RECOAT: Strategies and practices to increase the renewable carbon content of coatings

Coatings Innovatiedag, June 18th, 2025

Rolf Blaauw

Wageningen Food & Biobased Research

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Outline

- Wageningen Food & Biobased Research (WFBR)
- The RECOAT project
- Approaches to improve sustainability of paints and coatings
- Focus on **coating binders**:
    - R&D projects: EPIC, SMARTCASE

Wageningen Food & Biobased Research (WFBR)

- **Contract research organization**
- More than 30 years of experience in the development of technologies to produce **biobased chemicals and materials**
- **over 250 highly qualified experts**
- Close link to the Wageningen University departments
- Modern laboratories and a fully equipped **biobased products innovation plant**
- Research from initial idea to production pilot scales and processes

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Society-oriented research programmes

Nature Based Materials

Renewable Plastics

Safe and Circular Biobased Products

Circular Water Technologies

Food Loss and Waste Prevention

Postharvest Quality

Agro Food Robotics

Proteins for Life

Sustainable Nutritious Foods

Nutrition for Optimal Health

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Safe and Circular Biobased Products

Developing looping strategies and safe, biobased alternative processes, chemicals and materials for circularity

Circular design of coatings and composites

Biodegradable alternatives to products that end up in sewage water

Safe and sustainable substitutes for substances of (very high) concern

Towards safe and circular

(food) packaging materials

Contact

Jacco van Haveren
+31 317 480179
Jacco.vanhaveren@wur.nl

WFBR-led project – **RECOAT**

- Dutch consortium of suppliers of biobased chemicals, paint/coating companies and research institutes
- Exchange of knowledge: what is already available and possible?
- Understanding hurdles for getting biobased formulations into the market
- Establish new connections and supply chains
- Deliverable: booklet (Q3 2025) on biobased coatings for broad audience (English & Dutch)

VVVF Verf en Inkt

Cargill

GF Biochemicals

avans university of applied sciences

CHAINCRAFT

Approaches to improve sustainability of coatings

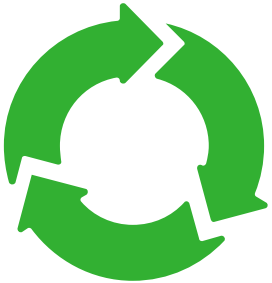
- Substitution of fossil-based components by **biobased alternatives**
  - Raw materials considered to have the largest impact on carbon footprint
- Reduce **VOC levels** (solvent-borne → waterborne)
- Increase (biobased) **recycled content** in coating formulation
- Others, e.g.:
  - measures that enable thinner coatings
  - increase durability / service life of coated products
  - switch to a more sustainable coating technology (solvent-borne → powder)

The only three sources of renewable carbon

Biomass

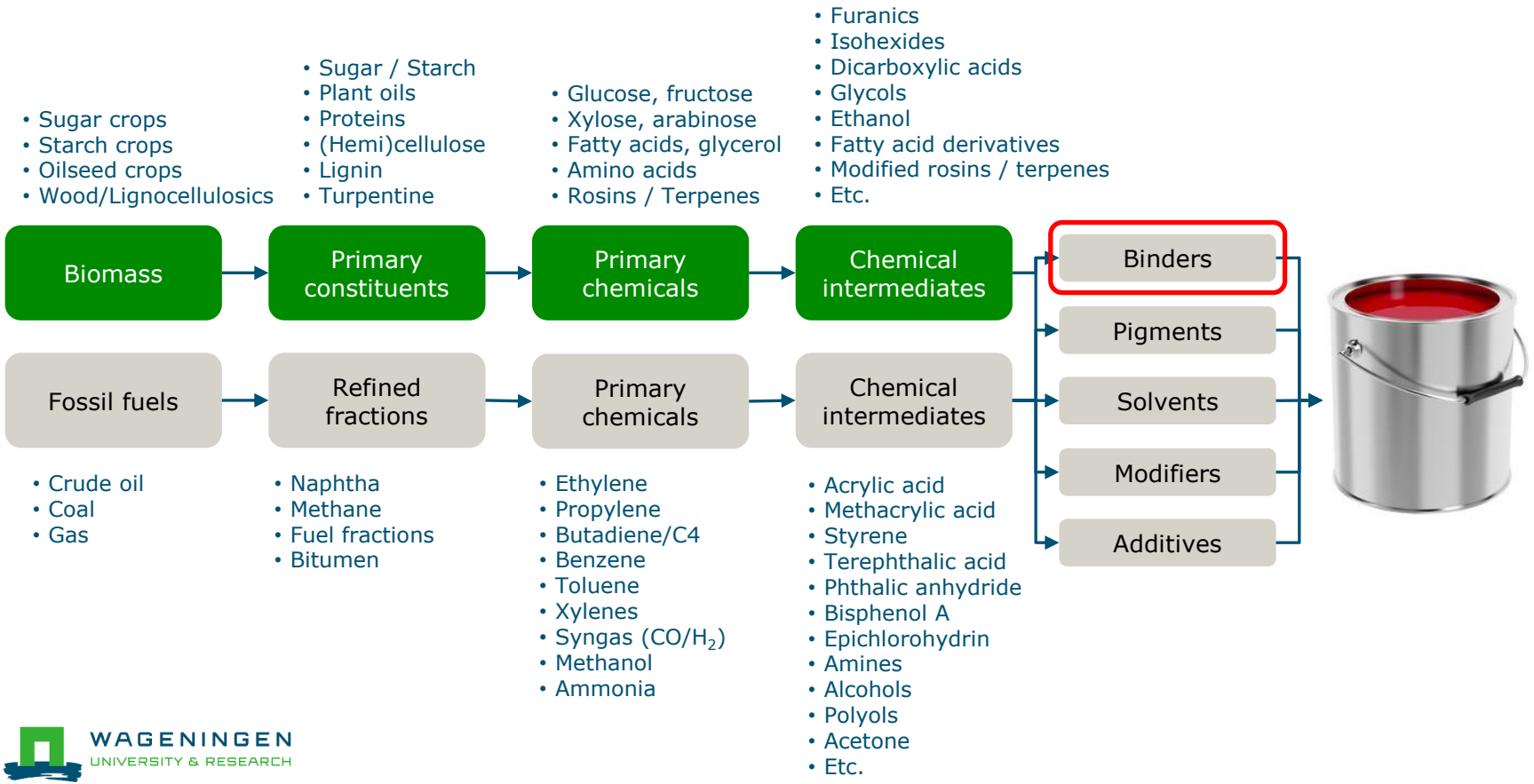
(This presentation)

Direct CO_2 utilisation



Recycling of carbon-based materials

Paints and coatings production chain (simplified)



Approaches to increase the biobased content of coating binders

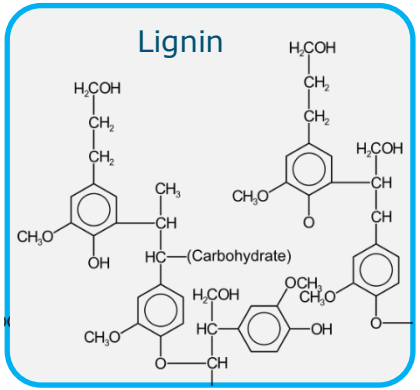
More innovative

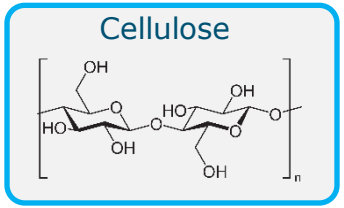
1. Develop improved versions of traditional **biopolymer binders**
2. Polymerize biobased monomers to create **new polymeric binder types**
3. Polymerize biobased monomers with the same polymerizable group as their petrochemical counterpart but with a different structure to create **biobased 'look-alikes' of petrochemical binders**
4. Polymerize biobased monomers with a structure identical to their petrochemical counterparts ('drop-ins') into **biobased versions of existing petrochemical binders**

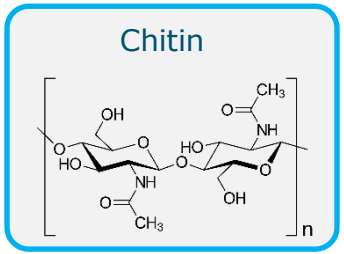
Easier to implement

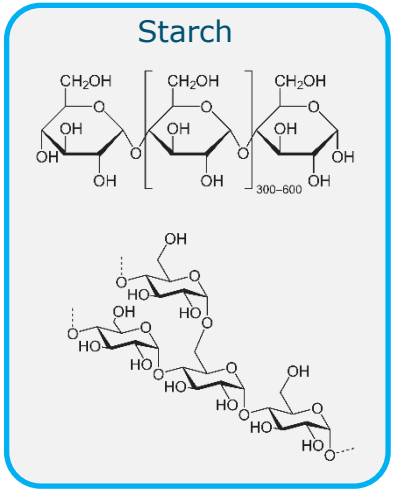
Biopolymers versus biobased polymers

- Biopolymers = naturally occurring polymers like cellulose, chitin, starch, lignin, proteins
  - Most abundant biomass constituents
  - Typically, very high molecular weight
  - Insoluble by nature (cellulose, chitin, lignin); difficult to chemically modify
  - Water-soluble types are highly viscous even at low concentrations
  - Limited design flexibility





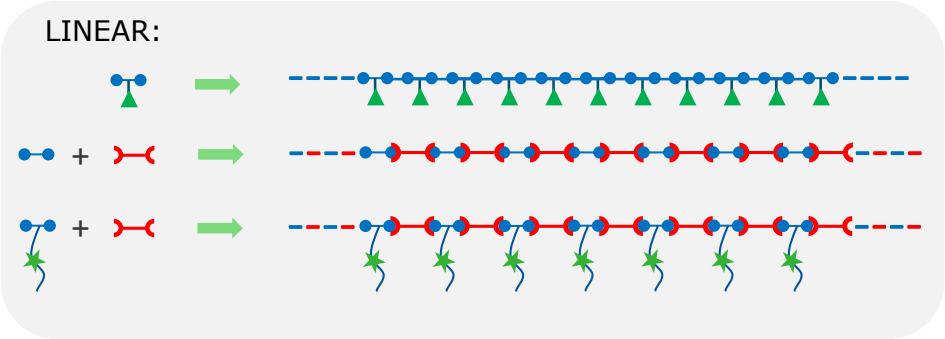


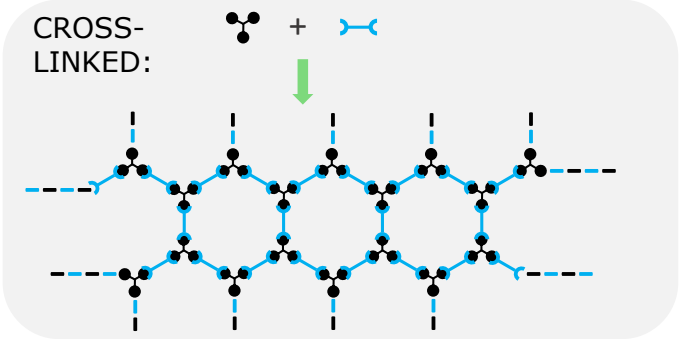


Biopolymers versus biobased polymers

- Biobased polymers = man-made /synthetic polymers based on biobased building blocks
  - Easier to introduce water- and temperature resistance
  - Much more **design freedom**; many combinations of building blocks possible
  - Biobased building blocks can be used for the main classes of binders for paints and coatings:
    - Polyesters (including alkyds)
    - Vinyl polymers: poly(meth)acrylates, styrene copolymers, polyvinyl acetate etc.
    - Polyurethanes
    - Epoxy resins

Simplified structure of five main binder types



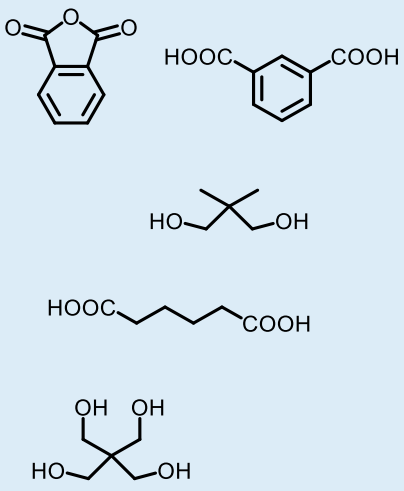
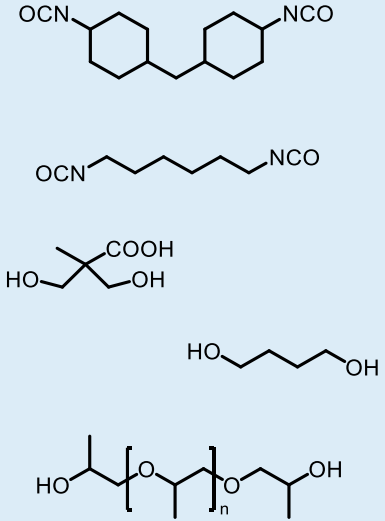
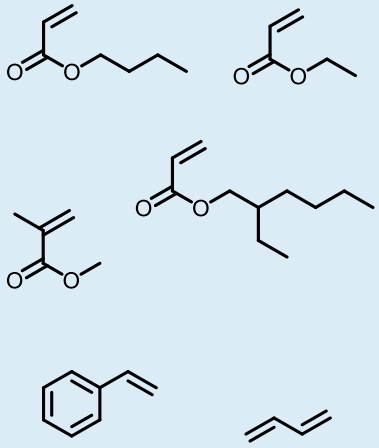
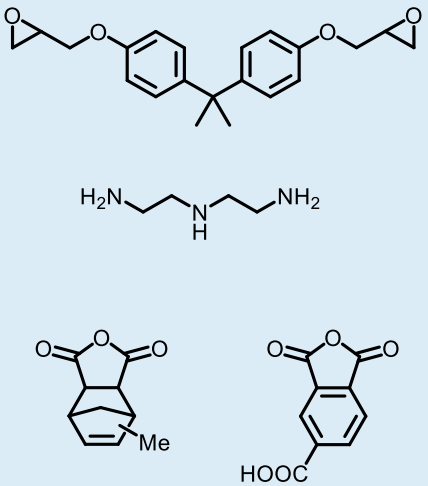


							**Drying process**
Polyacryl / -vinyl	(meth)acrylate	-	-	-	-	-	physical
Polyesters		diol	diacid	-	-	-	physical
Alkyd		-	diacid	fatty acid ester polyol	-	-	chemical (oxidative curing)
Polyurethane		diol	diisocyanate	-	polyol	diisocyanate	physical (PUD) or chemical (2K)
Epoxy / amine		-	-	-	polyamine	diepoxide	chemical (2K)

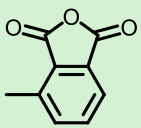
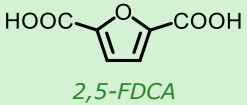
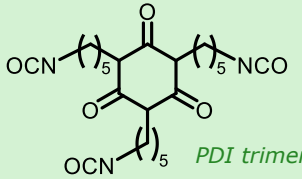
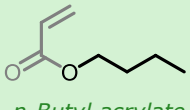
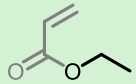
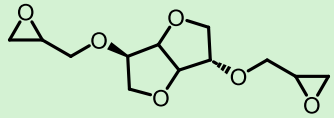
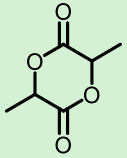
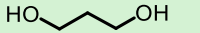
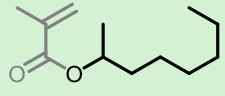
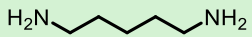
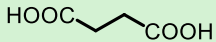
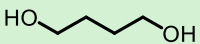
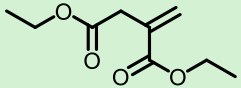
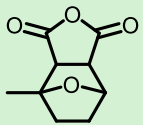
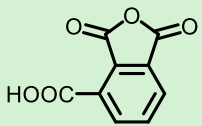
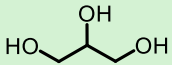
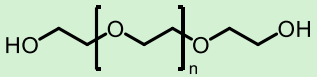
Building blocks for main binder types

Polyesters & Alkyds	Polyurethanes	Polyacrylates & co-polymers	Epoxy
aromatic diacids or anhydrides	di-isocyanates	acrylates	diglycidyl ethers
aliphatic diacids or anhydrides	polyisocyanates	methacrylates	diamines
diols	diols	alcohols	polyamines
polyols (≥ 3)	polyols (≥ 3)	Styrene, butadiene (for co-polymers)	acid anhydrides
(polyunsaturated) fatty acids (alkyds)			

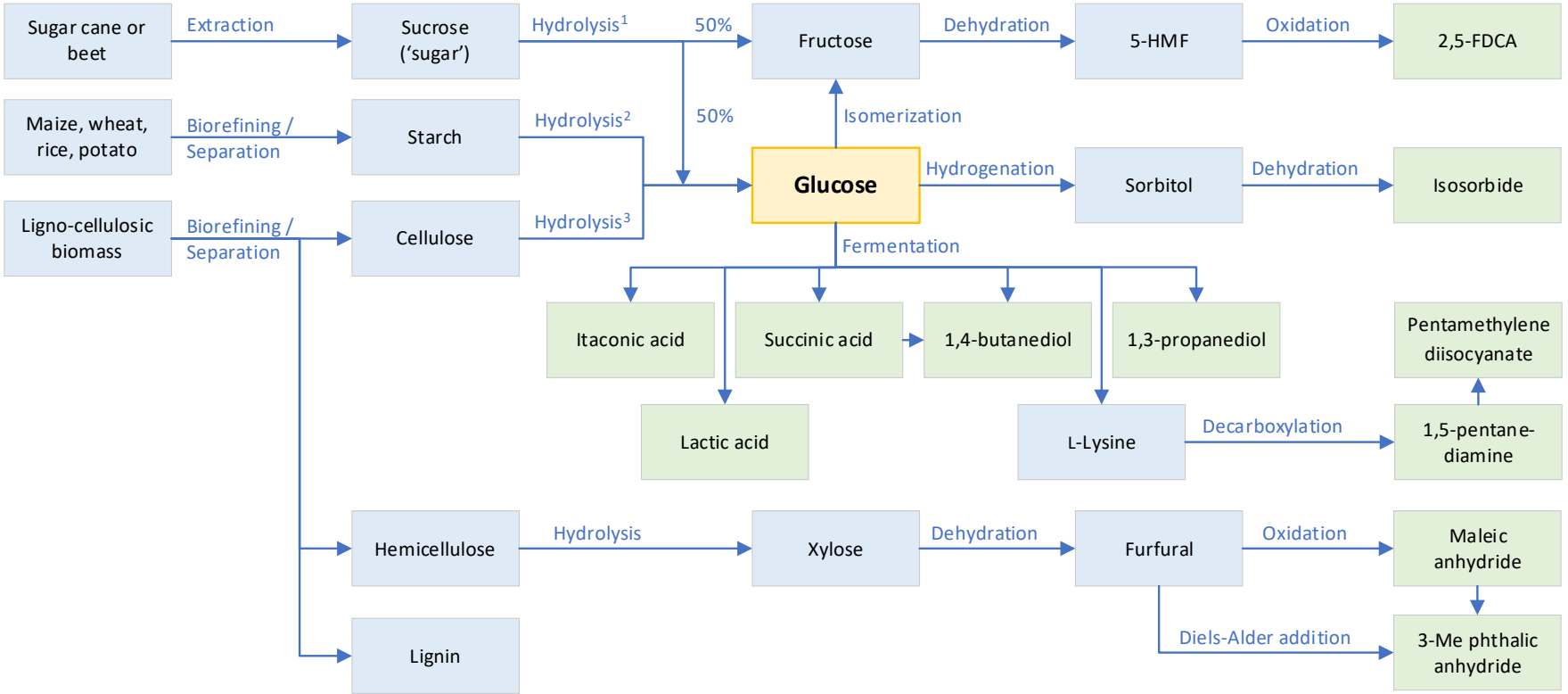
Building blocks for main binder types: petroleum

Polyesters & Alkyds	Polyurethanes	Polyacrylates & co-polymers	Epoxy
			

Building blocks for main binder types: biomass

Polyesters & Alkyds	Polyurethanes	Polyacrylates & co-polymers	Epoxy
 3-MPA	 2,5-FDCA	 PDI trimer	 n-Butyl acrylate	 Ethyl acrylate	 Isosorbide diglycidyl ether
 Lactide	 1,3-propanediol	 Pentamethylene diisocyanate (PDI)	 2-Octyl methacrylate	 1,5-Pentanediamine
 Succinic acid	 1,4-butanediol	 Diethyl itaconate	  Furfural-derived anhydrides
 Glycerol	Linoleic acid	 polyethylene glycol	 1,3-Butadiene	

Routes from biomass to binder building blocks



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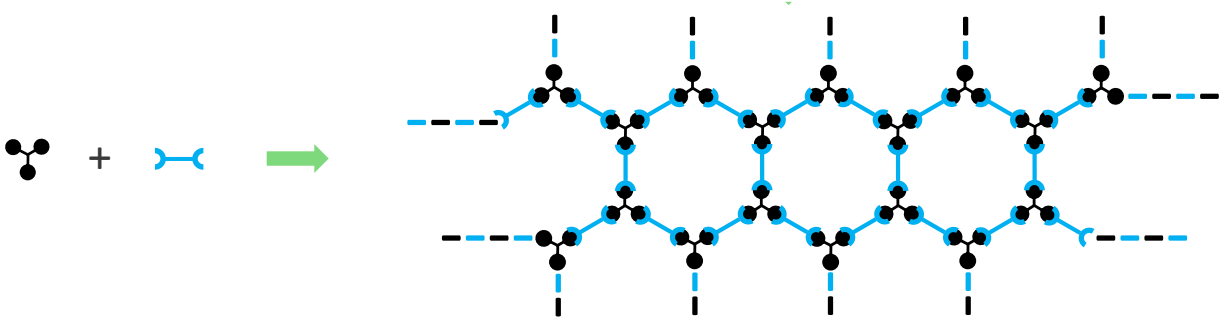
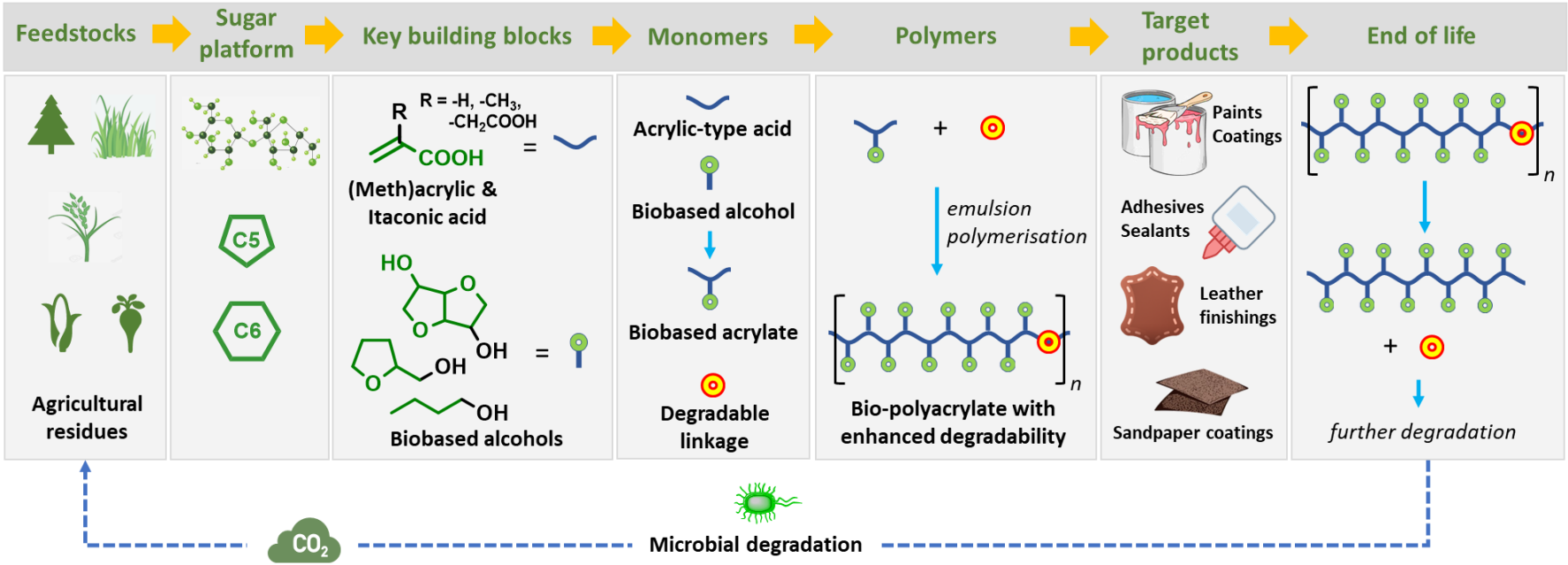
Two recently started WFBR-projects on biobased resins

- Biobased acrylics: **EPIC** project

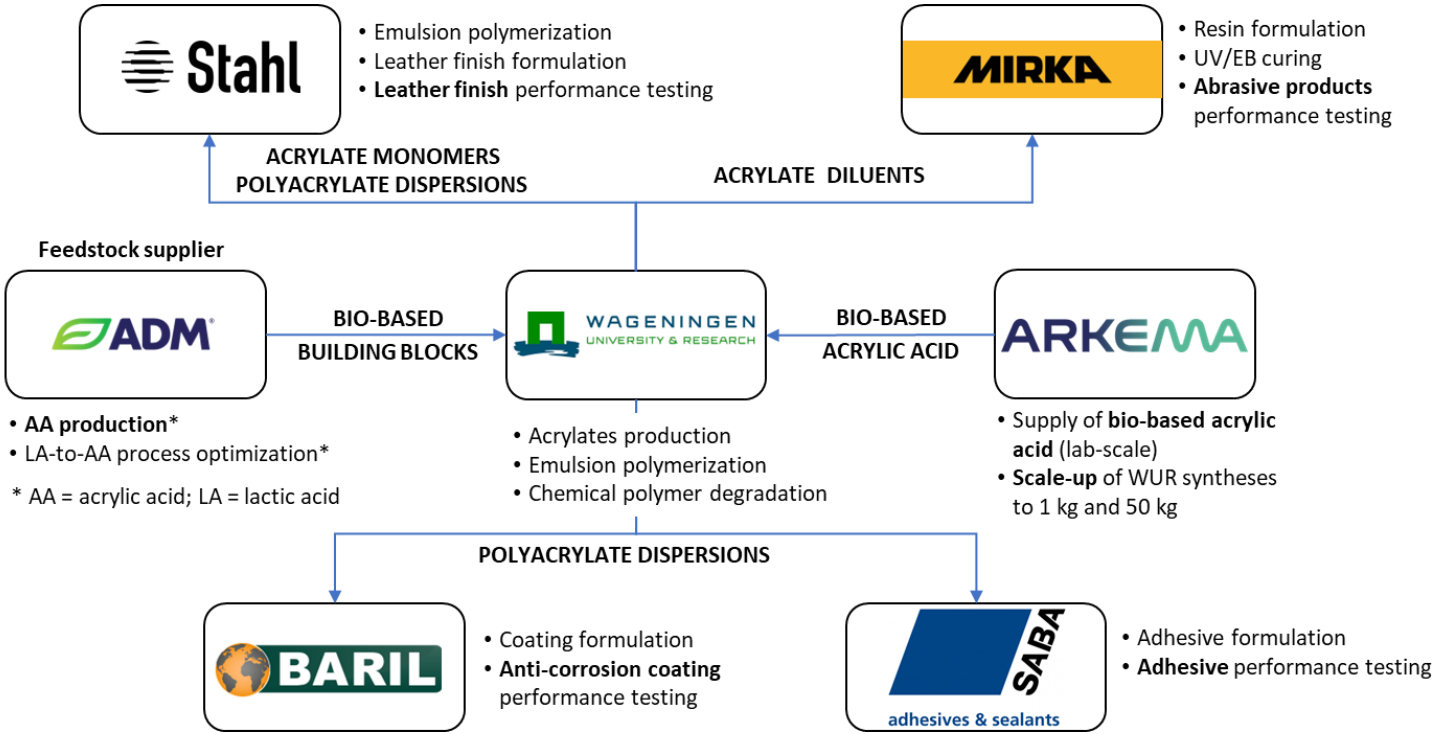
- Biobased isocyanate/epoxy-free 2K resins: **SMARTCASE**



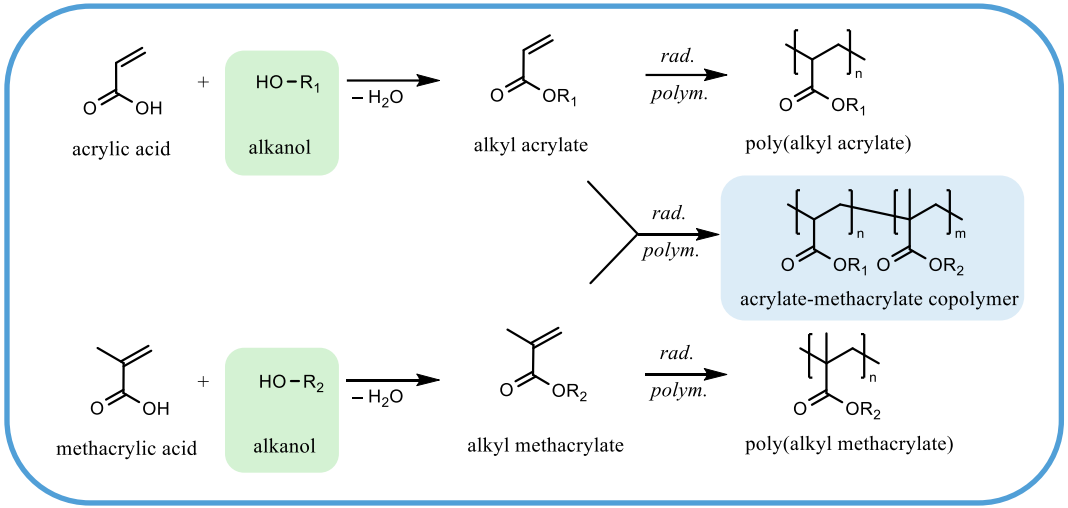
EPIC: biobased acrylics



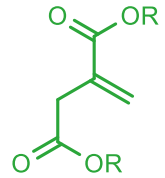
EPIC: biobased acrylics



EPIC: biobased acrylics



Commercial example:
Decovery® by Covestro



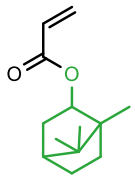
dialkyl itaconate

- Acrylic and methacrylic acid are not (yet) biobased.
  Bio-based alternative: itaconate esters
- Bio-based alcohols used: *n*-butanol, ethanol, 2-octanol, isobornyl alcohol

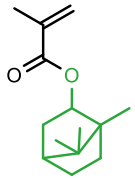
from castor oil

from tree bark terpenes

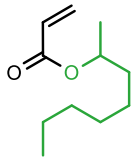
EPIC: biobased acrylics



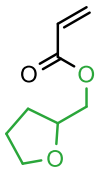
isobornyl acrylate



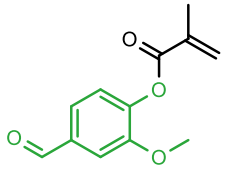
isobornyl methacrylate



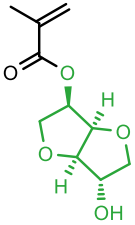
2-octyl acrylate



tetrahydrofurfuryl acrylate



vanillin methacrylate



isosorbide methacrylate

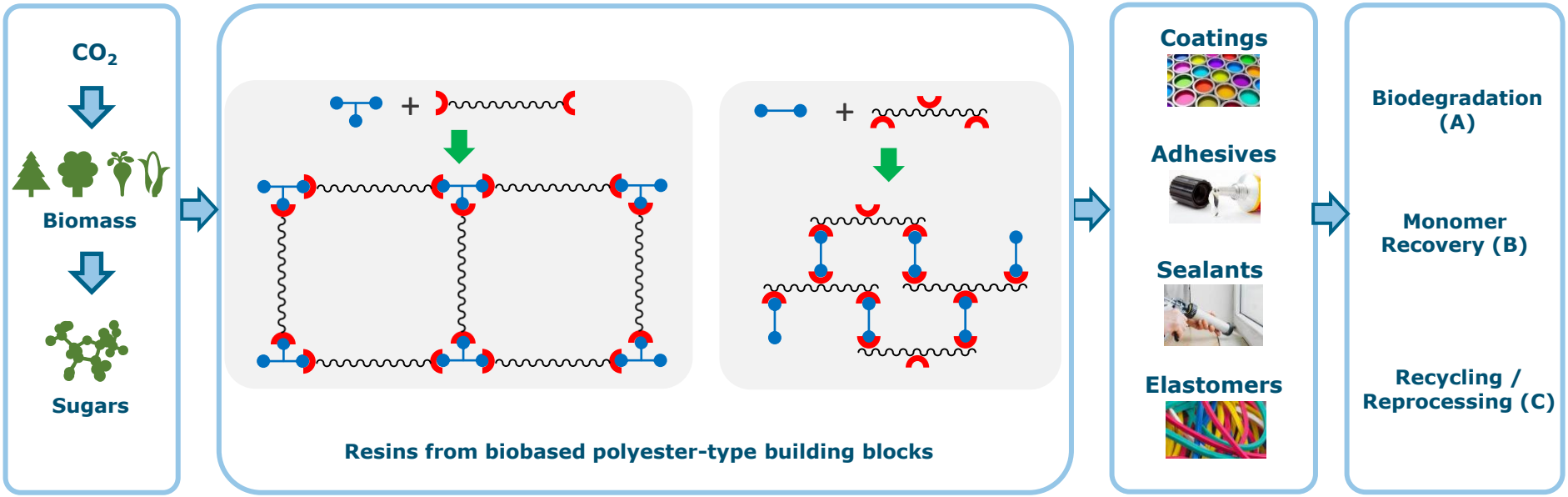
Biobased C	77%	71%	73%	63%	67%	60%
T_g (°C)*	97°C	150°C	–44°C	–11°C	110°C	80°C

* T_g (glass transition temperatures) of the homopolymers.

- Suppliers of (some of) these (meth)acrylates include Evonik (Visiomer Terra®), Allnex (Ebecryl®), BASF, Arkema (SARBIO®), and others.

SMARTCASE: biobased 2K resins

- **2K Michael-addition polymerization**



SMARTCASE: biobased 2K resins

Feedstock | Technology | Sustainability | Applications

Take-home messages

- Biobased alternatives for typical building blocks for coating binders are slowly entering the market
- Biobased coating resins are increasingly being promoted and offered by resin suppliers
- Further market penetration relies on factors such as:
    - sufficient availability of building blocks
    - performance benefits that would justify a higher price

Thank you for your attention

Contact:

rolf.blaauw@wur.nl

Het RECOAT-project ontvangt financiële steun vanuit de Kennis- en Innovatieagenda Landbouw, Water, Voedsel. Binnen de KIA werken bedrijfsleven, kennisinstellingen en overheid samen aan innovaties voor veilig en gezond voedsel en een groene leefomgeving voor 9 miljard mensen in een veerkrachtige wereld.