sirris The innovation companion of the technology industry

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Comparison of bio-based & fossil-based protective coatings for wood

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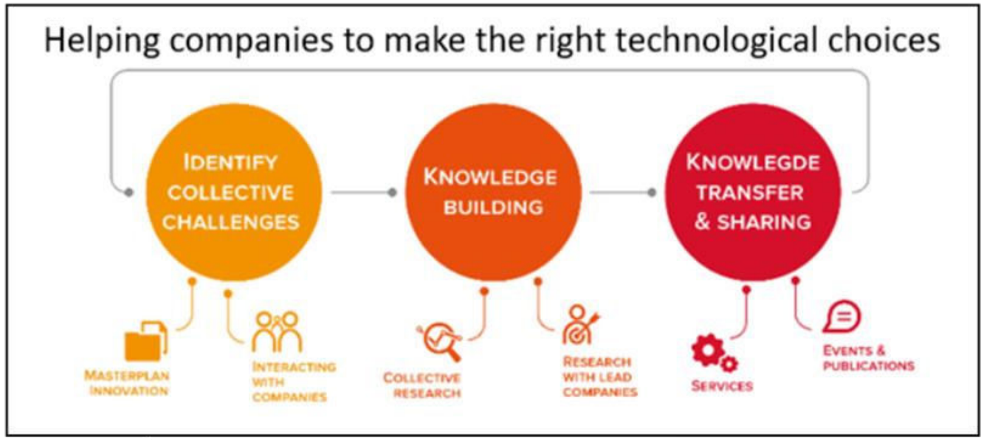
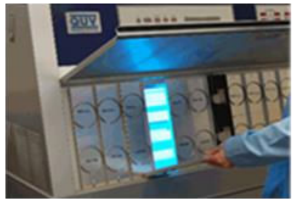
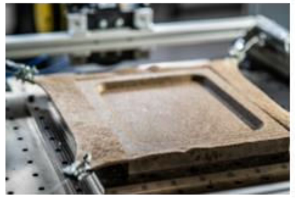
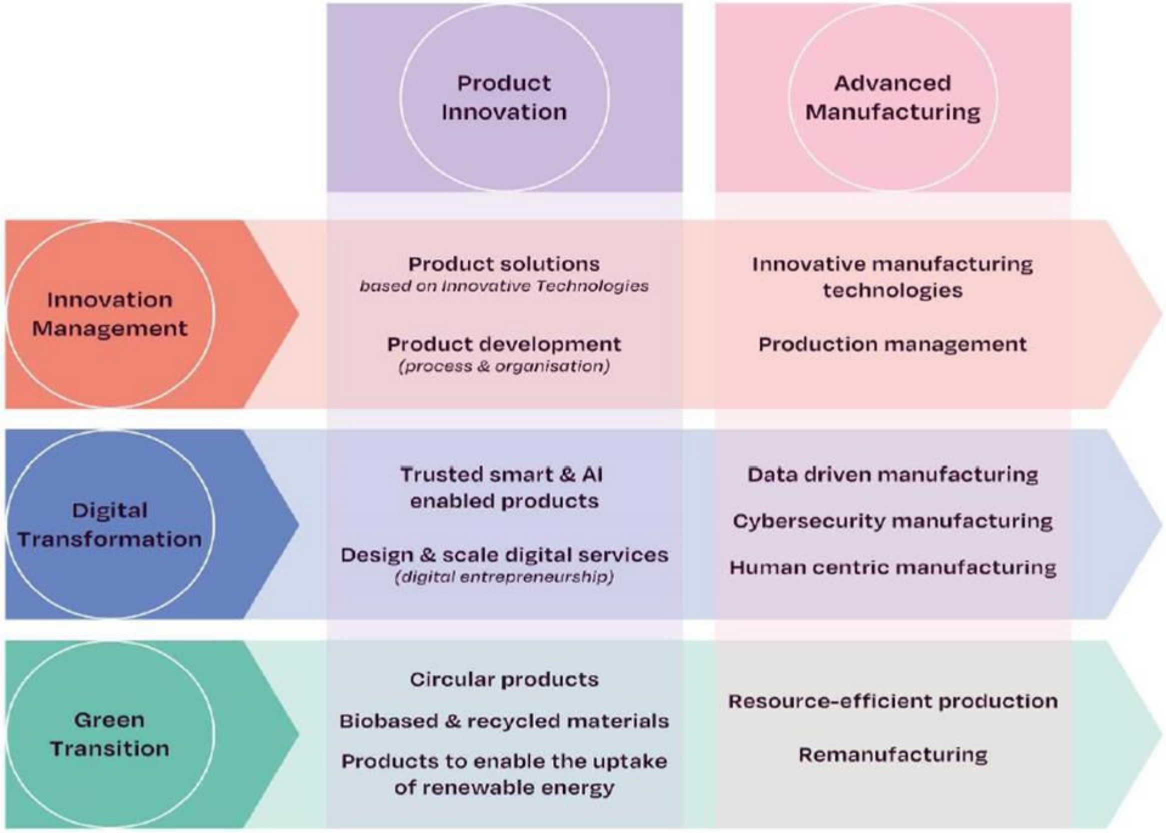
Together, we turn innovation into success



Sirris|Innovation forward is the collective research centre of the Belgian technology Industry (1949) with 170 expert engineers in more than **20 technology domains with high-tech infrastructure & huge partner network of 2500 member companies**














Dip-coating

Spray-coating

Flow-coating

Surface cleaning and pretreatment

UV curing

Thermal curing


"Support the value chain of the Belgian manufacturing industry from technological expertise to help them innovate their products, production and business towards a more circular economy."

Sirris Department: Innovation in Circular Economy

Materials Sourcing

- ❑ Bio-based materials in composites and coatings
- ❑ Valorising residual side streams and waste products for high value applications
- ❑ Recycling of materials
- ❑ Material selection, processing and manufacturing for functional properties and devices

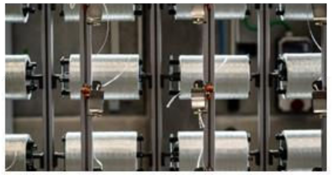
Life-time Extension

- ❑ Protective coatings
- ❑ Corrosion control
- ❑ Mechanical durability
- ❑ Weathering resistance
- ❑ Moisture and water resistance
- ❑ Friction, lubrication
- ❑ Barrier functionality
- ❑ Anti-microbial activity
- ❑ ....

CE Entrepreneurship

- ❑ Circular design strategy and eco-design thinking
- ❑ Exploring potential of circularity for your company
- ❑ Scaling your CE pilot
- ❑ Integrated action plan and risk control
- ❑ Measuring circularity (eco-impact, simplified LCA)
- ❑ Smart and digital CE enablers

Value-chain collaboration: Shared Infrastructure and Testing Environment

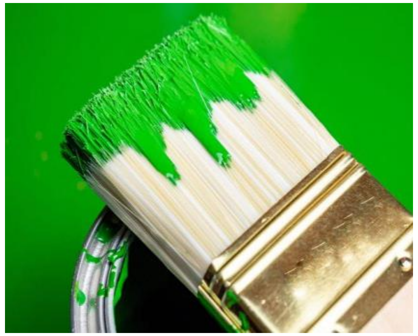






BioCoating research at Sirris

- Collective research and development projects (VLAIO – COOCK)
- Composition with bio-based ingredients
- Processing and application conditions
- Bio-based barrier coatings for paper packaging
- Bio-based anti-microbial coatings for high-traffic surfaces
- Performance of bio-based versus fossil-based coatings:

  mechanical properties, weathering, water repellence, durability, lifetime



- **CASE 1: Bio-based acrylates under UV curing**
- **CASE 2: Bio-based epoxy under thermal curing**
- **CASE 3: Improving performance with bio-based fillers**

Illustration on processing and properties of bio-based relatively to fossil-based coatings

= opportunities and functionalities for bio-based coatings

cornet AGENTSCHAP INNOVEREN & ONDERNEMEN Vlaanderen is ondernemen European Commission

Wood Coating and UV Curing Conditions

High curing speed
increased production: UV coating cure in a matter of seconds, rather than minutes or hours

Improved productivity

Environmental benefits
- Reduction in atmospheric pollution of exhaust by-products (except ozone)
- No airborne contaminations of the coatings
- Volatilization of solvents used in the conventional solvents (100% solid, no VOC).
- Disposal of lacquer waste eliminated

Fast start-up and shut-down
no energy or time lost for oven to come to temperature, no standby-mode needed;

Lower energy cost
compared to the heat generated by gas fir or electric ovens in some conventional coatings

Compatibility
can be used on temperature-sensitive substrates (wood and plastic).

Ease of use
one pack system, no pot life for the lacquer when it is stored away from the UV light, constant viscosity and no need to clean the application machinery

Control of coating properties
crosslinking depending on selection of monomers and oligomers

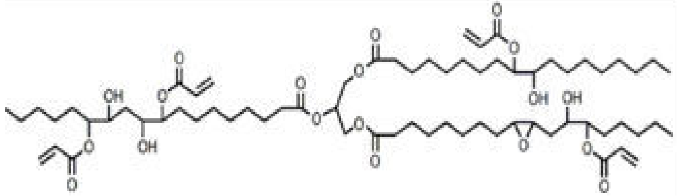
Economic factory space
no space is taken up when drying

Wood substrates

- **Stability (swelling/shrinkage): moisture and drying; 100% solids**
- **Composition (extractives, density, porosity)**
- **Good interface adhesion (elasticity, flexibility, small schrinkage)**

Case 1 : Bio-based Acrylate Coatings

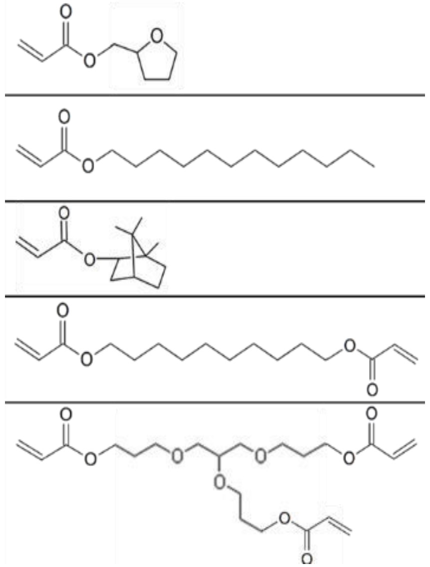
- **Oligomer (prepolymerized acrylate)**



Basic film forming properties: hardness, chemical resistance, flexibility, toughness, abrasion resistance, adhesion, weathering

(e.g. acrylated vegetable oils, itaconic acid based)

- **Monomers (diluent)**



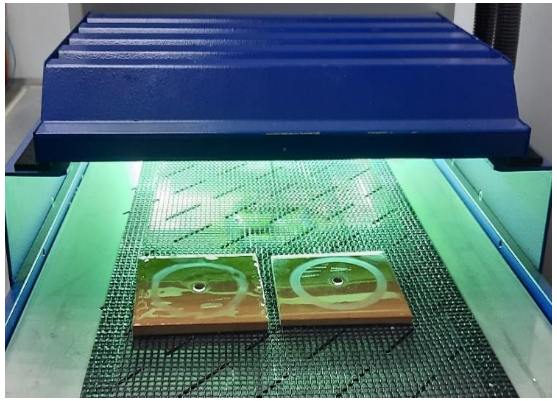
Processing and performance: viscosity reduction, flexibility (mono-functional), crosslinking (multifunc-tional), curing speed

- **No bio-based acrylic acid**
- **Bio-based content in side-chain apart from the functional group:**

  hemicellulose-based, lignoscellulosic, vegetable oil…

- **Photo-initiator**

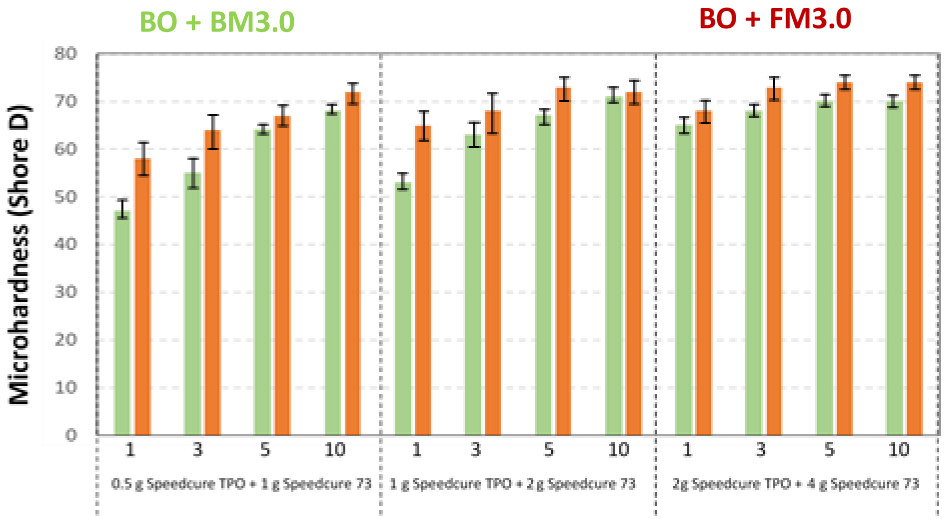
Bar coating (manual wire rod)
Wet coating thickness 70 µm
Substrates: softwood (beech), hardwood (pine),
Belt speed 7 m/min
Number of crosslinking steps
Mercury lamp UV intensity 60 to 220 mW/m^2



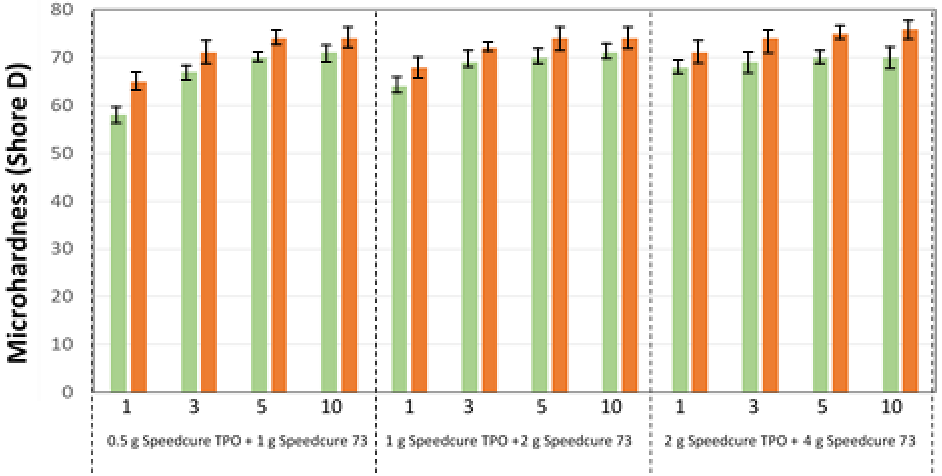
Type	Biobased content	Name	Supplier
Acrylic dispersion	48%	Decovery SP-8406	DSM
Hybrid acrylates	10-70%	Sarbio	Sartomer Arkema
Polyester acrylate resin	56%	Ebecryl 5849	Allnex
Acrylic resin	-	Piccasian® AC-290	Stahl

P. Samyn et al., Express Polymer Letters 16 (2022), 718-724

Case 1 : Bio-based Acrylate Coatings



60 W/cm



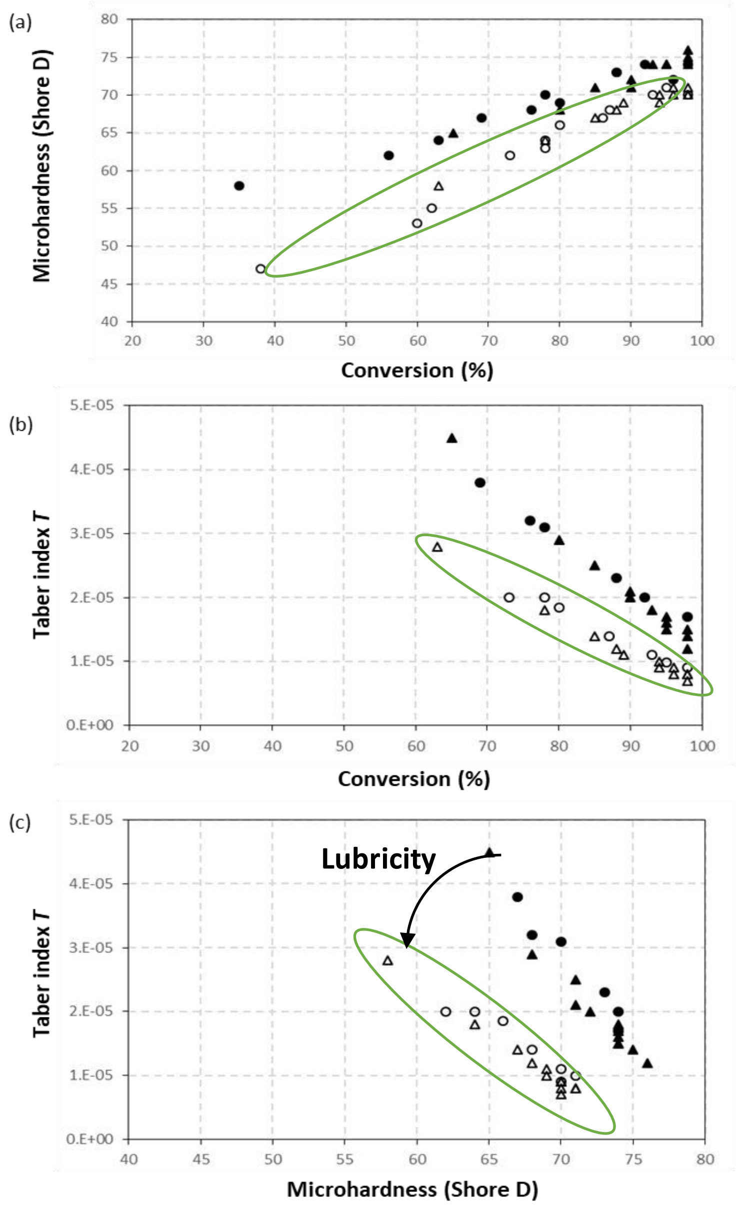
220 W/cm

Relationship between intrinsic mechanical properties and abrasive wear resistance

bio-based (○ 60 W/cm, Δ 220 W/cm)

fossil-based (● 60 W/cm, ▲ 220 W/cm)

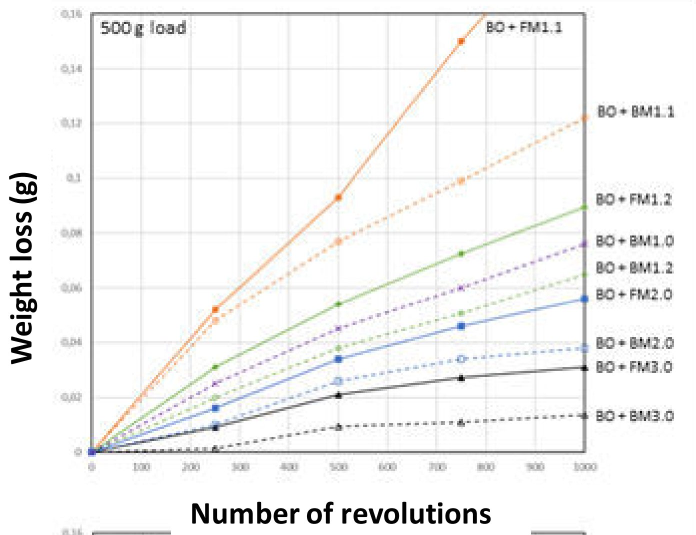
Lubricating properties of residual Monomer fraction in the composition

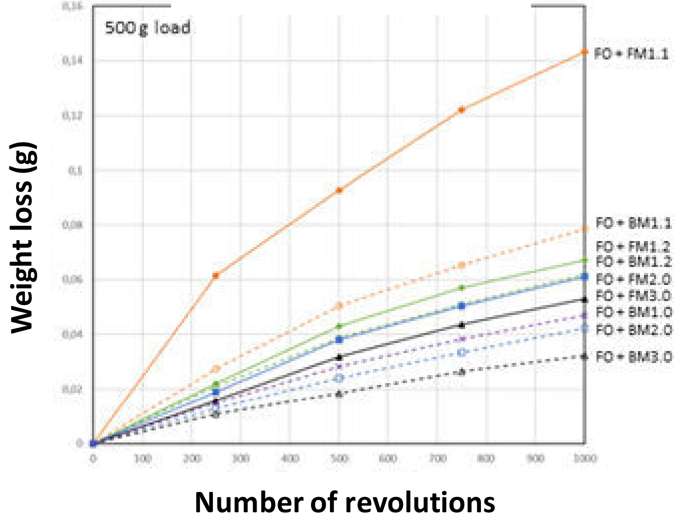


P. Samyn et al., Materials Today Communications 32 (2022), 104002,

Case 1 : Bio-based Acrylate Coatings

BO + BM1.1





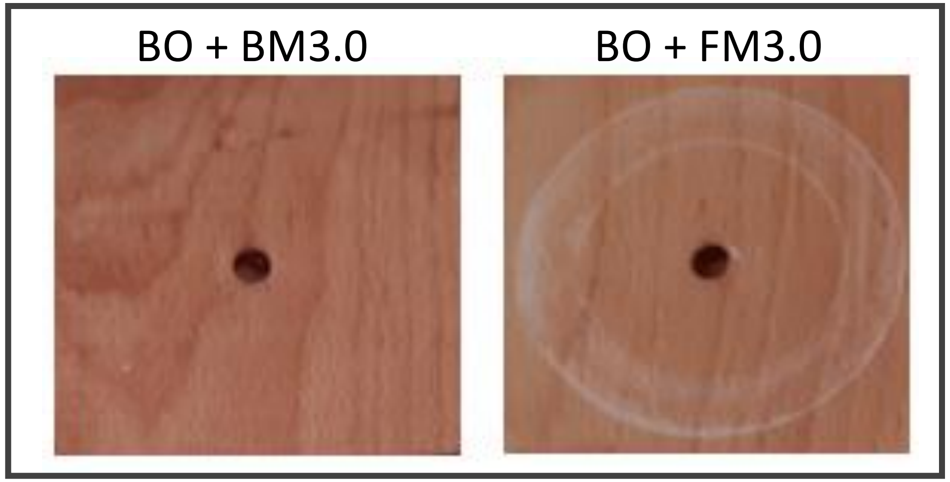
Effect of monomer

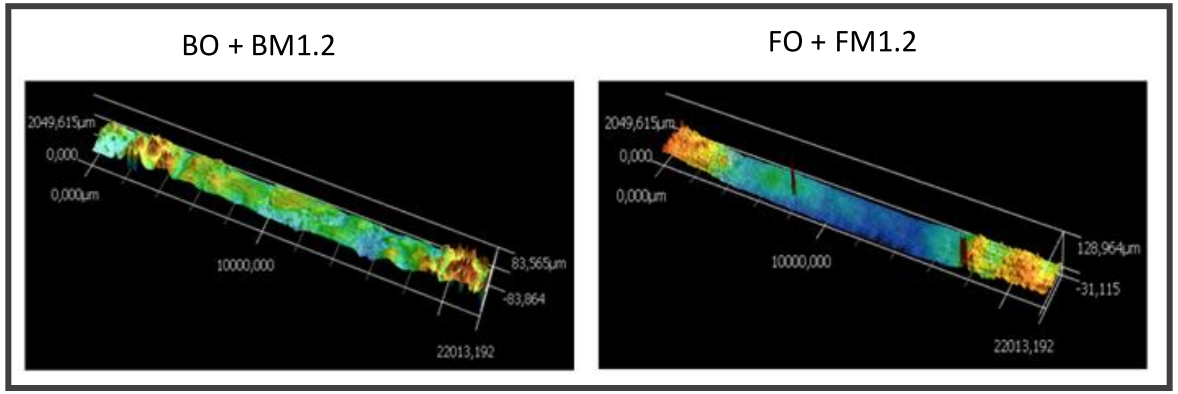
- Better performance for bio-based
- Rather overlap at low functionality (Tg)
- Comparable results for both substrates

Effect of oligomer

- Better performance for bio-based
- Strongly depending on functionality
- Bio-based best at high functionality

Abrasive wear track analysis



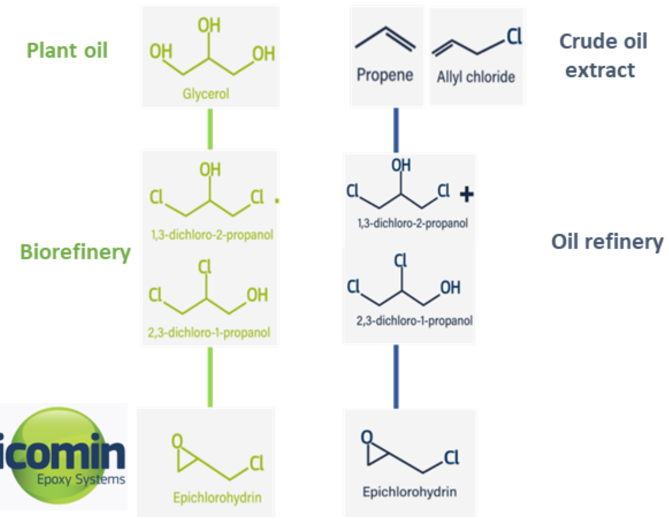


P. Samyn et al., Materials Today Communications 32 (2022), 104002,

Case 2 : Bio-based Epoxy Coatings

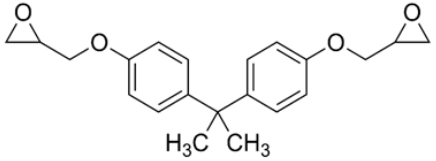
Green epoxy = resin + diluent + hardener

Liquid epoxy resin produced from epichlorohydrin based on glycerine
Renewable content 28 %



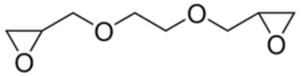
Sicomin Epoxy Systems

Fossil-based DGEBA



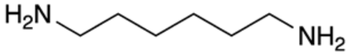
Fossil DGEBA

Fossil-based

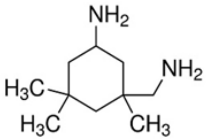


glycol diglycidyl ether

Fossil amine



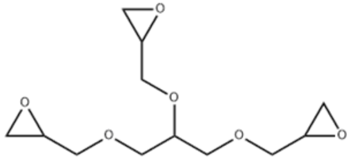
Hexamethylene-diamine



Fossil m-fenyleenbis(methylamine)-

CNSL Cardanol

Bio glycol derivatives



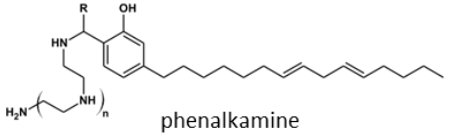
glycol triglycidyl ether

Specific Polymers BIOSYNTH

CNSL Cardanol

Renewable content > 60 %

anacarda Cardolite Chemistry for Tomorrow



phenalkamine

Case 2 : Bio-based Epoxy Coatings

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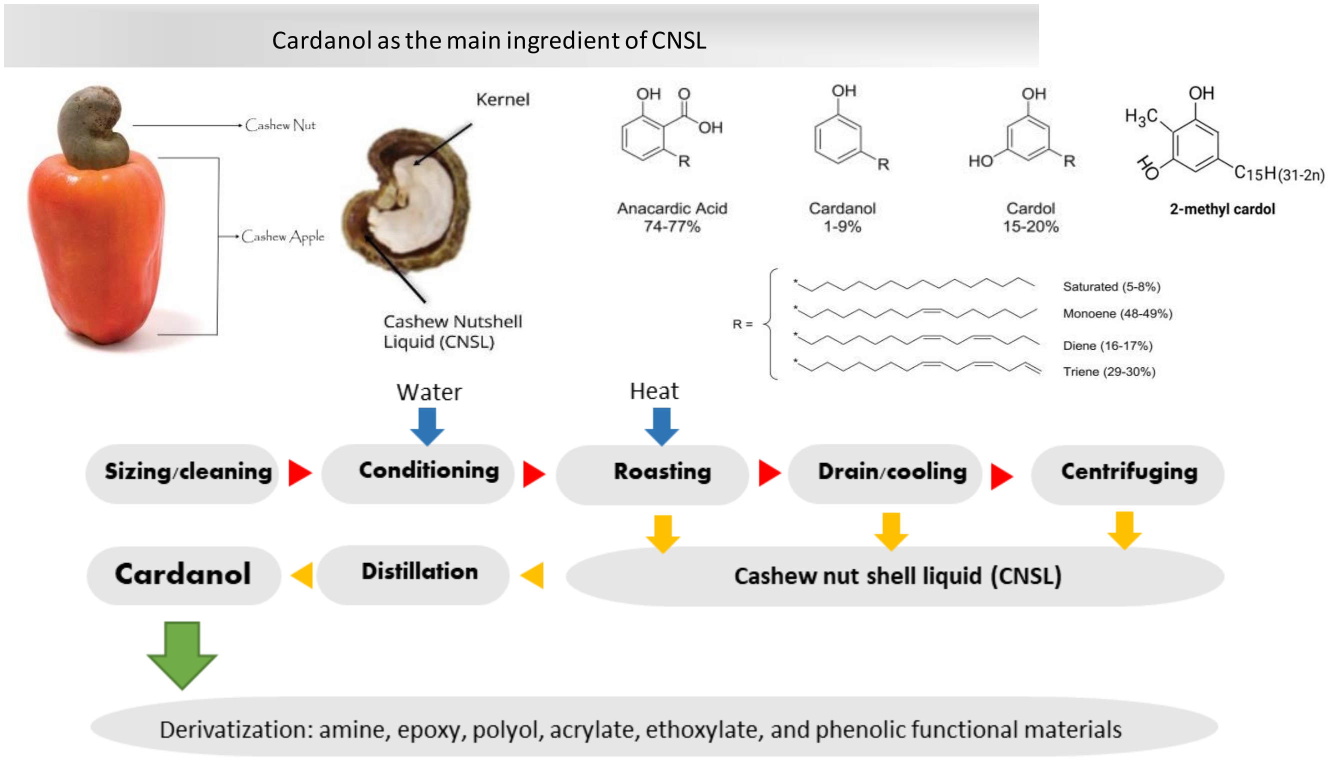
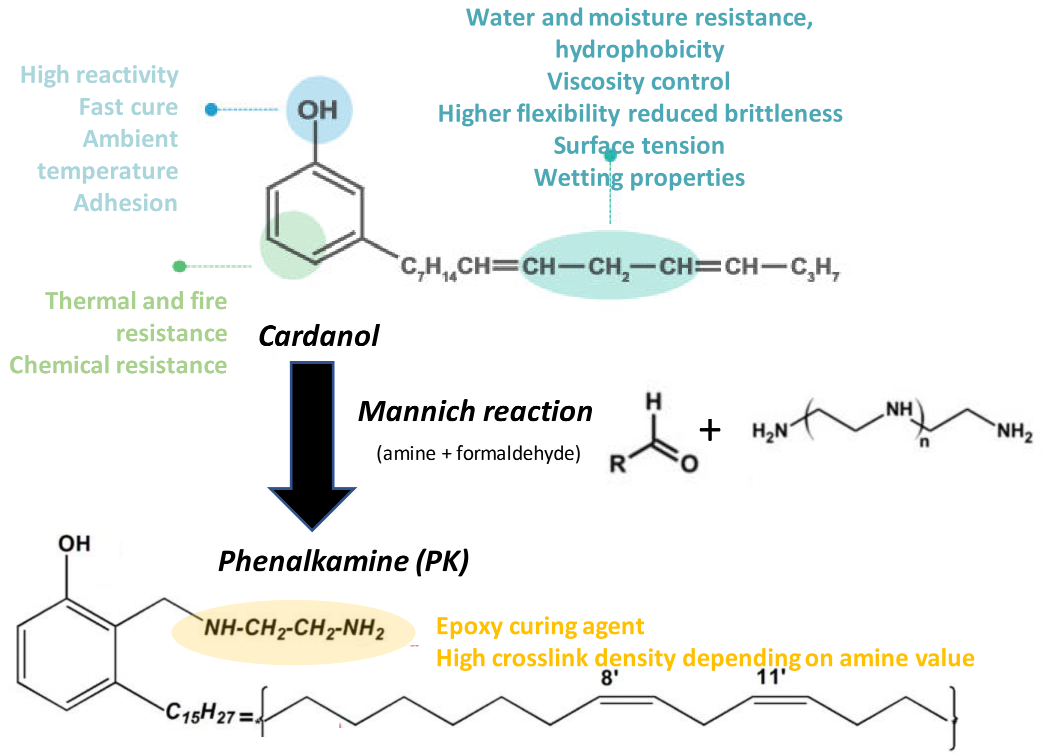
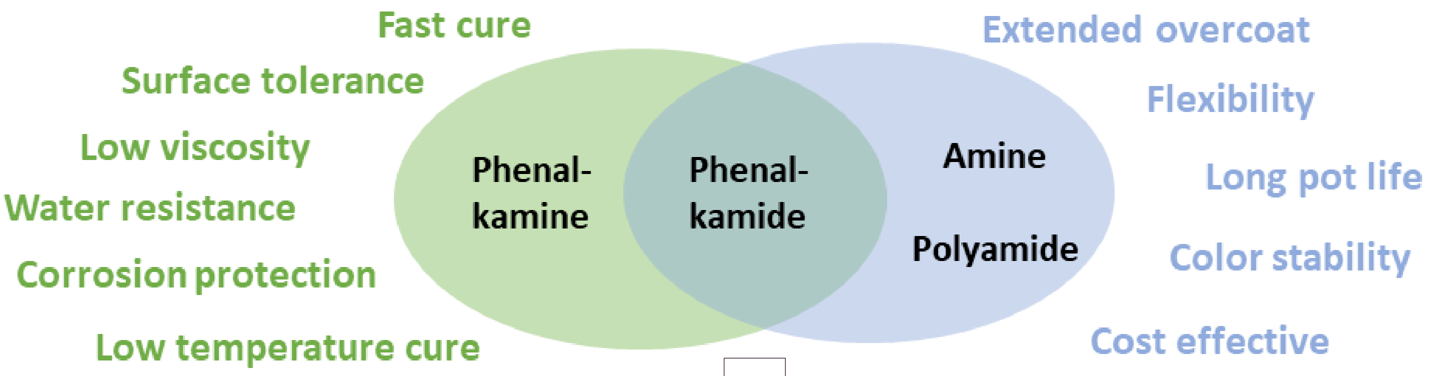




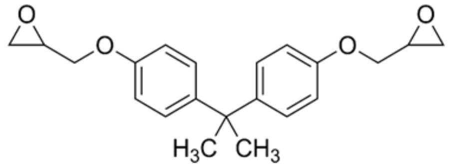


Cardolite
Chemistry for Tomorrow

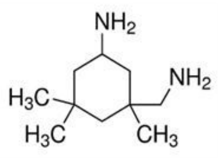
Case 2 : Bio-based Epoxy Coatings

Bio-epoxy coating

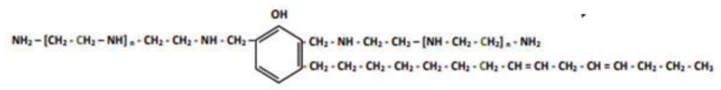
Effect of crosslinker



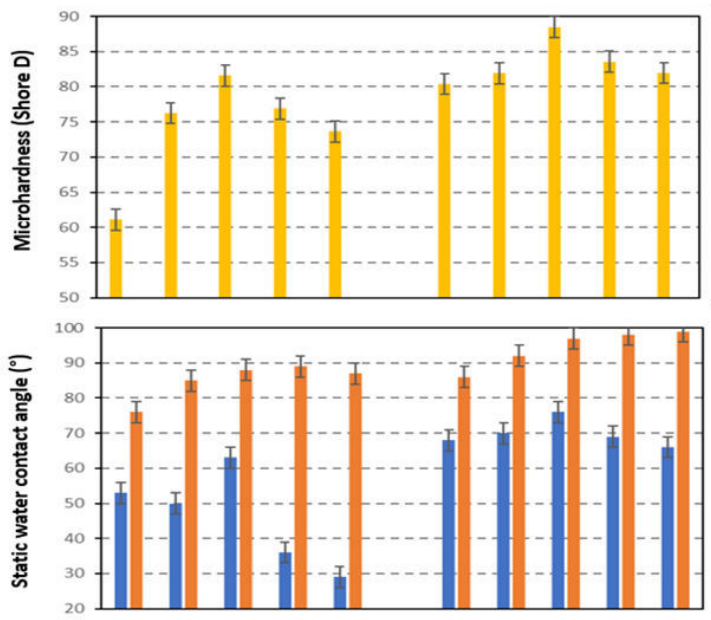
Fossil DGEBA



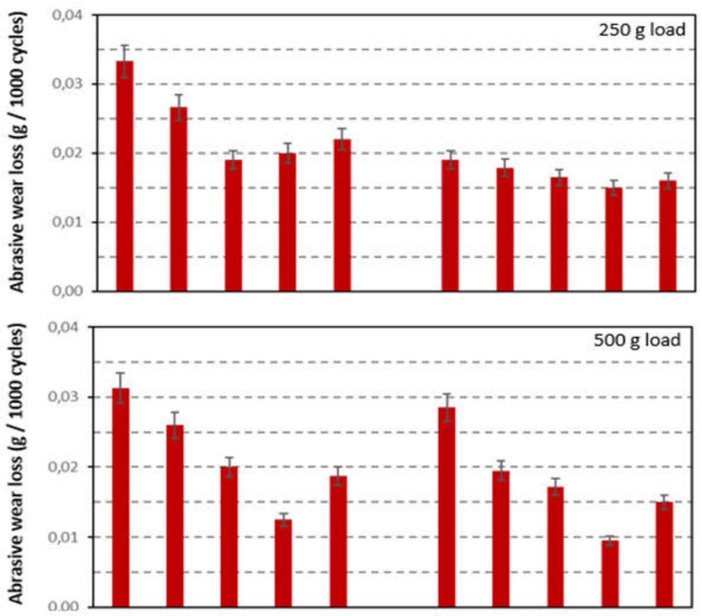
Fossil m-fenyleenbis(methylamine)



Bio Phenalkamine



DGEBA	10	10	10	10	10		10	10	10	10	10
Fossil amine	3	4	5	6	7		-	-	-	-	-
PK3	-	-	-	-	-		4.25	5.25	6.25	7.25	8.25



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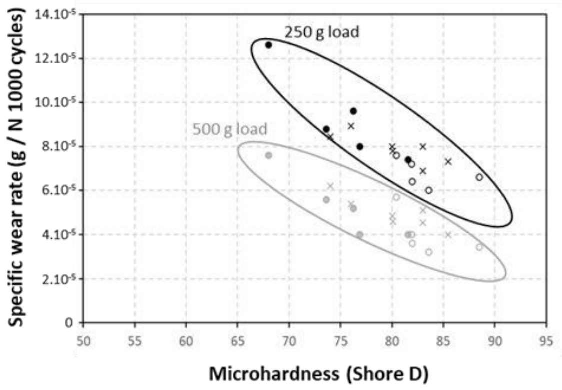
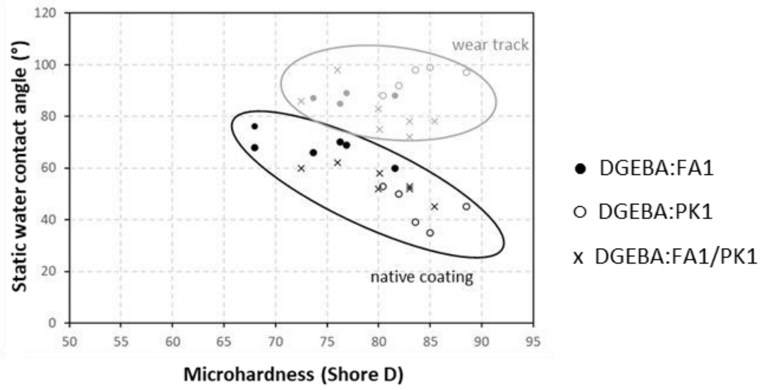




Singular trends for the coatings with FA1 or PK1 crosslinkers as a function of microhardness, which is measure for degree of crosslinking.

P. Samyn et al., Molecules 28 (2023), 4259.

innovation forward

Case 3 : Converting Residual Biomass Streams

into functional coating additives with reproducible properties

VLAIO-COOCK Project AddBio : 2024-2026

Bottom - up

Supplier of residual biomass → Supplier of conversion technologies for processing of biomass residues / Producer of fillers, additives → Formulator of Coatings, composites → End-user → Recyclability

Top - down

2 research institutes, 17 companies

What is the sense or non-sense of using biobased fillers in my product?

What type of biofillers exist and how can I apply them to my product?

Can we still recycle biobased products that contain biofillers?

How can we build a value chain between the different stakeholders?

High variability in composition, physical properties, purity, chemical properties, compatibility, …

Physical and Mechanical pretreatment

- High-shear homogenization
- Grinding
- Cryogenic grinding
- Ball-mill grinding
- Centrifugation
- Sonication
- …

Size, Shape, Granulometry, Particle size distribution, Uniformity, Porosity, (Surface) Morphology

Chemical and (Thermo-)Mechanical pretreatment

- Extraction / Surface Modification
- Pyrolysis
- Hydrolysis / oxidation
- Alternative processing routes, alternative solvents
- In-situ modifications

Dispersibility
Chemical interface compatibility
Hydrophilic turns hydrophobic

- Roadmap for pretreatment of bio-additives
- Characterization techniques for physical and chemical properties
- Coating formulation and properties

innovation forward

From filler to functional Bio-Additives

Intrinsic Properties and Synergystic Effects

Wood, industrial and architectural coatings

Biomass types we are mainly focussing on @Sirris in AddBio:

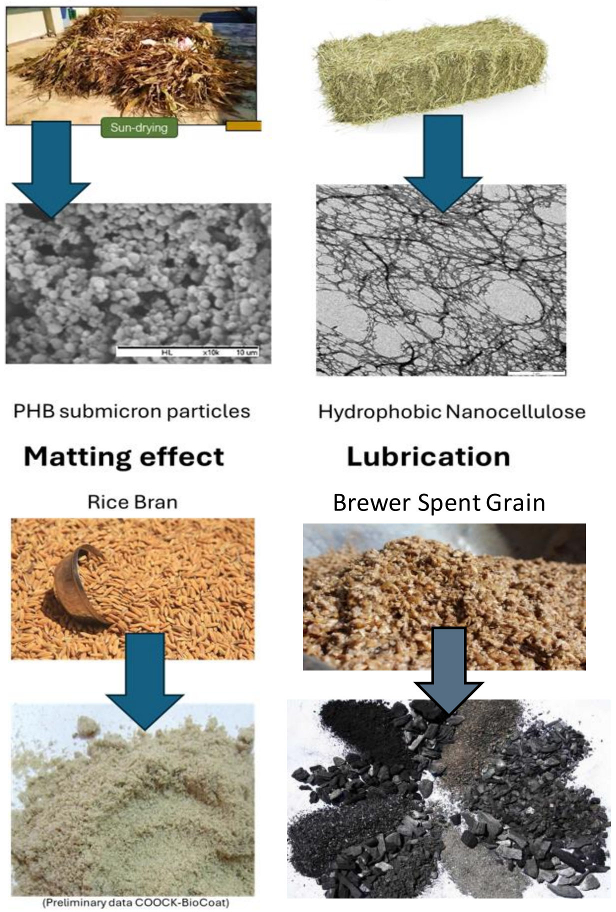
- Alginate
- Biochar
- Biowax
- Brewer Spent Grain
- Cork
- Eggshell
- Lignocellulosics: cellulose fraction, tannin, grass, straw
- Nanocellulose
- Nutshell / Olive pit powders
- Orange peels
- Rice Husk

Functionality we are mainly focussing on @Sirris in AddBio:

- Durability
- Mechanical/Abrasion resistance
- Anti-corrosion and weathering
- Surface properties and aspect
- (Super-)hydrophobicity
- Rheology
- Barrier properties
- Anti-microbial properties
- Surfactant
- Anti-tacking
- Opacifier
- Anti-cracking
- Compatibilizers
- UV protection
- Anti-sagging

Polymer fermentation

Lignocellulosics



Rice Bran Wax Powder

Biochar

Hydrophobicity

Dampening

Conclusion

Opportunities

- One-by-one replacement (drop-in solutions) do not result in best performance
- Increasing availability of bio-based building blocks, however, recently rather stagnating
- Rethinking of a coating formulation based on bio-based components
- Optimization of processing conditions according to the requirements of the end-user
- Access to toolbox of different coatings ingredients, to be selected from industrially available grades
- Valorization of under-utilized resources or residuals into higher value applications

Challenges

- Long-term degradation in presence of water
- Economic competitiveness should balance against better performance
- Availability of new bio-based feedstock (e.g., algae, chitin/chitosan, nanocellulose, …)
- Need of development time

sirris innovation forward

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