Recycling Used Canola Oil into 3D Printing Resin

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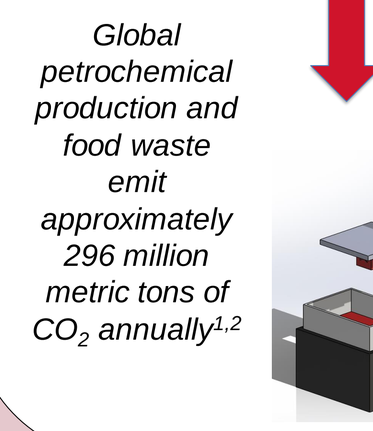
3D Printing Resin

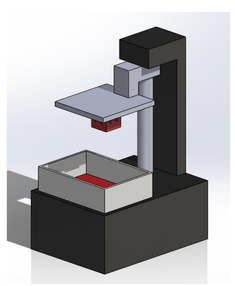
Resin Printing, also known as Stereolithography (SLA), uses UV light to cure liquid resin layer-by-layer in additive manufacturing.

Petrochemicals
(Standard Resin)

Plant-based Oils
(Sustainable Resin)



Global petrochemical production and food waste emit approximately 296 million metric tons of CO_2 annually[1,2]



Utilizing recycled plant-based oils reduces reliance on fossil fuels and repurposes waste

Reaction Flowsheet[3]

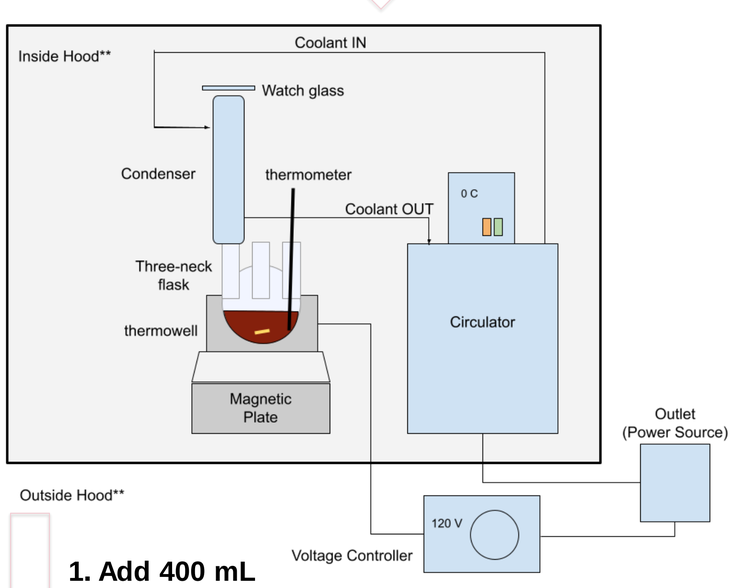
100 mL Recycled & Filtered Oil

44 mL Acrylic Acid

8 mL Boron Trifluoride Etherate

6hrs Heating & Mixing
80 °C – 120 °C

18hrs Cooling & Mixing
Room Temperature

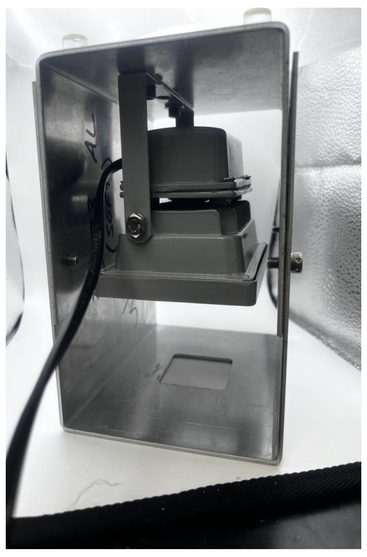


1. Add 400 mL Hexane

2. Add 5% $NaHCO_3$ & NaCl Aqueous Solution

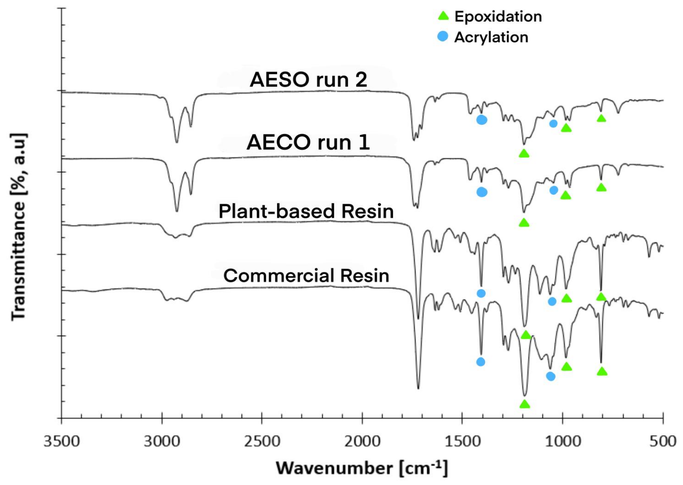
3. Rotary Evaporate Hexane

4. Centrifuge water



UV Curing Apparatus

Lower Epoxidation from Pure Oil



All expected bands are present.

Compared to literature, most noticeable differences at are 1192, 983, and 810 cm^{-1} (▲).

These differences indicate lower epoxide groups.

Reacting Oil into Resin

Traditional 2-Step Reaction

1st Step – Epoxidation

- Pure Oil + Formic Acid + Hydrogen Peroxide
- Pure Oil's double bonds react with the organic peroxyacids

2nd Step – Acrylation

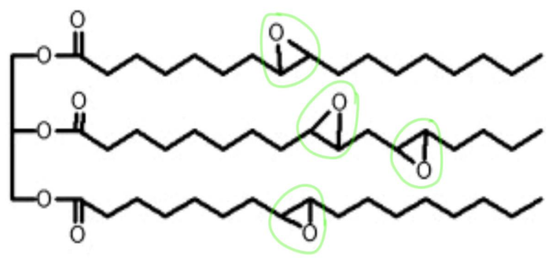
- Epoxidized Oil + Acrylic Acid + Triethylamine (Catalyst) + Hydroquinone (Inhibitor)

Novel 1-Step Reaction

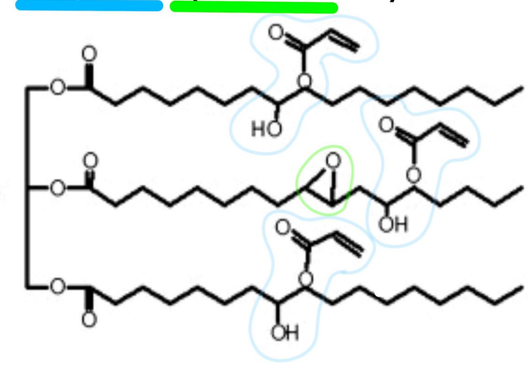
1st Step – Acrylation

- Heat treatment through cooking epoxidizes the carbon chains
- Epoxidized Oil + Acrylic Acid + Boron Trifluoride Etherate

Epoxidized Soybean Oil



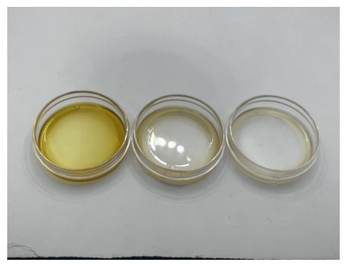
Acrylated Epoxidized Soybean Oil



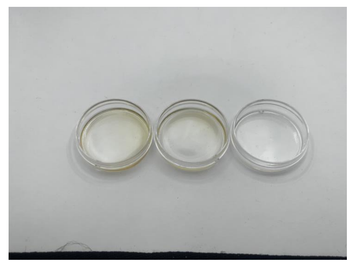
Recycled Oil cures more effectively than Pure Oil

Run #6: Recycled Canola Oil heated to 80 °C for 6 hours

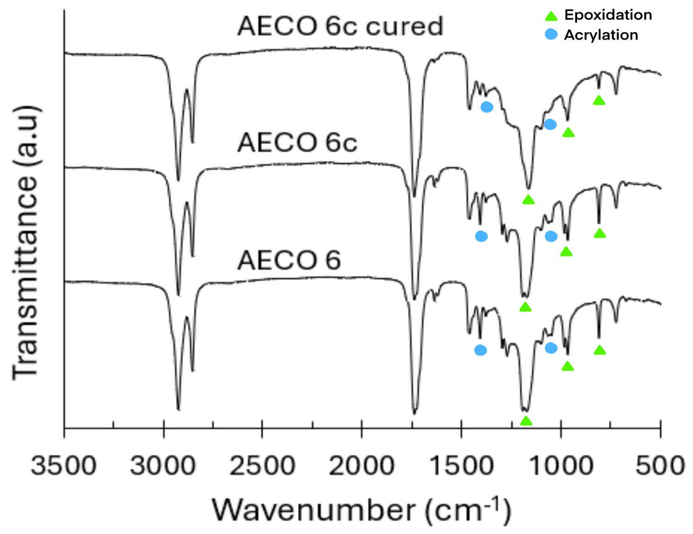
Run #9: Recycled Canola Oil heated to 80 °C for 6 hours with catalyst and inhibitor



Run #6 after curing for 0, 1, and 5 days



Run #9 after curing for 0, 1, and 5 days



Infrared Spectroscopy Analysis of **Run #6** pre-centrifuge (AECO 6), post-centrifuge (AECO 6c), and post-curing for 5 days (AECO 6c cured)

Similar to petrochemical-based resin, when our resin is exposed to UV light, short molecular chains join together, polymerizing monomers and oligomers into a solidified shape.

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- *Professor Geoffrey Tompsett and Skyler Kauffman* for running Infrared Spectroscopy Analysis on our Samples.
- *Ian Anderson* for helping construct our UV Light Apparatus.

References

[1]Jaglo, K., Kenny, S., & Stephenson, J. (2021). From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste. *U.S. Environmental Protection Agency*. https://www.epa.gov/system/files/documents/2021-11/from-farm-to-kitchen-the-environmental-impacts-of-u.s.-food-waste_508-tagged.pdf

[2]Environmental Integrity Project. (2020). Greenhouse gas emissions from the petrochemical sector in the U.S. in 2018, by sector. *Statista*. https://www.statista.com/statistics/520627/petrochemical-project-greenhouse-gas-emissions-in-the-us-by-sector/

[3]Wu, B., Sufi, A., Biswas, R., Hisatsune, A., Moxley-Paquette, V., Ning, P., Soong, R., Dicks, A., & Simpson, A. (2020). Direct Conversion of McDonald's Waste Cooking Oil into a Biodegradable High-Resolution 3D-Printing Resin. *American Chemical Society, 8*(2), 1171-1177. https://doi.org/10.1021/acssuschemeng.9b06281