DEVELOPMENT OF BIO-BASED EMULSION POLYMERS FOR COATING SYSTEMS

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MOTIVATION & OBJECTIVES

"A raw material of feedstock should be renewable rather than depleting wherever technically and economically practicable."[1]

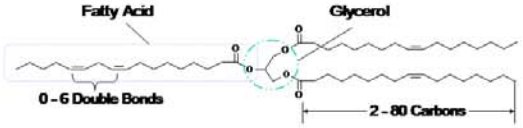
There has been significant focus within the scientific, industrial, and environmental communities on the use of renewable resources. One industry which stands to benefit from this type of research is the emulsion polymer industry. In 2000, the world emulsion polymer demand was $15 million. Over 50% of this demand was from the coatings industry[2]. Emulsions polymers for latex paints, generally produced from petroleum derivatives, are the highest volume resins in the coatings industry. This project seeks to develop emulsion polymers for architectural coatings from modified fatty acids of plant oils. Incorporating products from renewable plant oils in latex technology will provide a renewable and sustainable alternative for the coatings industry as well as a new market for plant oils.

[1]PJ Anastas, JC Warner, *Green Chemistry: Theory and Practice*, Oxford University Press Inc., New York, 1998

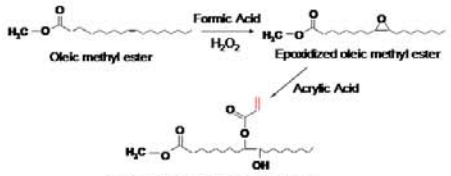
[2] The Freedonia Group, Inc., *Adhesives and Sealants Industry*, 9, 36-39 (2002)

MONOMER SYNTHESIS

Plant oils are composed of triglyceride molecule. These consist of three fatty acids attached to a glycerol center.

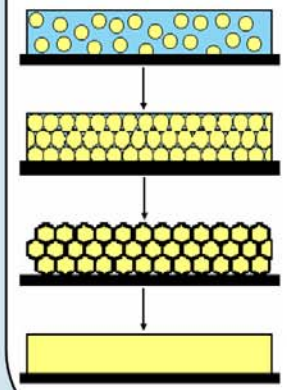


Oleic methyl ester (OME) can be obtained via methanolysis of triglycerides. It can be converted to acrylated oleic methyl ester (AOME), which can participate in the free radical polymerization process of emulsion polymerization.



LATEX FILM FORMATION[3]

Film formation of emulsion polymers occurs by coalescence of latex particles:



Aqueous latex with 20-50 wt% solids applied to substrate

Water evaporates until latex particles comprise 60-70% volume fraction. Particles are close-packed.

Particles deform at T > minimum film forming temperature (MFT). A continuous but weak film results.

At T > T_g polymer surface chains interdiffuse across interfaces, forming a mechanically rigid film.

[3]RP Wool, *Polymer Interfaces: Structure and Strength*, Hanser Publishers, New York, 1995

T_g & CO-MONOMER SELECTION

- Glass Transition Temperature (T_g) Paradox:
  - T_g of latex binders must be low enough for coalescence at the lowest application temperature but high enough to ensure durability[4].
- Architectural coatings: T_g = 0 – 25 °C[4]
- AOME: T_g = - 60 °C
  - AOME alone will form an inadequate, tacky film
  - Requires hard comonomer to achieve desired T_g
- Fox Equation used to predict amount of comonomer necessary for desired T_g

$$\frac{1}{T_{g,copolymer}} = \frac{w_1}{T_{g,1}} + \frac{w_2}{T_{g,2}} + \frac{w_3}{T_{g,3}} + \ldots$$

[4]ZW Wicks, FN Jones, SP Pappas, *Organic Coatings: Science and Technology*, Wiley-Interscience, New York, 1999

CURRENT WORK

Comonomer: Methyl Methacrylate (MMA), T_g = 105 °C

AOME Miniemulsions and Film Formation

- 40-60 weight % MMA as comonomer
- Surfactant: SDS
- Initiator: AIBN
- Miniemulsion preparation:
  - Continuous ultrasonification of components for 5 minutes.
  - Emulsion subsequently heated to 80 °C in round bottom flask and continuously stirred for 1 hour
- Samples of each emulsion allowed to form films at room temperature
  - Very tacky, clear, uniform films formed

CURRENT WORK

Glass Transition Temperature

- Fox Equation Predictions:

% AOME	% MMA	Predicted T_g (°C)
40	60	15.6
50	50	-0.53
60	40	-14.9

- Differential scanning calorimetry measured the Tg of all films to be less than -40 °C
  - Result of unreacted MMA?
  - Molecular weight problems?

FUTURE WORK

- Investigation of T_g discrepancy
  - Molecular weight dependence
  - Monomer conversion
- Optimization of AOME and comonomer
  - Search for a suitable and renewable comonomer
  - Incorporate use of sticker/receptor groups onto polymer to promote substrate adhesion
  - Examine addition of crosslinking functionality
- Eventual production and incorporation of plant oil based latex binder into actual coating formulation

ACKNOWLEDGEMENTS

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