PLANT OIL BASED THERMOSETTING POLYMERS

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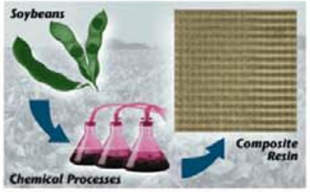
OBJECTIVE

Synthesis and Characterization of Thermosetting Polymers from Plant Oils

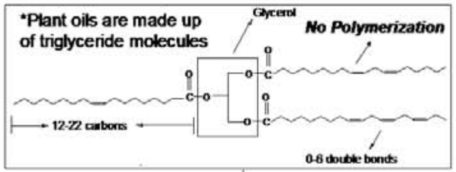


MOTIVATION

- Renewable resources instead of petroleum
- Economical advantages
- Environmental advantages
  - -petroleum resources depleting
  - -potential biodegradability of bio-based polymers

GENERAL APROACH

Plant oils are not readily polymerizable, thus accomplishing this goal involves designing a synthetic chemical route to introduce polymerizable functional groups onto the triglyceride structure.

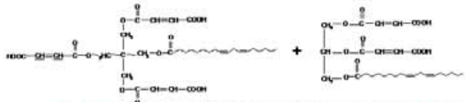


Chemical Modifications: Optimization of reaction conditions

Monomer characterization: H'-NMR, IR, HPLC Mass Spectroscopy,

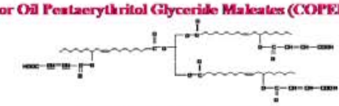
Characterization of the thermosetting polymers using standard mechanical tests

CHEMICAL STRUCTURES OF THE PLANT OIL BASED MONOMERS SYNTHESIZED



Soybeanoil Pentaerythritol Glyceride Maleates (SOPERMA)

Castor Oil Pentaerythritol Glyceride Maleates (COPERMA)



Castor Oil Maleate (COMA)

δ ,St, Initiator

Rigid,Thermosetting Polymer

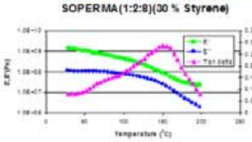
MECHANICAL PROPERTIES (33% styrene)

Resin Type	E' (30°C)(GPa)	Tg (°C)	Flexural Modulus (GPa)	Flexural Strength(MPa)
SOPERMA (1:3:8)	2.08	152	1.27	56
COPERMA (1:3:12)	3.74	158	2.49	112
COMA (1:3)	1.24	82	0.78	33
*Ortho-UPE		100-130	3.45	80
*Iso-UPE		100-130	3.59	130

* *www.matweb.com*

* The use of castor oil instead of soybean oil in the formulation causes nearly a %100 increase in both the modulus and the strength of the resulting polymers due to the fatty acid incorporation in the polymerization.

DMA ANALYSIS OF SOPERMA POLYMERS



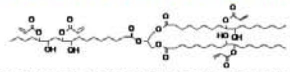
* Broad transition from glass to rubbery state.

SEM ANALYSIS OF THE FRACTURE SURFACE OF THE SOPERMA POLYMER (33%Styrene)

Elastic fracture surface: SOPERMA rich

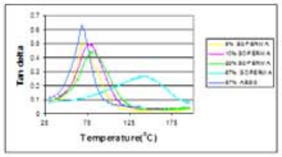
Brittle fracture surface: styrene rich.

AESO-SOPERMA POLYMERS



Acrylated Epoxidized Soybean Oil (AESO)

Resin Type (33%styrene)	G_{Ic} (J/m^2)	K_{Ic} (MPa m$^{1/2}$)	Tg(°C) (Tan delta)	Flexural Modulus (GPa)	Flexural Strength (MPa)
67% AESO	1510	1.725	69.1	1.219	47.3
5%*SOPERMA + 62%AESO	1466	1.479	71.7	1.338	49.3
10%*SOPERMA + 57%AESO	967	1.361	77.4	1.337	54.47
20%*SOPERMA + 47%AESO	363	1.009	84.0	1.197	46.03



CONCLUSIONS

- Novel thermosetting liquid molding resins from soybean and castor oil :
  - SOPERMA E' = 2GPa (30°C) Tg = 152°C, Flex. mod.=1.27GPa, Flex. str.= 55.8MPa
  - COPERMA E' = 3.7GPa (30°C) Tg=158°C, Flex. mod.=2.49GPa, Flex. str.= 112 MPa
- Comparable properties to those of UPE.
- Phase separation of the SOPERMA from styrene
- The addition of 5-10 % SOPERMA to the AESO polymer causes a decrease in the fracture toughness and an increase in the Tg, modulus and flexural strength of the resulting copolymers.

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