SSUCHY
DEVELOPING ADVANCED BIO-BASED COMPOSITES

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FROM BUILDING BLOCKS TO BIO-BASED THERMOPLASTIC AND THERMOSET POLYMERS

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BBI JU Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

Final Event *– Videoconference – 9th February 2022*

Composites Structure

Organic Matrix

Thermosetting polymers:

- Polyepoxide
- Unsaturated polyester
- Polyurethane

Thermoplastics polymers:

- Polylactic Acid
- Polyethylene
- Polypropylene
- Polyhydroxyalkanoates

Fibre-Reinforced Polymer (FRP) Composite

Reinforcement

Synthetic fibres:

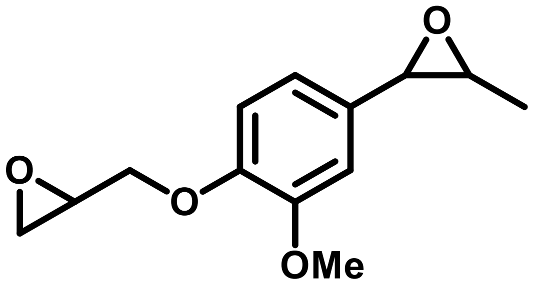
- Carbon
- Glass
- Kevlar
- Aramid

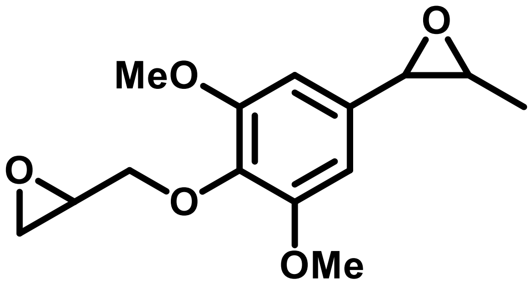
Natural fibres:

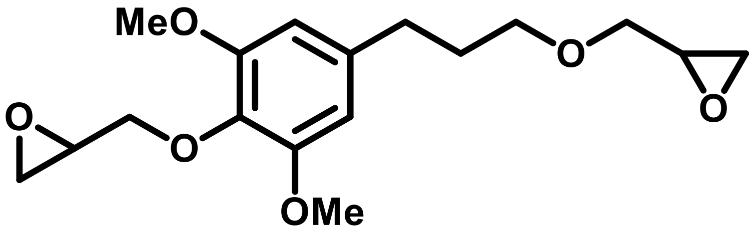
- Hemp
- Flax
- Miscanthus

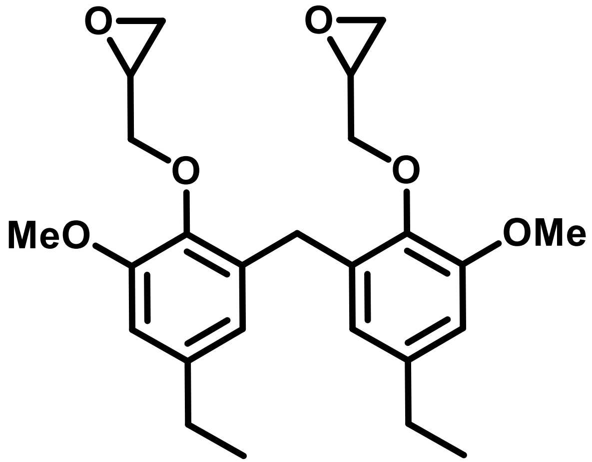
SSUCHY'S APPROACHES

Lignin









Stockholm University
Department of Organic Chemistry
Arrhenius Laboratory Sweden

Bio-based Thermoplastics (Polyesters)

Bio-based Thermosets (Epoxy)

CNRS-ENSCP
Institut de Recherche de Chimie Paris
Chimie ParisTech France

Bio-based Matrices

UB-CNRS
Institut de Chimie Moléculaire de l'Université de Bourgogne Dijon France

SSUCHY's Specifications

Description	Criteria
Good thermal properties	$T_{5\%} > 200°C$ $T_g > 100°C$
Adapted implementation conditions	$T_P < 200°C$ $\eta < 1$ Pa.s Gel time sufficiently long for the preparation of the composite
High mechanical properties	Flexural Modulus, $E_F > 3$ Gpa Flexural Strength, $\sigma_F > 100$ Mpa
Fire resistance	Decrease of the total heat release of 25%
Bio-based origin	Increase the content of bio-based carbon in thermoplastics and epoxy resins to reach 100%

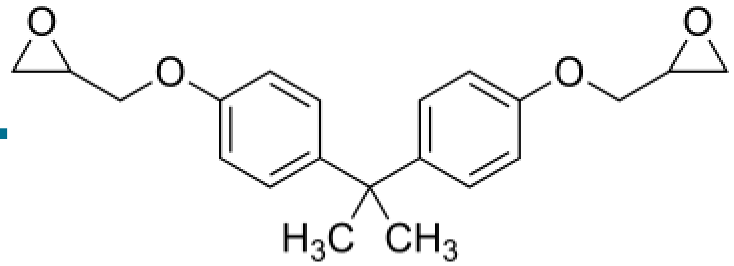
Scooter

Aerospace

Automotive

Acoustics

Thermosetting Resins



DiGlycidylEther of Bisphenol A
DGEBA
or
BADGE

Phenol Derivative

Endocrine Disruptor

Bisphenol A epoxy resin

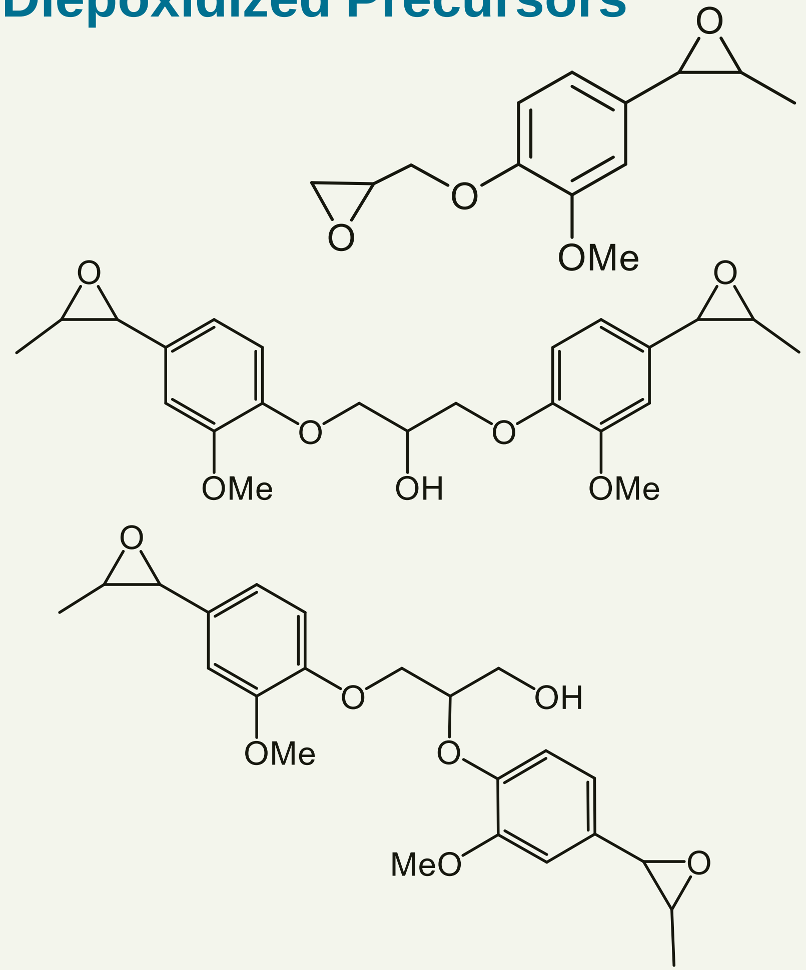
- **70% of commercialized epoxy resins**
- **High thermo-mechanical properties**

- Polyamines
- Acid anhydrides
- Phenols
- Alcohols and thiols

Need to find greener alternatives!

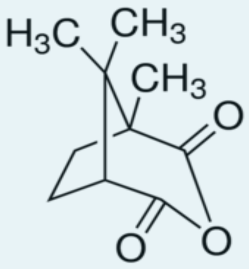
BioIgenox Resin

Diepoxidized Precursors



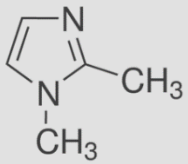
Mixture of derivatives of *iso*-eugenol

Hardener



Camphoric Anhydride

Catalyst



DMID

$\xrightarrow[\Delta]{}$

Polyepoxides

- T_g > 100°C (130-160°C)
- E' = 2.5 Gpa (40°C)
- $T_{5\%}$ > 200°C (300°C)

Hemp Fibres

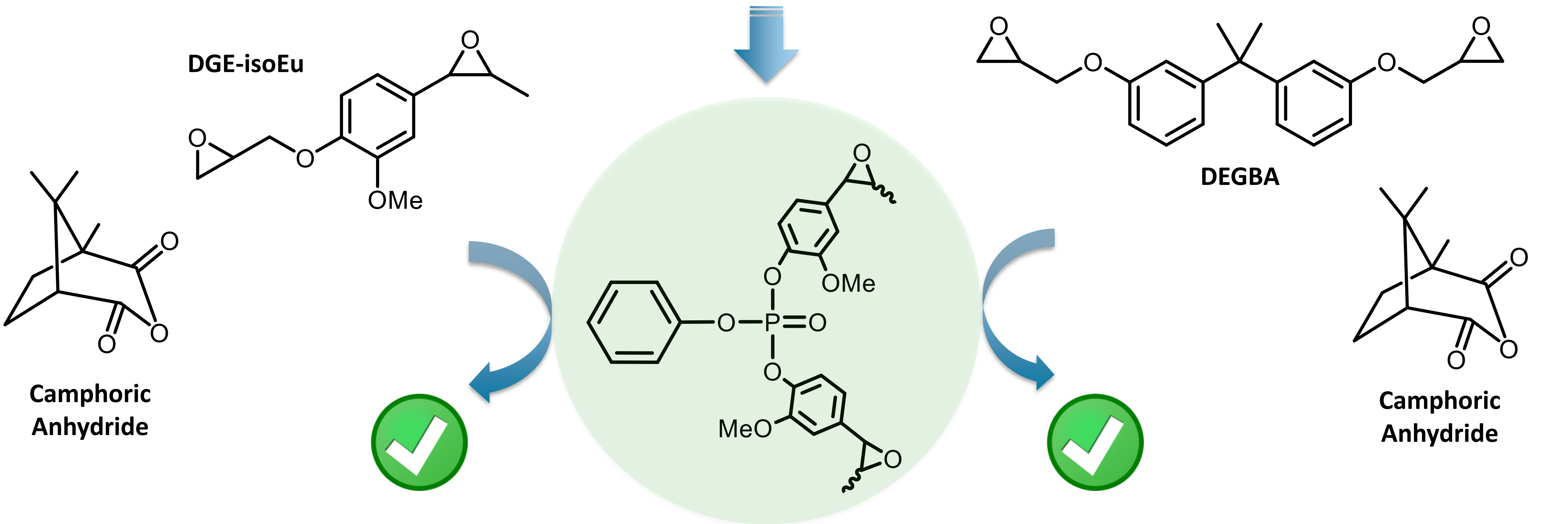
Highly Bio-Based Composite

Also possible with bisguaiacol/phtalic anhydride

Bio-based flame retardant

SSUCHY's Specifications	Fire resistance	Decrease of the total heat release of 25%

***Iso*-Eugenol**

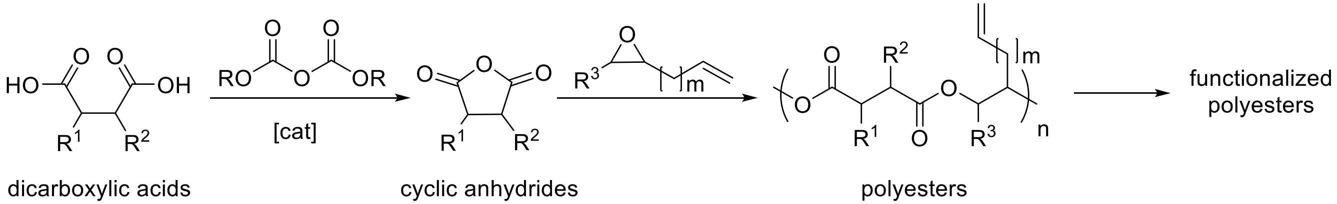


- Significant increase of the rate of residues
- Notable improvement of flame retardancy

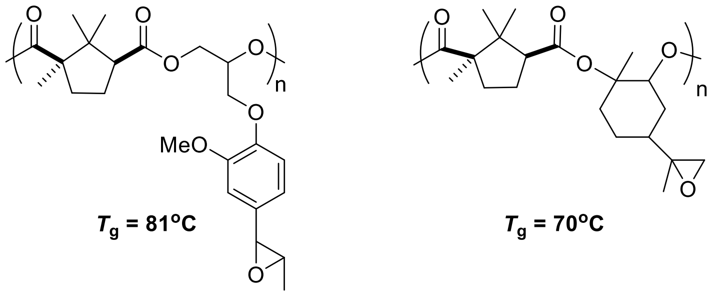
Acting as Copolymer

- Thermal stability up to 250 °C
- T_g values are maintained above 100 °C

One-pot synthesis of Polyesters

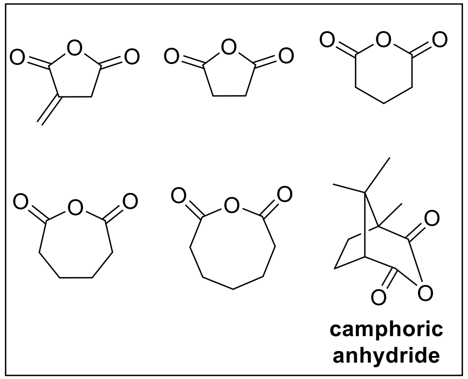


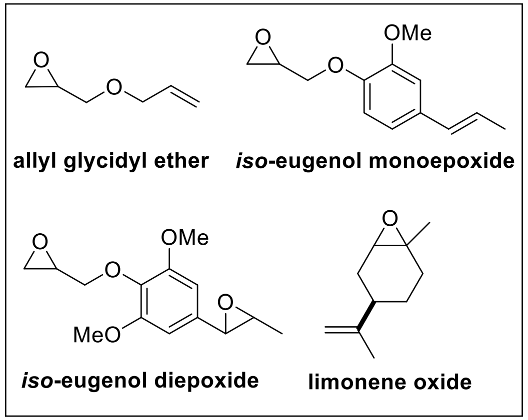
- Environmentally friendly process for camphoric anhydride with full conversion at 40°C
- Preparation of new thermoplastic polyesters



- Main remaining lock: upscaling of polymer production
- For a polymer with an initial T_g of 70-80°C, we obtained a polymer on a larger scale which had a T_g of 50-60°C.

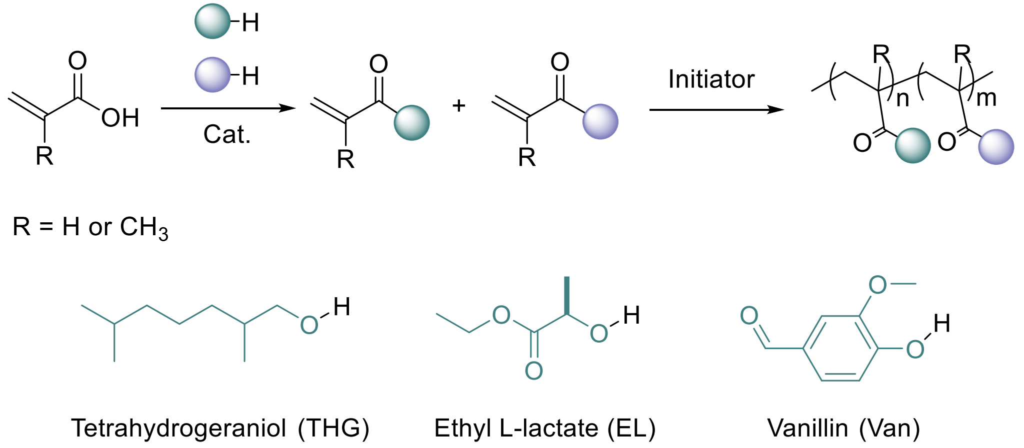
- One-pot approach
  - No formation of side-products
  - No purification of intermediates
  - Dicarboxylic acids: important renewable building blocks
  - Cyclic anhydrides can also be used as hardeners
  - Epoxides from SU or commercially available

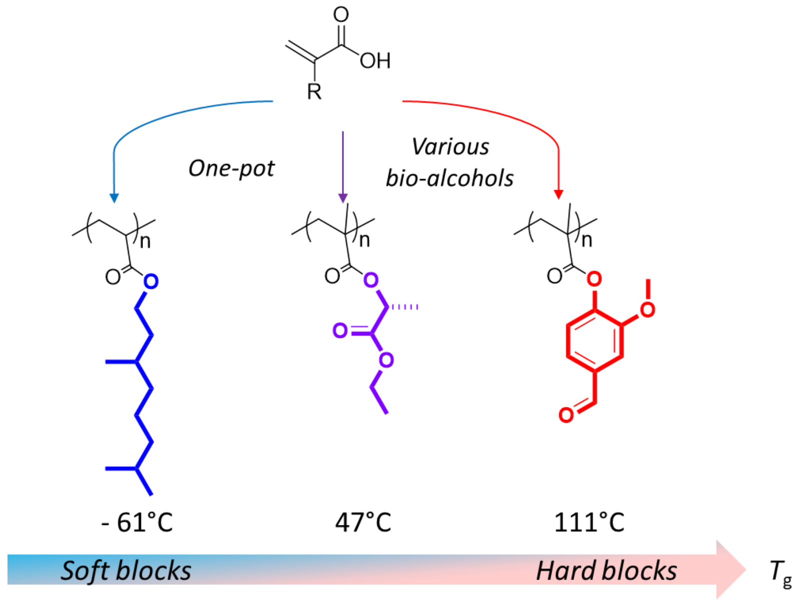




ONE-POT SYNTHESIS OF POLY((METH)ACRYLATE)S

- Monomer preparation => efficient and selective
- No intermediate purification
- (meth)acrylatic acids can be biobased
- Key intermediate:
  (meth)acrylic anhydride
- Access to homopolymers, random and block copolymers
- Polymerization and materials characterization => synthesis of various polymer architectures: wide range of T_g (T_d up to 310°C)





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This project has received funding from the Bio-Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation program under grant agreement No 744349.