New Polymeric Materials and Biocomposites from Oilseed Lipids

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Lipid Chemistry Group's BioMaterials Program

The Lipid Chemistry Group (LCG) performs basic and applied research in laboratories equipped for materials science, analytical chemistry and for the synthesis of new materials from fats and oils. The two core areas are:

1. The development of processes for the conversion of lipid resources into biomaterials.
2. The advancement of analytical methods for the study of lipids of importance in agriculture, food, nutrition and health.

The objective of biomaterials program is to develop new, industrially-relevant polymeric materials and monomers from renewable lipid resources such as oilseeds. We currently have several projects focusing on the development of bio-polyols and epoxidized plant oils and their potential commerical applications.

LCG canola oil bio-polyols are undergoing evaluation in polyurethane (PU) foams formulations for the automotive and building materials industries as well as other PU applications including adhesives, plastics, and coatings.

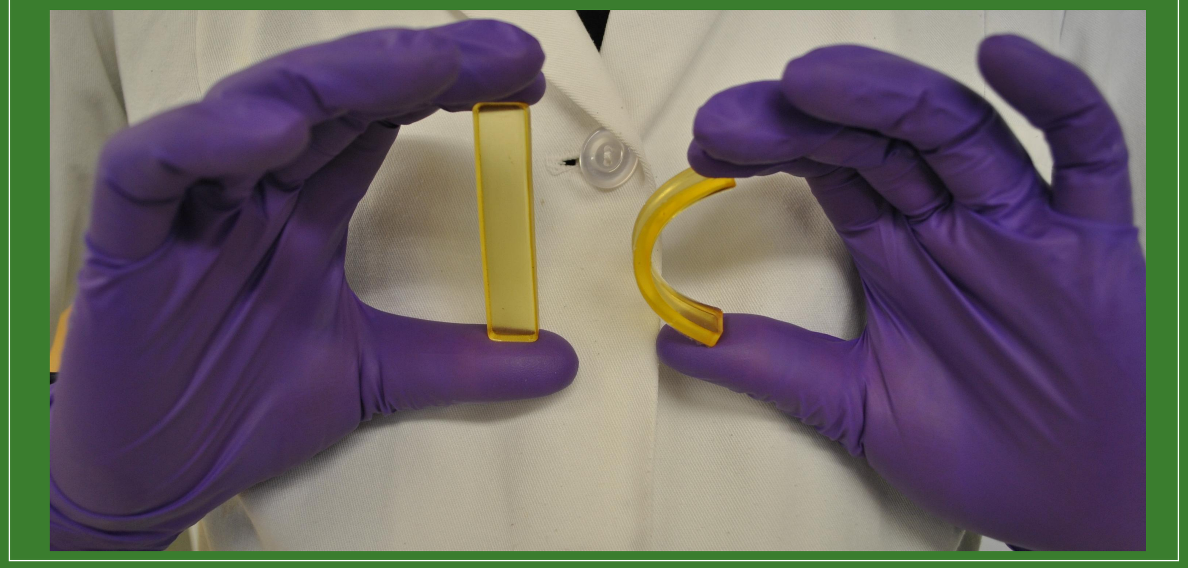
In parallel to the bio-polyol project, our reactive resins project develops epoxy oil compounds useful as thermoset resins or to bind fibres in biocomposite construction.

ECO Epoxy Resin from Canola

Epoxidized Canola Oil (ECO) is the product from the first step of the Liprol manufacturing process formed by reaction of double bonds in canola oil with peroxide. ECO is a clear, viscous liquid with a long shelf life.

Flexible and Rigid ECO Thermosets

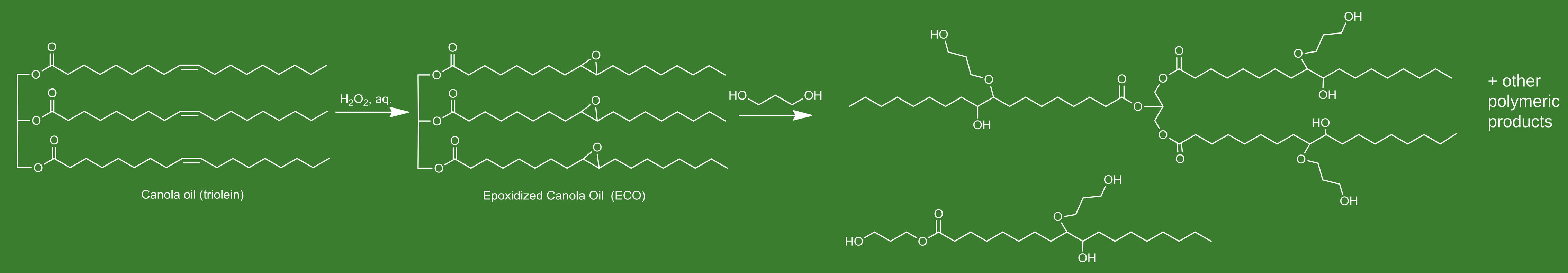
When blended with low percentages of common and inexpensive polymer components, ECO can form a thermosetting polymer. Either a rigid (left) or flexible (right) thermoset polymer can be produced depending on curing conditions as the photograph below indicates.

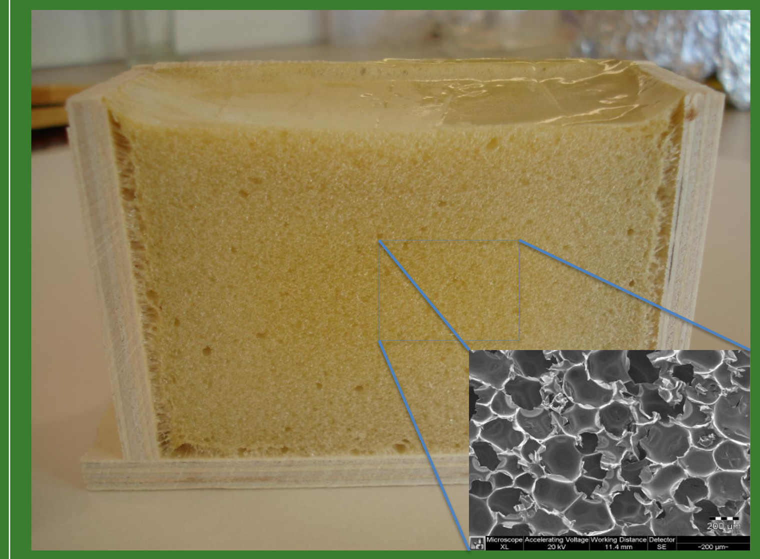


From Liprol™: A Variety of Polyurethanes and Materials

LCG's patent-pending polyol synthesis allows unprecedented flexibility in creating polyols. Hydroxyl number, MW and viscosity may all be tailored to the end-users requirements. Proof-of-concept work was aimed at a simple, efficient polyol synthesis using the highest amount of renewably-sourced content available. The result was Liprol 270™, made from canola oil and diol derived from a corn fermentation process. (1,3-propanediol, DuPont Tate and Lyle) A second bio-polyol, Liprol 290™, with a higher hydroxyl number and a different MW distribution has also been recently developed.

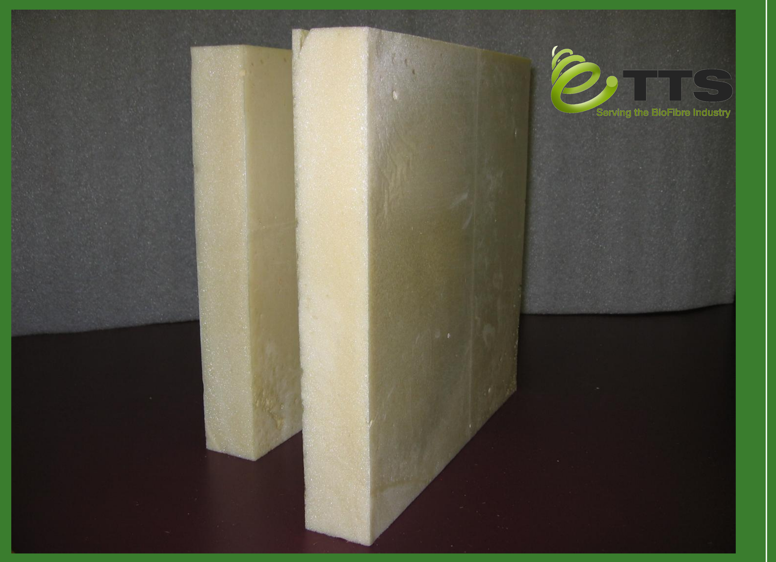
Liprol 270 is used as the polyol component for making polyurethane materials such as foams, adhesives, plastic films and coatings. In one project, increasing amounts of Liprol 270 are blended with conventional polyol to make rigid foam with good insulation values. To maximized the renewable content of the final product. Manufacture of Liprol has been proven using 12 L and 22 L reactors with 100-200L scale-ups planned.





←LCG 1st generation PUR insulating foam
- Bio-polyol 48%
- Poly-MDI 48%
- Water 2%
- Surfactant, catalyst, etc 2%
- Open cast, cure at 90 °C
- Renewable content 50%

TTS Commercial Formulation Trial →
- Liprol 270™
- Renewable content ~25%
- R Value (*per* inch) 5.5



ECO Biocomposites

ECO epoxy resin derived from canola oil heat-cures into either a strong, flexible polymer or a rock-hard transparent thermoset depending on the curing conditions. ECO can be applied to various fibres to form biocomposites with >90% total renewably-sourced content.

LCG is grateful for support from

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TTS Serving the BioFibre Industry

The Woodbridge Group®

Polyurethane Wood Adhesive

The presence of both secondary and primary hydroxyl groups in Liprol confers favourable strength, reactivity and resistance to PU adhesives. Three commercially available wood glues were purchased and tested against Liprol PU for shear strength and chemical resistance. Liprol-based PU adhesives had similar or better adhesive properties in terms of lap shear strength compared to commercial PU products. The overall chemical resistance of Liprol-based adhesive was comparable to commercial PU adhesives whilst its resistance to hot water was superior. The effect of the diisocyanate–to-hydroxyl number molar ratio used in the formulations (NCO/OH) on wood bonding was also studied by lap shear testing. It was found that an optimal molar ratio as well as elevated curing temperature improved the wood adhesive properties.

The adhesives were prepared by the reaction of Liprol with pMDI without the addition of hardeners, surfactants or catalysts. The two compounds were hand mixed for ten minutes and then applied to the wood surface. Three different molar ratios were chosen: NCO/OH = 1.2, 1.5, 1.8. The two coated pieces of wood were placed together and cured at either room temperature or 100 °C at 0.1 MPa for 48 hours.

Effect of curing temperature on lap shear strength

	Lap shear strength (MPa) Curing at 25 °C	Lap shear strength (MPa) Curing at 100 °C
Liprol/pMDI (1.5/1.0)	3.9 ± 0.4	5.7 ± 0.7
Commercial adhesive A	4.9 ± 0.7	5.5 ± 0.6

Effect of molar ratio on lap shear strength on test specimens cured at 100 °C for 48 hours

	Lap shear strength (MPa)
pMDI/Canola polyol (1.2/1.0)	5.2 ± 0.3
pMDI/Canola polyol (1.5/1.0)	5.7 ± 0.7
pMDI/Canola polyol (1.8/1.0)	5.7 ± 0.4

Chemical resistance of polyurethane adhesives as measured by lap shear testing

	Lap shear strength (MPa) (before)	Lap shear strength (MPa) (after treatment)			
		Cold water	Boiling water	Acid solution pH=2	Alkali solution pH=12
Liprol/pMDI (1.5/1.0)	5.7 ± 0.7	5.4 ± 0.5	5.4 ± 0.6	3.5 ± 0.7	5.3 ± 0.8
Commercial adhesive A	5.5 ± 0.6	5.6 ± 0.2	3.9 ± 0.7	3.4 ± 0.5	5.4 ± 0.6
Commercial adhesive B			3.2 ± 0.4	3.4 ± 0.3	
Commercial adhesive C			4.6 ± 0.6	3.7 ± 0.3	