

# AGRICULTURE

## Project Fact Sheet



## FUNCTIONALIZED VEGETABLE OILS FOR UTILIZATION AS POLYMER BUILDING BLOCKS

### BENEFITS

- Reduces U.S. dependence on foreign oil
- Lowers overall carbon dioxide emissions
- Offers a higher value-added product alternative to farmers and other agribusiness
- Potential 2020 total market is 1.7 million lb of novel polymers per year
- Projected 2020 total energy savings are 3.4 trillion Btu
- Projected 2020 fossil fuel feedstock displacement is 32.1 trillion Btu

### APPLICATIONS

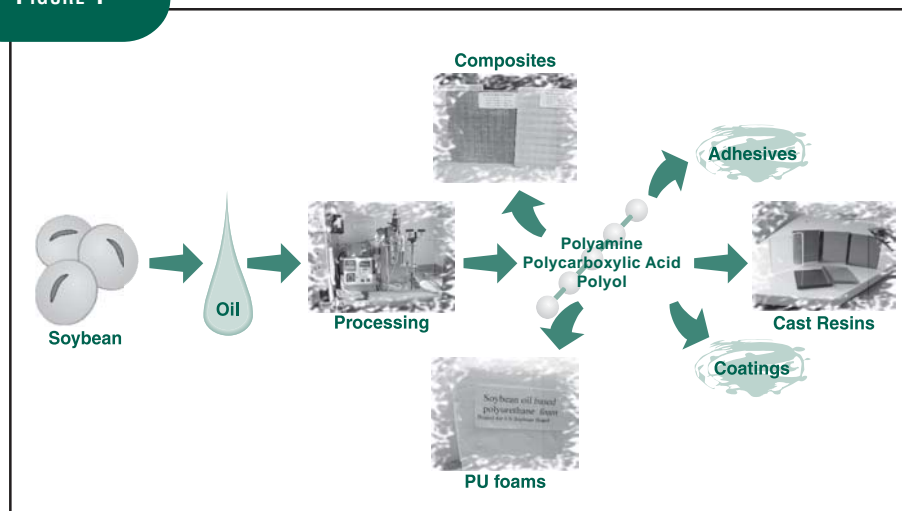
Functionalized vegetable oils can be used to manufacture plastics for use in the automotive, construction, electrical, and transportation sectors. The hydroformylation catalyst system may be applied to the conversion of vegetable oils into other products in the future.

## ROBUST CATALYTIC PROCESS OFFERS NEW USE FOR SOYBEAN AND OTHER VEGETABLE OILS

The U.S. produces 2.8 billion bushels of soybeans, making it the largest producer of soybeans in the world. Soybean oil is used in many food products such as margarine, soft spreads, breakfast cereals, and snack foods. However, its price, adaptability, and performance make it appropriate for use in composite materials, paint removers, solvents, and other non-food products. This project will develop a catalytic process to functionalize soybean oil for other applications as polymer building blocks in high performance plastics. The use of soybean oil-based products would reduce use of petroleum as feedstock, lower emissions of carbon dioxide, nitrous oxides, and sulfur dioxide, and provide farmers and agribusinesses with a higher value-added product alternative.

The key step is the conversion of soybean oil to polyaldehyde using a hydroformylation process in which carbon monoxide and hydrogen are reacted with the oil in the presence of a catalyst. Hydroformylation is a well-developed process with low viscosity, fossil-based oils and uses distillation to separate and recover the catalysts after the reaction. However, vegetable oils have a much higher viscosity and will require a catalyst system that completes the reaction efficiently and allows easy catalyst recovery and product separation. Once the polyaldehyde is isolated it can be converted to novel polyol, polyamine, polycarboxylic acid, or polyacetal functional monomers. These functional monomers can then be used to make novel polymers for use in the construction, automotive, packaging, and electronic sectors.

FIGURE 1



End uses of vegetable oil-based functional monomers.



## Project Description

**Goal:** To develop a catalyst system that has a high efficiency towards the hydroformylation of vegetable oils such as soybean oil, and allows efficient catalyst recovery and easy product separation. Processes to convert polyaldehydes, the product of hydroformylation, into polyol, polyamine, and polycarboxylic acid will be investigated.

The main hurdle to overcome is developing the catalyst for the hydroformylation process. A rhodium-catalyzed hydroformylation process that uses water-soluble ionic phosphine ligands will be synthesized by the Kansas Polymer Research Center (KPRC). The catalyst must have a high rate of conversion of soybean oil to polyaldehyde while allowing the recovery of the rhodium catalysts from the product. The loss of rhodium must be equal to or less than the part per billion (ppb) range. KPRC will also investigate hydrogenation of polyaldehyde to polyol using Raney nickel, oxidation of polyaldehyde to form polycarboxylic acid using medium strength (40%) hydrogen peroxide with a phase transfer catalyst, and addition of an amine group to polyaldehyde to yield polyamine.

BF Goodrich (BFG), Performance Materials Division will evaluate the commercial feasibility of each process and perform pilot plant and manufacturing process development. In the initial stages of product development, BFG will help in structural characterization and evaluation of physical properties of the polymers made using these new functional monomers. BFG will also help develop commercial applications for the functionalized vegetable oil-based polymers.

## Progress and Milestones

- Prepare polyaldehyde through hydroformylation using two types of rhodium catalysts and compare the economic feasibility of the two processes.
- Convert polyaldehyde into polyol through hydrogenation with hydrogen and Raney nickel catalysts. Evaluate the process economics.
- Using oxidation, convert polyaldehyde into polycarboxylic acid and analyze the economic feasibility of the process.
- Prepare polyamine through the addition of amine to polyaldehyde. Establish the feasibility of converting polyaldehyde to polyamine.
- Develop applications for the functionalized vegetable oil-based polymers as adhesives, coatings, foams, composites, plastics, additives, or elastomers.
- Utilize the services of the Pittsburg State University Business and Technology Institute, as well as the expertise of BFG, to commercialize the functional vegetable oil-based polymer products.



### PROJECT PARTNERS

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