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

Taylor Gresham, Tavia Spidel, and Maha L. Shrestha*
Department of Chemistry & Physics
West Texas A&M University

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 an isocyanate free, plant-based epoxy cast resins that are polymers containing epoxy or oxirane group. 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, 3 D printing, wind turbines, automobiles parts, etc.

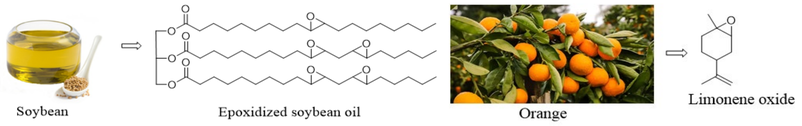
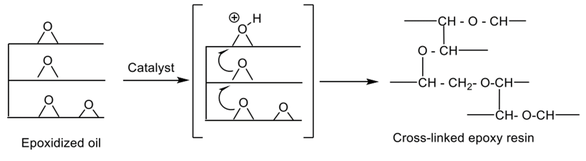


Figure 1: Structures of starting materials obtained from soybean oil and orange peel

Image source for soybean and orange : Google

Methods

- Synthesized by mixing epoxidized soybean oil (ESO) and or limonene oxide (LO) in presence of the catalyst, tris(pentaflorophenyl)borane.
- Cured in an oven at 100 °C for about 12 hours
- Characterized by various instruments including Infrared spectroscopy (IR), Thermogravimetric analysis (TGA), Differential scanning calorimeter (DSC), Tensile strength, etc.



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

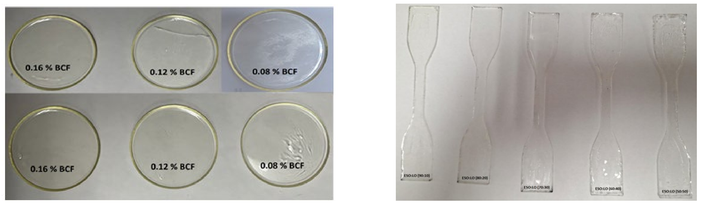


Figure 1: Epoxy cast resins prepared from Soybean oil and orange peel derived starting materials

Results and Discussion

- Gelation occurred much faster at room temperature while dry solvents were used.
- Various instrumental analysis suggested the better results while samples were prepared by using dry solvents.

Sample ID	Gelation time @ rt, minutes	Hardness, Shore A	Degradation Temp, °C @ 5% wt. loss
ESO+0.16% BCF in toluene	NA	89.3 ± 3.3	363
ESO+0.12% BCF in toluene	NA	88.1 ± 7.1	381
ESO+0.08% BCF in toluene	NA	90. 0 ± 3.0	368
ESO+0.16% BCF in toluene-dry	20	90.0 ± 2.0	372
ESO+0.12% BCF in toluene-dry	20	88.7 ± 3.7	367
ESO+0.08% BCF in toluene-dry	25	89.5 ± 2.5	359
ESO+0.16% BCF in DCM	NA	90.7 ± 2.7	356
ESO+0.12% BCF in DCM	NA	89.7 ± 1.7	369
ESO+0.08% BCF in DCM	NA	79.6 ± 1.6	357
ESO+0.16% BCF in DCM-dry	31	90.1 ± 1.9	365
ESO+0.12% BCF in DCM-dry	42	88.3 ± 2.3	358
ESO+0.08% BCF in DCM-dry	60	87.3 ± 2.3	368

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

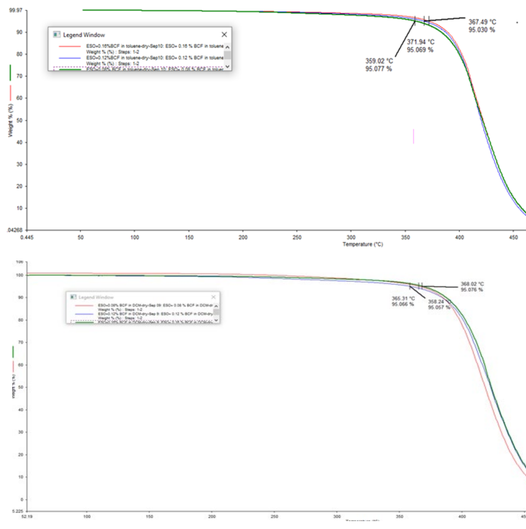


Figure 3: Thermal analysis of samples prepared from ESO+BCF in toluene and dichloromethane

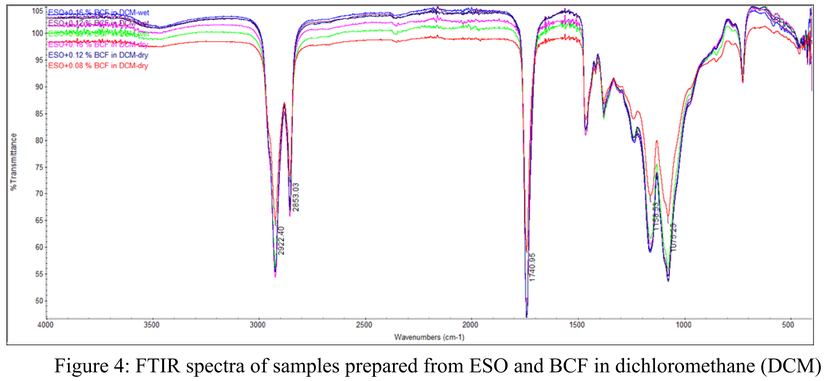


Figure 4: FTIR spectra of samples prepared from ESO and BCF in dichloromethane (DCM)

Applications

Image source: Google

Work in Progress

- Study of thermal and mechanical properties of the epoxy cast resins prepared from soybean oil and orange peel
- Utilization of various Lewis acidic catalysts
- Evaluation of other bio-based materials

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