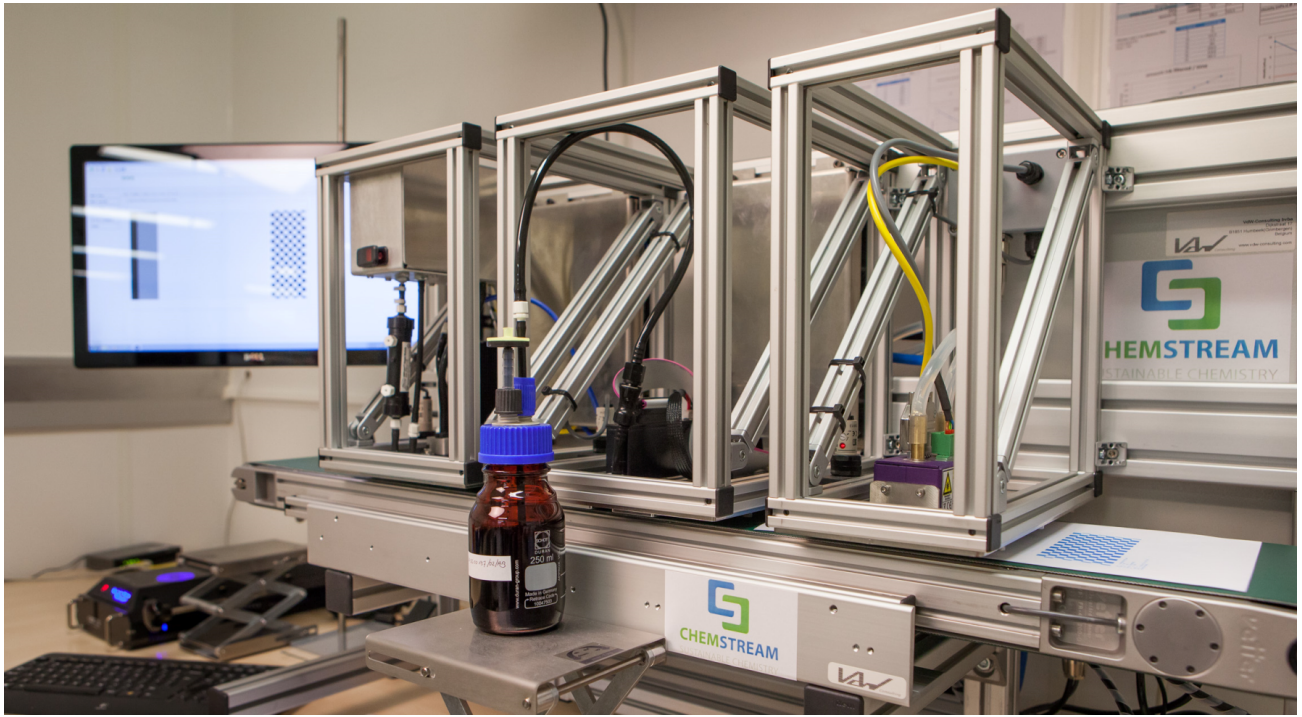
How to translate this dynamic iteration process in a lab workflow?

MPU:

Modular Printing Unit

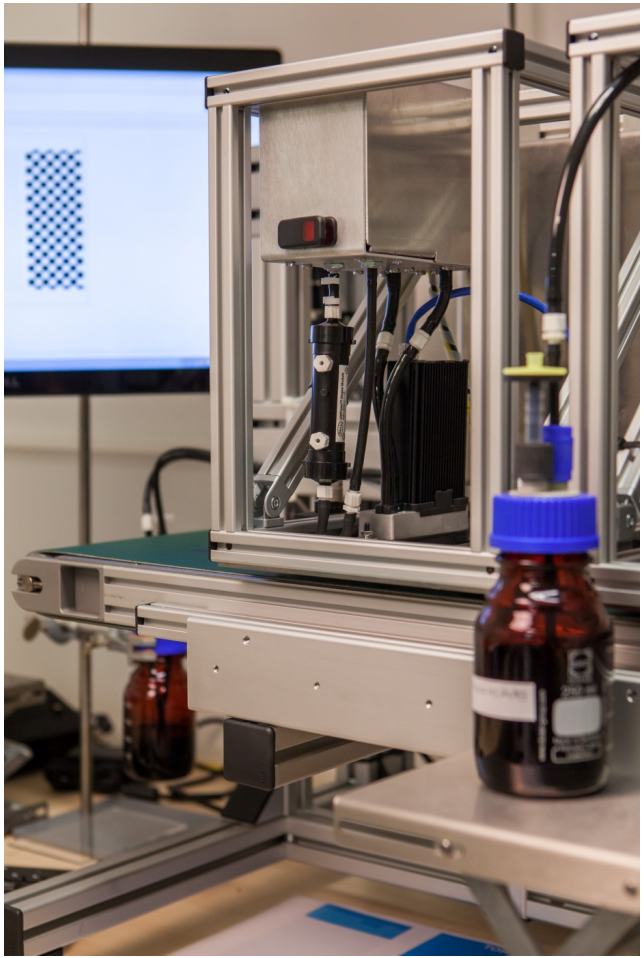
in cooperation with

VA Consulting



Modular printing unit: easy tool for feasibility research

- Mimic of an in line coating/printing process
- Fast iterations of ink prototypes
- Fast iterations with different printheads
- Low investment level for customer
- Ink/media interactions
- Easy to provide test samples



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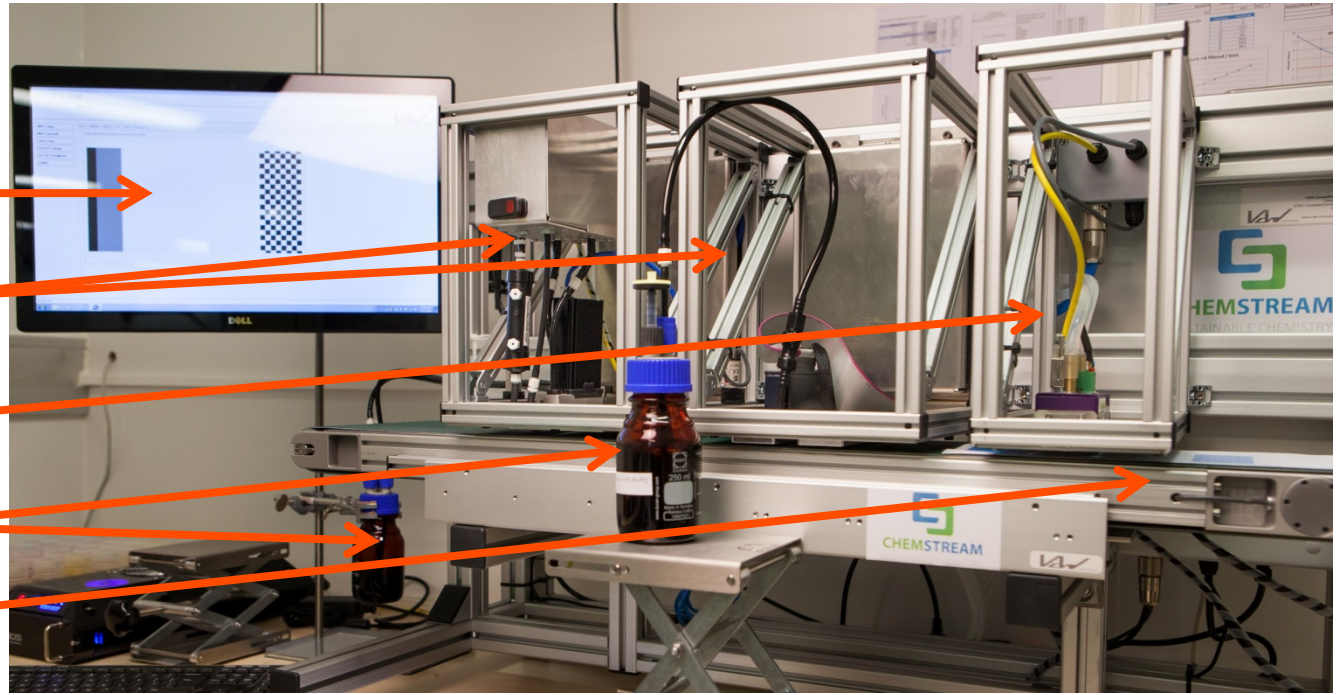
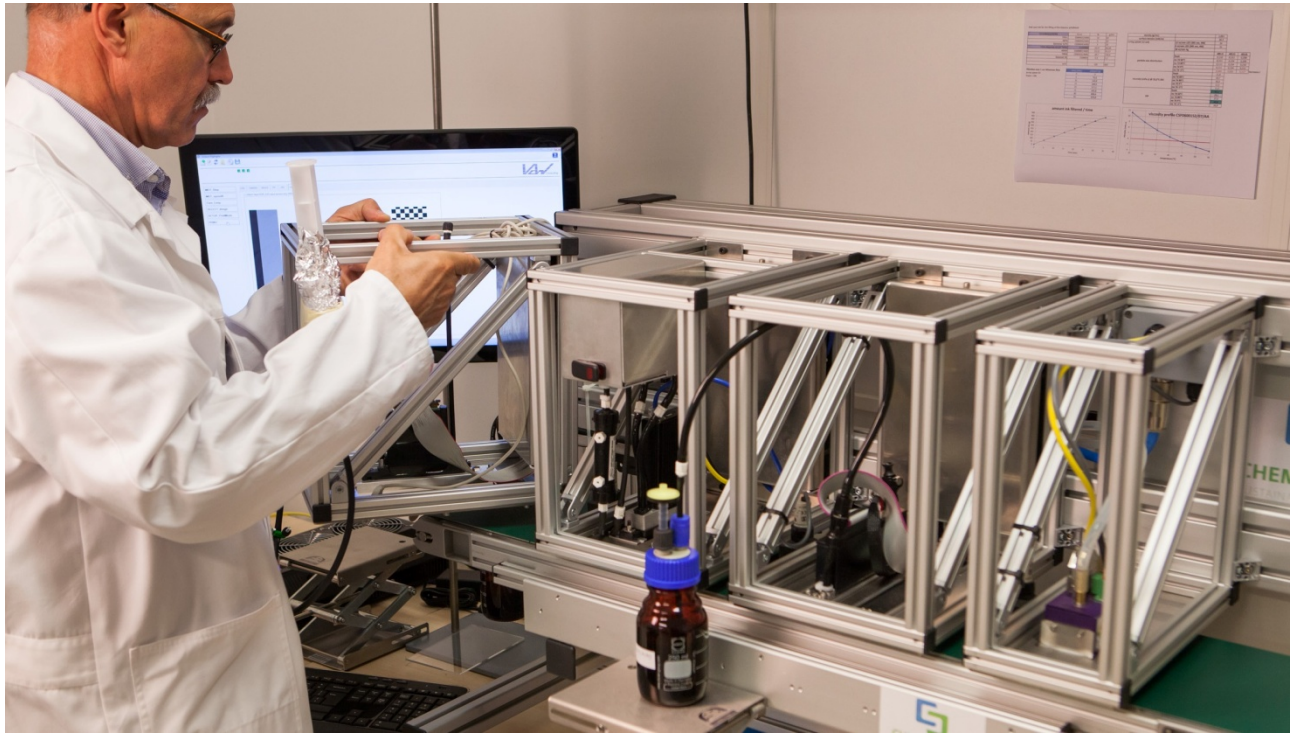
MPU

- User interface
- Printhead module
- Curing module
- Prototype ink
- Transport belt



MPU:

Easy removal and/ or addition of printheads with their appropriate driver electronics

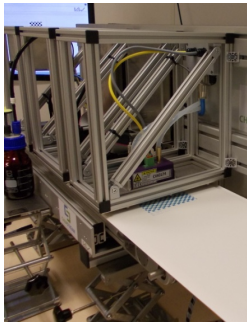


MPU

A variety of substrates:

- Plastics
- Metals
- Textiles
- Glass
- DCP
- 3D Objects
- …

PVC

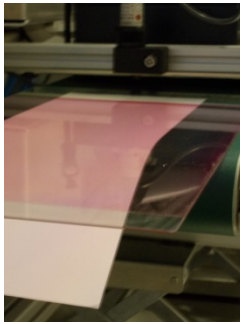


Cu-Tube

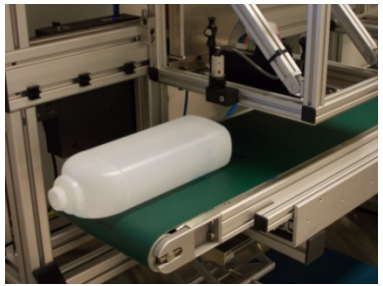
Al-profile

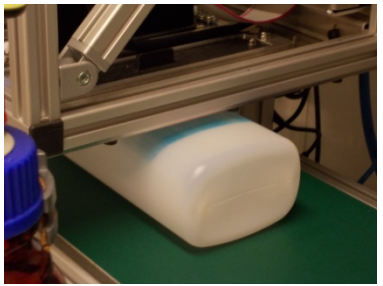
Cotton

SiN/Glass



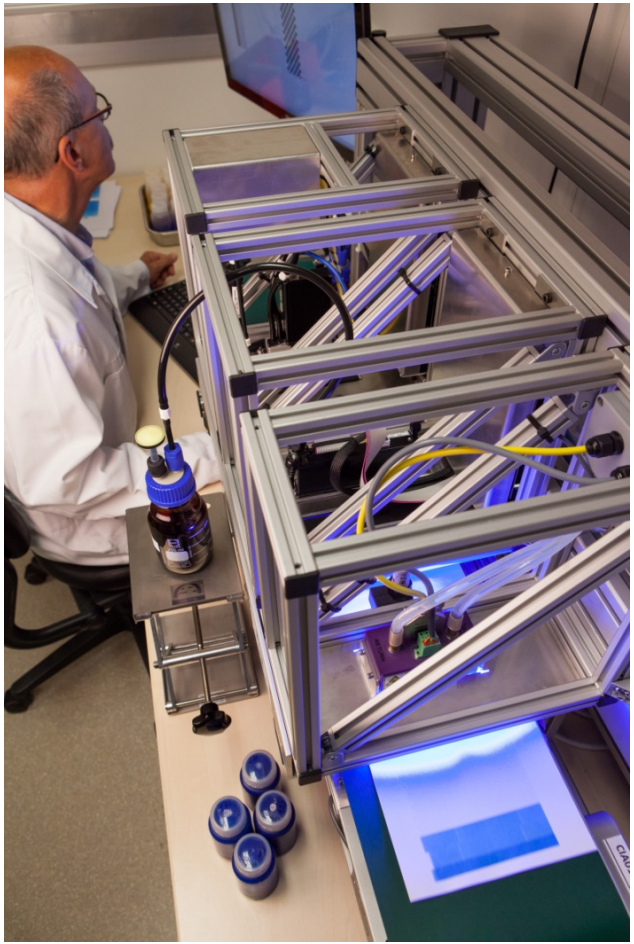
DCP:
Direct to Container Printing





MPU: Features

- 'Down to earth' printing system
  - Table top dimensions
  - No special infrastructure
  - Belt based system for single pass
  - Potential for crude multi pass
  - Small ink amounts
- Flexible towards:
  - Head selection and replacement
  - Substrate height
  - Print strategies
  - Ink replacement



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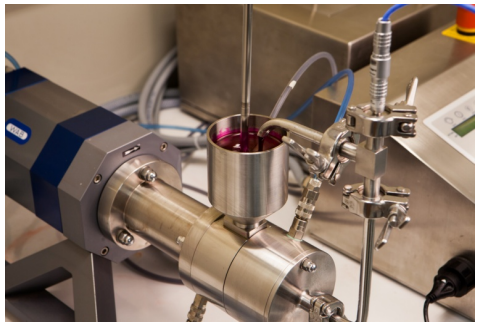
Ink design: The basics



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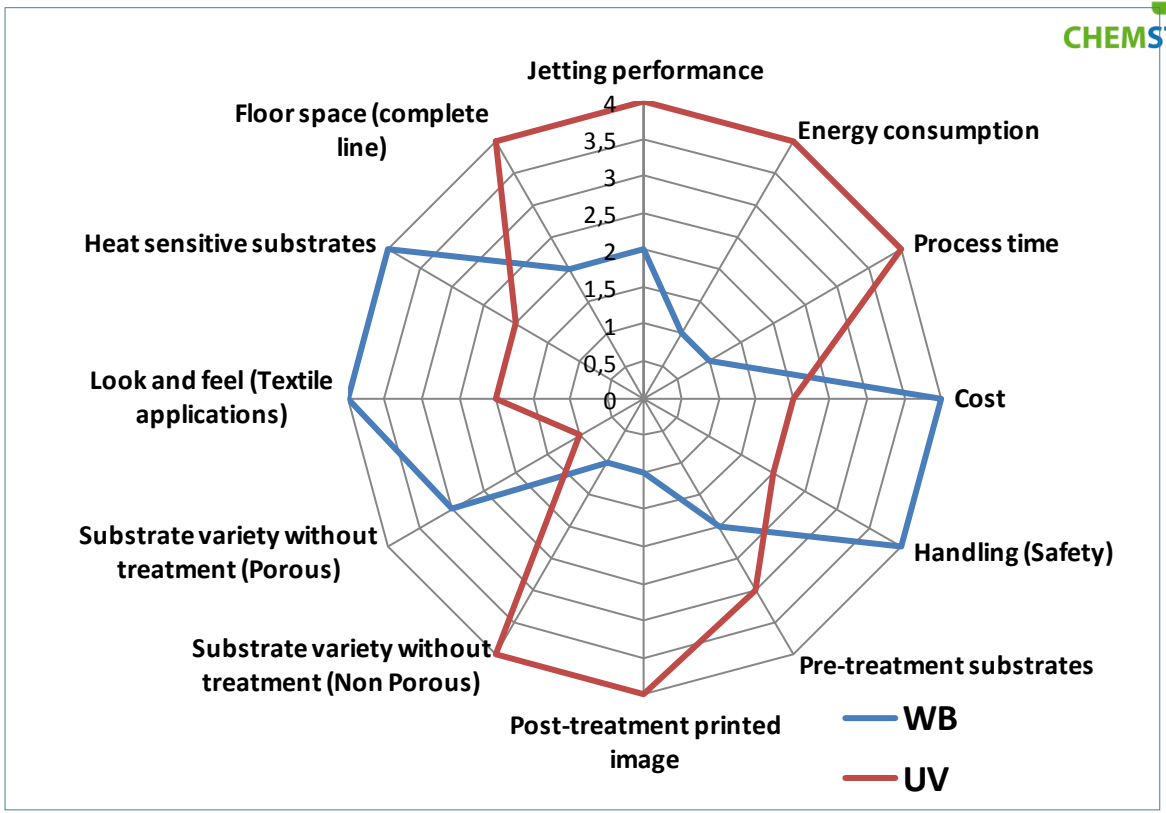
Carrier design:
- Process/application driven
- Rheology – WB / UV
- Ink/media interaction
- Ink/Printhead interaction
- …

End user requirements

Jetting performance

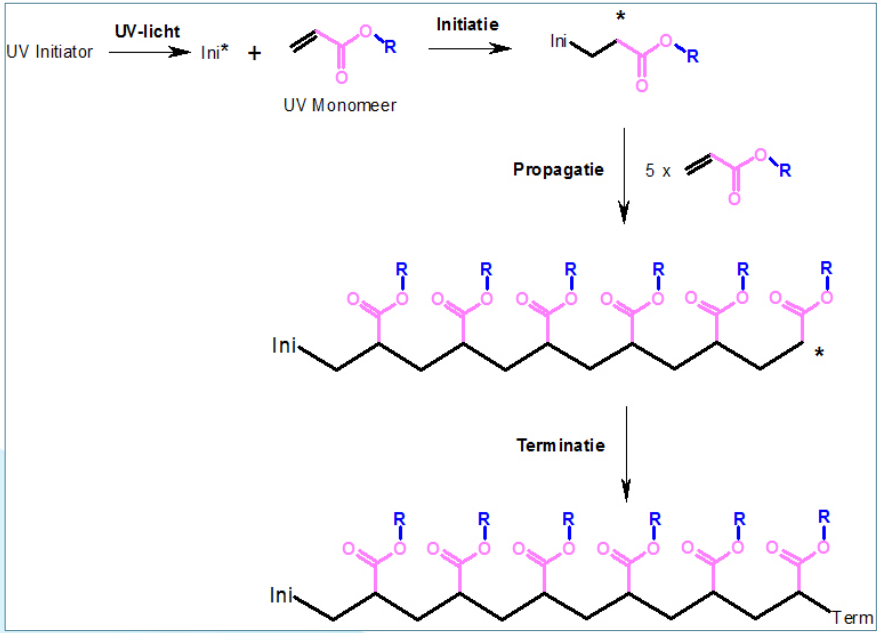
Carrier design

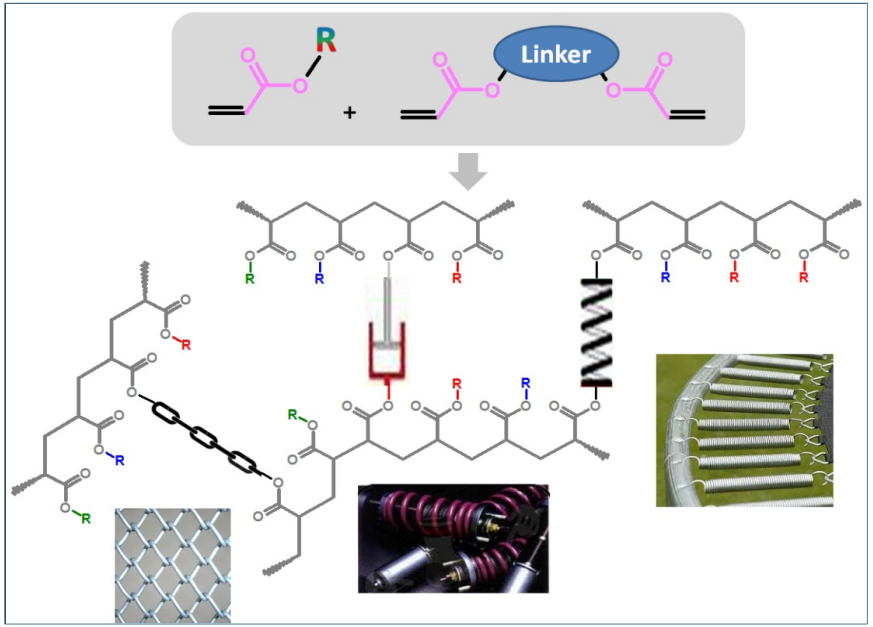
Waterborne inks
compared to
UV curable inks



Ink design: chemistry of UV curable inks

Smart choice of building blocks > Variety of physical properties



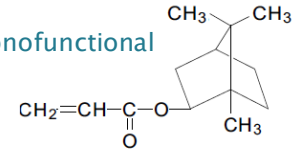


Ink design: chemistry of UV curable inks

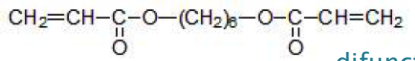
Polyfunctional acrylates
- Cross linking density

Acrylate resins
- Variety of functionality

monofunctional

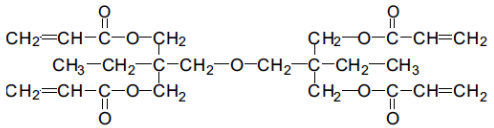


Isobornylacrylate



Hexanedioldiacrylate

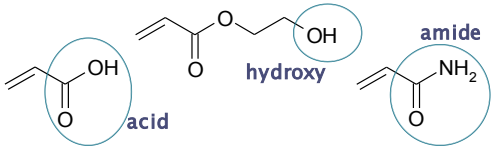
difunctional



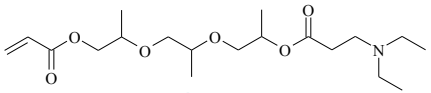
Di-trimethylolpropanetetra-acrylate

tetrafunctional

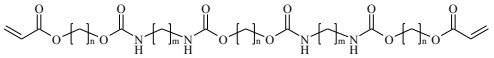
Variety of functional groups



small monomers



oligomers

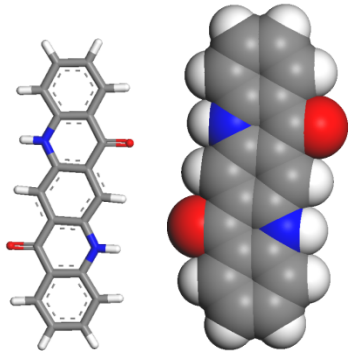


polymers

- Epoxy acrylate
  - High T Resistance
  - High hardness
- Urethane acrylate
  - High Flexibility > High Hardness
  - Chemical resistance
  - Scratch resistance
  - Adhesion
- Polyester acrylates
  - All-rounders
- Polyether acrylates
  - Reactivity
  - Abrasion resistance

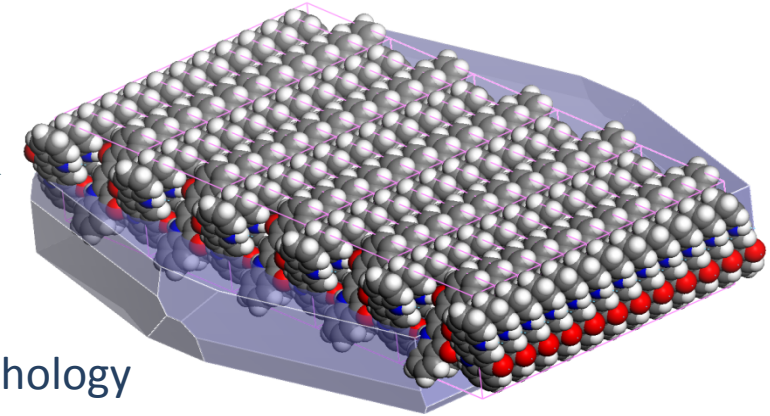
Ink design: chemistry of polymeric dispersants

Stabilized nano sized dispersions: Understanding the interaction of polymeric dispersants with crystal surfaces



Molecular structure
(Quinacridone)

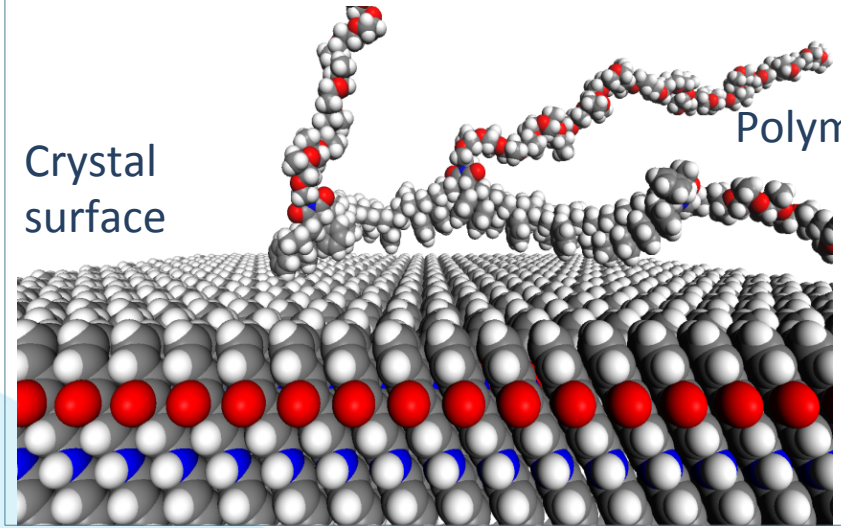
Molecular interactions



Crystal Morphology

Ink design: chemistry of polymeric dispersants

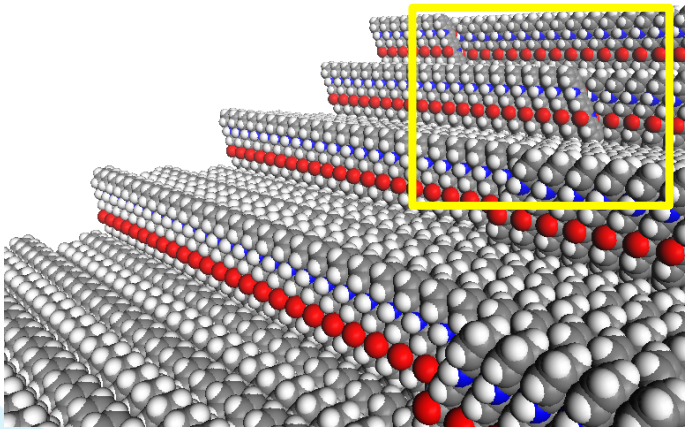
Understanding the interaction of polymeric dispersants with crystal surfaces



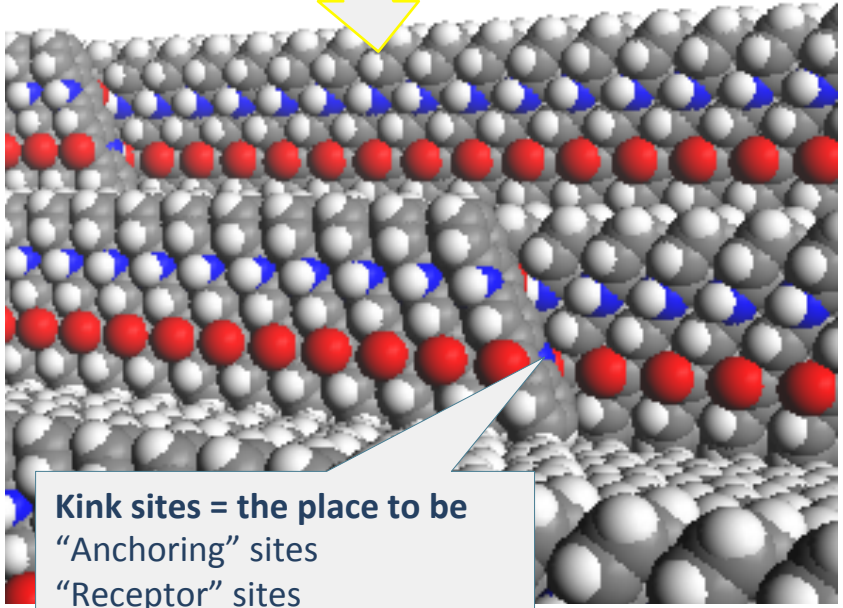
Detailed molecular interactions between the dispersant and the crystal surface can be calculated with high accuracy

Ink design: chemistry of polymeric dispersants

Understanding the interaction of polymeric dispersants with crystal surfaces



Real pigment world is even more exciting:
crystal surface contains **steps and kinks**

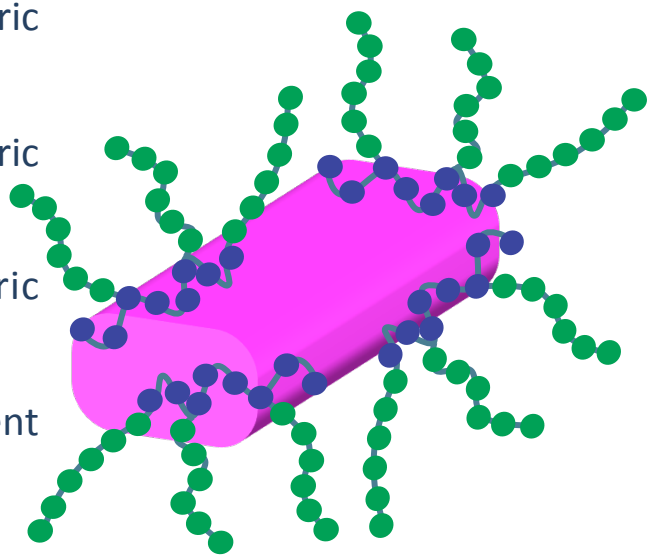


Kink sites = the place to be
"Anchoring" sites
"Receptor" sites
"Catalytic" sites

Ink design: chemistry of polymeric dispersants

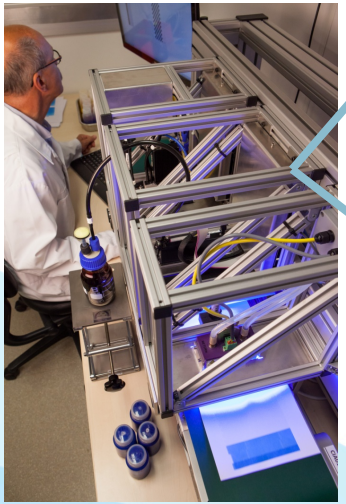
Polymeric dispersants with optimal architecture

- Design the **pigment-anchoring chemistry** of the polymeric dispersing agent or redesign the **pigment surface**
- Design the **colloidal-stabilizing chemistry** of the polymeric dispersing agent
- Design the optimal architecture of the polymeric dispersing agent
- Synthesis of the polymeric dispersing agent / pigment particle surface
- Evaluation in nano dispersion of pigment



Case studies based on

- MPU
- Nano dispersions
- Polymeric dispersants
- UV-technology
- Waterborne



Piezo DOD

- UV-LED Curable
  - In line encoding of rigids
  - Fluo marker on textile
- WB
  - Fluo pigment on textile
  - Hydrophobic functionality on textile

CIJ

- Solvent
  - Fluo dye in packaging

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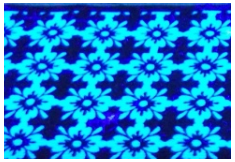

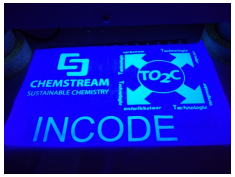

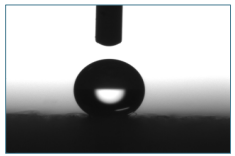

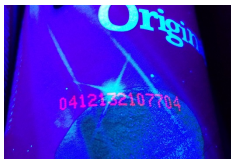

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In-line single pass encoding of rigids with UV LED curable inkjet inks

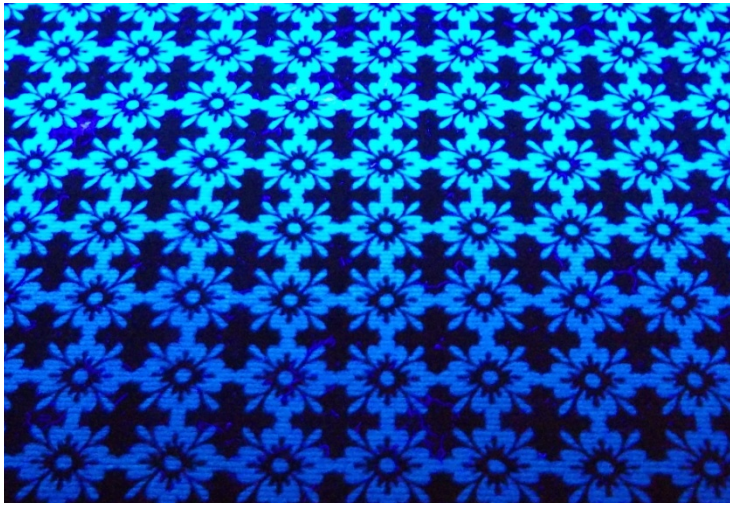
- High performance UV curable inkjet inks :
  - DOD (drop on demand) piezo printheads (Xaar, Konica-Minolta, Ttec…)
  - UV-LED Curable (395 nm)
  - Non yellowing after curing
- Concept
  - Nano dispersions of
    - C,M,Y,K pigments (mean particle size < 100 nm)
    - Fluorescent pigments (in case of invisible)
  - Low viscous monomers with dedicated functionalities depending on substrate: PVC, Cu, Al, Glass, PMMA
  - Appropriate photo initiation system

Example of an invisible image:

- *printed on a copper tube with Xaar 318*
- *illuminated with blacklight (365 nm)*

In-line single pass encoding of textiles with UV LED curable inkjet inks

- High performance UV curable inkjet inks :
  - DOD (drop on demand) piezo printheads (Xaar, Konica-Minolta, Ttec…)
  - UV-LED Curable (395 nm)
  - Non yellowing after curing
- Concept
  - Fluorescent dye
  - Appropriate mono functional monomers and oligomers
  - Appropriate photo initiation system

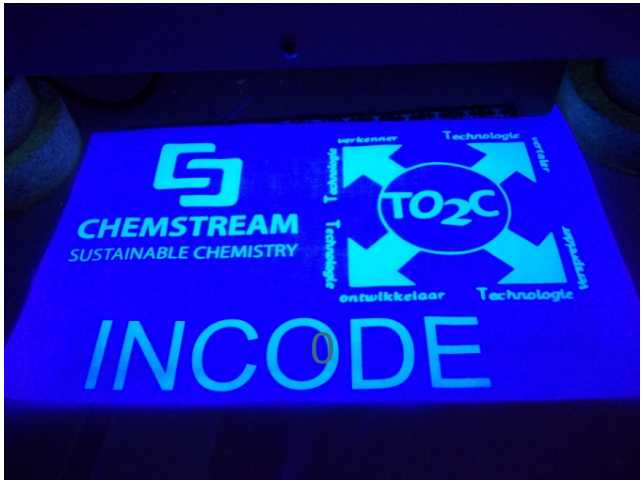


Example of an invisible image:

- *printed on a textile substrate*
- *illuminated with blacklight (365 nm)*

Encoding of textiles in single or multi pass mode with WB inkjet inks

- High performance WB inkjet inks :
  - DOD (drop on demand) piezo printheads (Seiko, Kyocera, Epson)
  - Textile substrate: 100% PES (100% Cotton)
  - Rub resistance (ISO105-X2) – 20x wet and dry
  - Wash resistance (ISO 6330) – 1x,5x,10x, @ 40°C
- Concept
  - Fluorescent nano pigment dispersion
  - Appropriate polymeric dispersant for adhesion on polyester.



Example of an invisible image:

- *printed on a PES textile*
- *illuminated with black light (365 nm)*

Encoding of textiles in single or multi pass mode with WB inkjet inks

Functional performance of printed textile samples

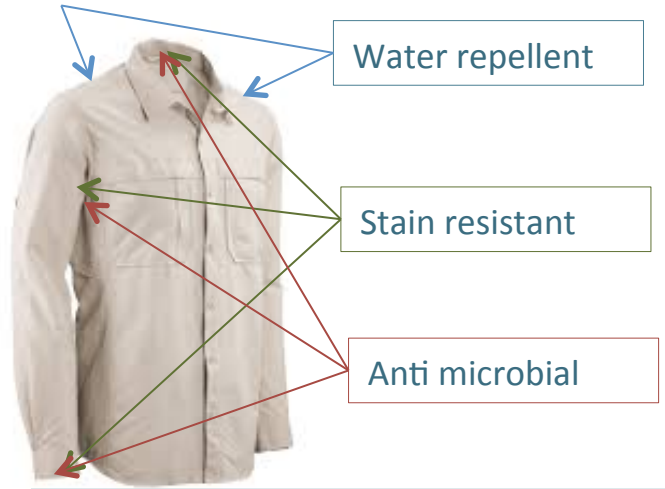
- On Cotton:
  - Wash resistance: Good
  - Rub resistance: Bad
- On Polyester:
  - Wash resistance: Excellent
  - Rub resistance: Good

Test results on printed textile samples

Patterned deposition of advanced functionalities on textiles

- High performance WB inkjet inks :
  - DOD (drop on demand) piezo printheads (Seiko, Kyocera)
  - Textile substrate: PES and PA
  - Water and oil repellent
- Concept
  - Lotus effect (combining micro and nano roughness)
  - Fluoro alkyl siloxane + C6 fluoro alkane
  - Fluoro surfactant and low viscous binder (viscosity modifier)

A two-year Crosstexnet European project, funded by IWT in cooperation with UGent (TO2C), VdW-Consulting, TST, FOV and UBoras
Project is focusing on new finishing techniques in textile industry



Example of local deposition of functionalities on hiking shirt

Patterned deposition of advanced functionalities on textiles

- Technical performance
  - Contact angles on printed samples:
    θ > 130° means (super) hydrophobic
- Functional performance (load dependent)
  - On PA:
    - Water repellency and wash fastness: Excellent
    - Oil repellency and wash fastness: Good
  - On Polyester:
    - Water repellency and wash fastness: Medium – Good
    - Oil repellency and wash fastness: Medium – Good

Contact angles of H_2O

Printed fabric	Load of active agent on the fabric 7,5 g/m²	15 g/m²
PA 3660	139°	143°
PES 8209	135°	140°

Coding application by Continuous inkjet (Solvent based)

Requirements

- Coding of packaging for internal QA
- Coding often printed on pre-printed text
- Coding must be invisible to customer

Problem with commercial ink

Bad readability under black light illumination

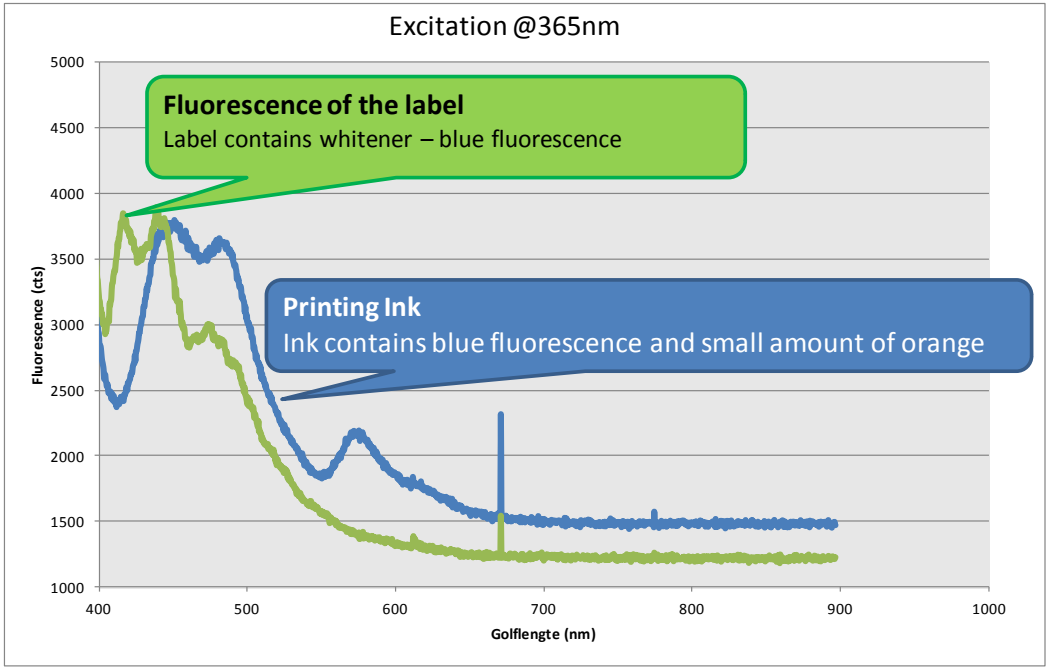
Normal light

Black light

Coding application by Continuous inkjet (Solvent based)

Problem analysis

- Fluorescence of commercial ink and label overlap
- Insufficient contrast to ensure adequate readability



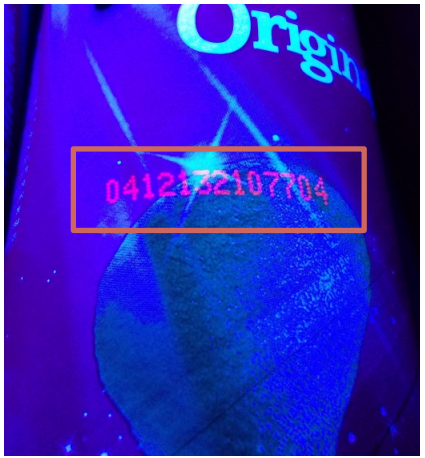
Coding application by Continuous inkjet (Solvent based)

Concept / Solution

- Addition of compound with sharp fluorescent peak towards **longer wavelengths**
- No overlap with fluorescence of the label

Increased readability

Normal light



Black light

Conclusion

Ink development: a dynamic iteration process between 3 sub processes

- Chemical formulation process
- System integrated process
- Customer driven interaction process in an open environment

Efficient implementation of these 3 processes in a lab environmental workflow during the whole ink development process (from design to prototype) leads to:

- Short development times
- Low investment level (during feasibility phase)
- Dedicated high performance end user requirements

Thanks for listening

You are invited at our booth for further information and discussions:

- Els Mannekens
- Yolanda Justo
- Frank De Voeght

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More info on our website:
www.chemstream.be