Preparation of Bio-based Resins from Soybean Oil and Orange Peel

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Abstract

The main objective of this project is to replace petroleum based raw materials with environmental-friendly, agricultural-based starting materials. Plant based starting materials obtained from soybean oil and orange peel were reacted with a Lewis acidic catalyst, tris(pentaflorophenyl)borane or BCF for synthesis of bio-based epoxy resins. Thermal and mechanical properties of thus prepared epoxy resins were analyzed.

Introduction

Many of the polyurethane cast resins available in the market are petroleum-based. In general, petroleum-based chemicals are reacted with toxic chemicals such as isocyanate to prepare cast resin. Our project focuses on creating isocyanate free, plant-based epoxy cast resins that are polymers containing epoxy or oxirane groups. Utilization of alternate resources; i.e., bio-based, agricultural products significantly minimizes health, safety and environmental hazards. Major application of these epoxy resins includes coatings, adhesives, electrical insulation, 3D printing, wind turbines, automobiles parts, etc.

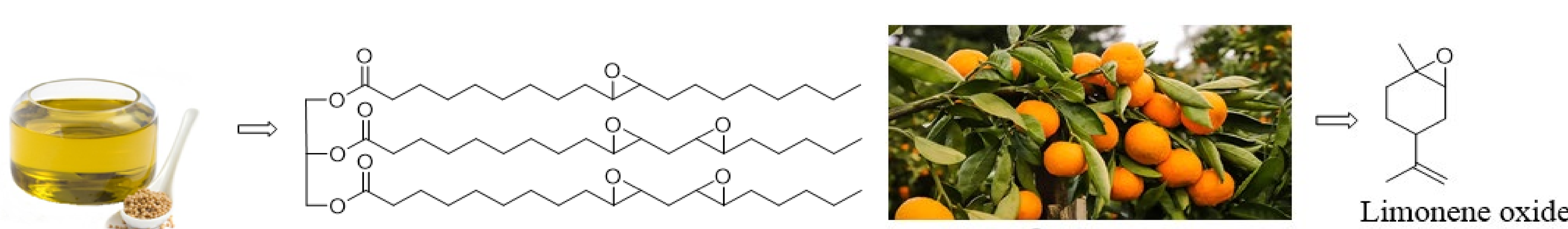
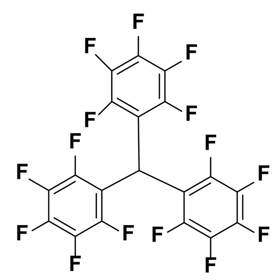


Figure 1: Structures of starting materials obtained from soybean oil and orange peel

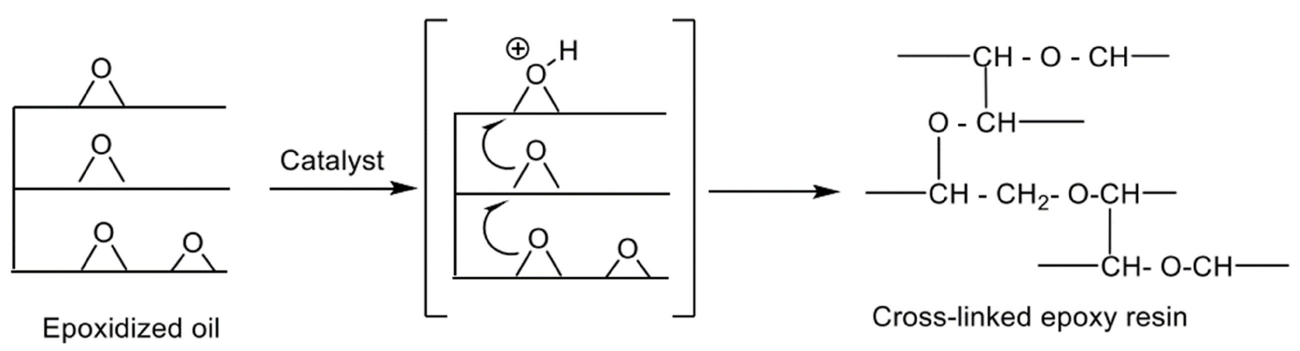
Image source for soybean and orange : Google

Methods

- Synthesized by reacting epoxidized soybean oil (ESO) and limonene oxide (LO) in presence of the catalyst, tris(pentaflorophenyl)borane, BCF.
- Poured the reaction mixture in a mold and cured in an oven at 100 °C for about 12 hours
- Characterized by various instruments including Fourier Transform Infrared spectroscopy (FT-IR), Thermogravimetric analysis (TGA), Differential scanning calorimeter (DSC).



Chemical Structure of the catalyst, BCF



Scheme 1: Synthesis of epoxy cast resins from derivatives of natural oils

Results and Discussion

- Samples were clear and transparent.
- Lowering the concentration of ESO or increasing the concentration of LO increases gelation time
- Higher concentration of ESO provided harder samples

Figure 2: Epoxy cast resins prepared from Soybean oil and orange peel derived starting materials

Sample	Gelation time, mins	Thickness, mm	Hardness, Shore A	Temperature °C, @ 5% wt. loss	Temperature °C, T_g
ESO:LO (90:10)	13	2.258	84.6	380	-41.11
ESO:LO (80:20)	16	1.814	86.6	374	-44.72
ESO:LO (70:30)	29	1.714	77.6	355	-44.9
ESO:LO (60:40)	35	1.914	75.6	324	-40.33
ESO:LO (50:50)	35	1.770	69.6	301	-39.30

Table 1: Properties of epoxy cast resins prepared from soybean oil derived raw materials

- FTIR results show epoxy groups of the starting materials reacted.
- Thermogravimetric analysis (TGA) confirms the stability at very high temperature.
- Low glass transition temperature, Tg suggests the rubbery nature of the bio-based cast resins.

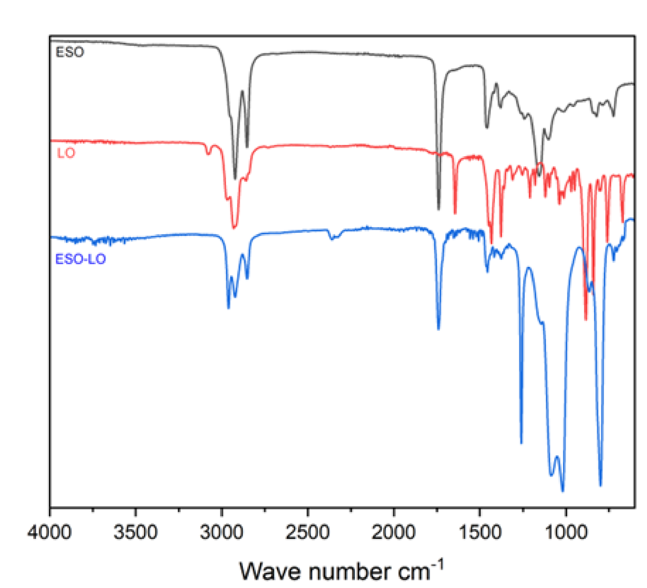


Figure 3: Overlay of FTIR spectra of the starting materials and product

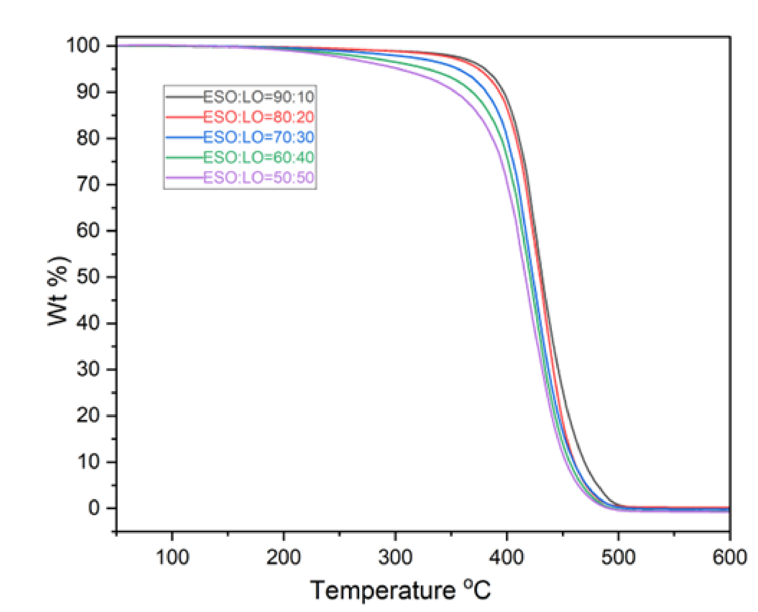


Figure 4. Thermogravimetric analysis (TGA) results of epoxy cast resins

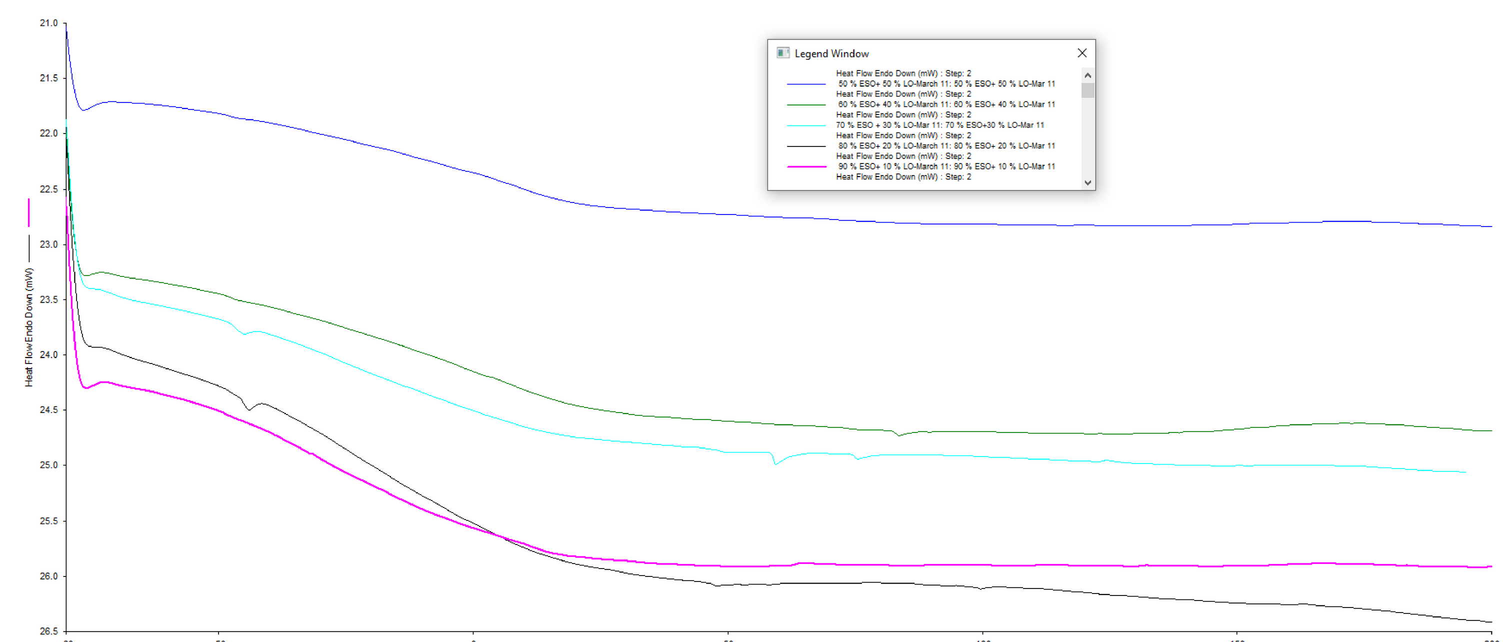


Figure 5: Differential Scanning Calorimetry (DSC) results of of epoxy cast resins

Applications




Image source: Google

Future Works

- Study of tensile properties
- Utilization of different Lewis acidic catalysts
- Evaluation of other bio-based materials containing aromatic functional group/s

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