SUNRISE BioProducts
A North Dakota State Center of Excellence
for Chemicals, Polymers, and Composites from Crop Oils

Contact:
Wayne Seames, Director, University of North Dakota
241 Centennial Drive, Stop 7101, Grand Forks, ND 58202-7101
701.777.2958
http://www.und.edu/org/sunrise/index.html

SUNRISE BioProducts
A North Dakota State Center of Excellence
for Chemicals, Polymers, and Composites from Crop Oils

Participants:
University of North Dakota, North Dakota State University, and Mayville State University

Department of Chemical Engineering
Department of Chemistry

Department of Coatings and Polymeric Materials
Department of Mechanical Engineering

Division of Science

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites
Mission

PURPOSE: invent, develop, and commercialize green industrial chemicals, polymers, and fiber composites using fatty acid-based oils as the primary raw material.

The center's aims to use fatty acid-based oils to produce products that are nearly identical to existing petroleum-based products and accepted as green replacements for those existing products for quick acceptance plus novel product formulations following a longer development time horizon.

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

The Center is part of a larger research and education group, known as North Dakota SUNRISE

An interdisciplinary cluster of North Dakota research scientists and engineers committed to solving complex energy related problems.

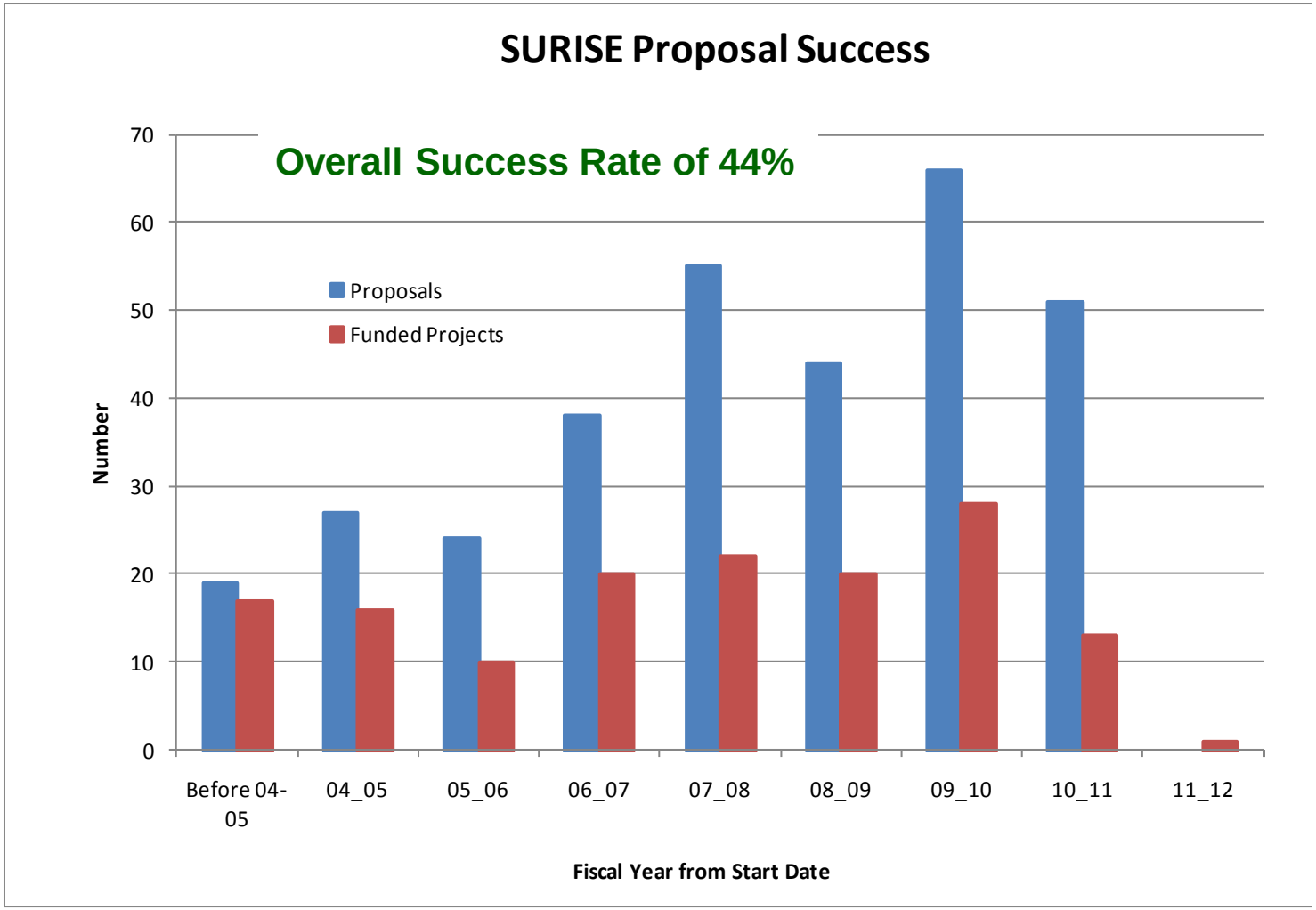
35 faculty participants from 13 separate departments at UND, NDSU, and two regional colleges

MISSION

- Conduct research to provide long-term sustainable energy, chemical, and material products
- Three Focus Areas:
  1. Renewable Fuels, Chemicals, and Polymers
  2. Sustainable Coal Utilization
  3. Energy from Diffuse Sources (wind/solar)

SUNRISE Measures of Success 2004-2010

- $35 million in awards from 44 separate funding authorities
- 215 student participants: 126 Grad, 78 Undergrad, 13 Post-doc
- 16 5 peer-review publications; 215 technical presentations



SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

ORGANIZATION

DIRECTOR: Wayne Seames, Professor of Chemical Engineering

Task Leaders:

1. Fatty Acid Oil Conversion Technology: Wayne Seames
2. Monomer and Polymer Products: Brian Tande, UND Chemical Eng
3. Fiber-based Composite Materials: Chad Ulven, NDSU Mech Eng
4. Renewable Coatings: Dean Webster, NDSU Polymers & Coatings
5. Carbon Products: Steven Benson, UND Chemical Engineering
6. Improved Feedstocks: Khawja Hossein, MSU Plant Science
7. Administration: Wayne Seames
8. Partnerships and IP: Wayne Seames


Tande

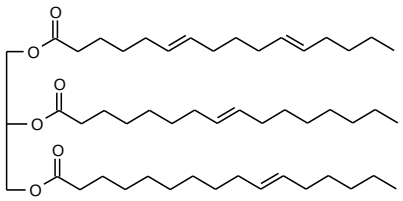

Ulven


Webster

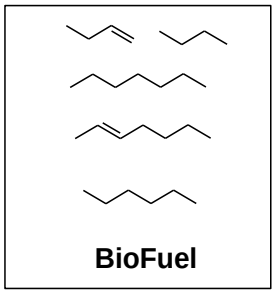

Benson

UND's Proprietary Cracking Processes

Both traditional and nonfood oils can be processed, including algal oil and animal fats

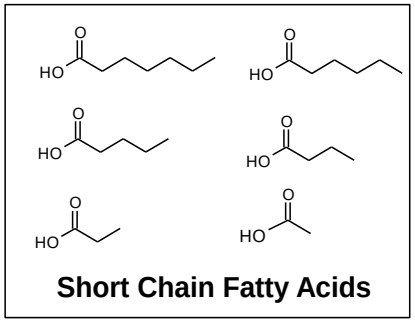


Fatty acid based oil



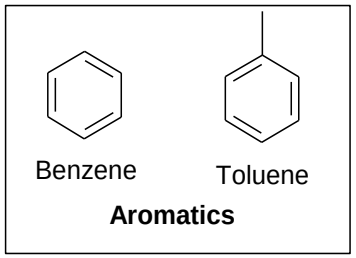
BioFuel

+



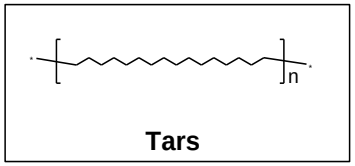
Short Chain Fatty Acids

+



Aromatics

+



Tars

Fuels

Cold-flow Diesel

Jet Fuel

Polymers

- PVAc
- PVA
- Cellulose esters

Polymers

- Polycarbonate
- Polyurethanes
- Polystyrene
- Polyester Resins
- Epoxy Resins

Carbon Products

- Granulated Carbon
- Carbon Fiber
- Activated Carbon

Identified over 1000 products That can be made from this technology

Currently focused on ~ 45

Aromatics from Crop Oils Process

- Crop oil feed is thermally cracked under presence of a catalyst
- Fatty acids form many hydrocarbon compounds including benzene and toluene
- Any unreacted fatty acids are recycled

- Solvent is used to preferentially extract aromatic compounds
- Non-aromatic compounds are stripped off for fuel blending
- Solvent is separated from aromatics and recycled

- Distillation used to separate and purify benzene and toluene to commercial grade specifications
- Xylenes used in fuel blending (or could be further purified and sold)

OUR GOAL: Satisfy increasing consumer demand for biobased polymeric materials – *without compromising performance*.

OUR PRIMARY APPROACH: Develop renewable routes to make commodity-scale feedstocks which are *chemically identical* to those derived from petroleum – but also to develop new products through a longer RD&C timeline

ADVANTAGES:
- No changes for manufacturers
- Easily fits into existing chemical infrastructure

→ Faster adoption

→ Lower risk

RENEWABLE ROUTE

Crop Oils

Petroleum/ Natural Gas

Benzene

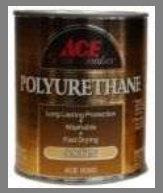
Propylene Oxide

Resin Suppliers

MDI

Polyol

Polyurethane



SUNRISE BioProducts Center of Excellence

Biobased Chemicals, Polymers, and Composites

Biocomposite Materials

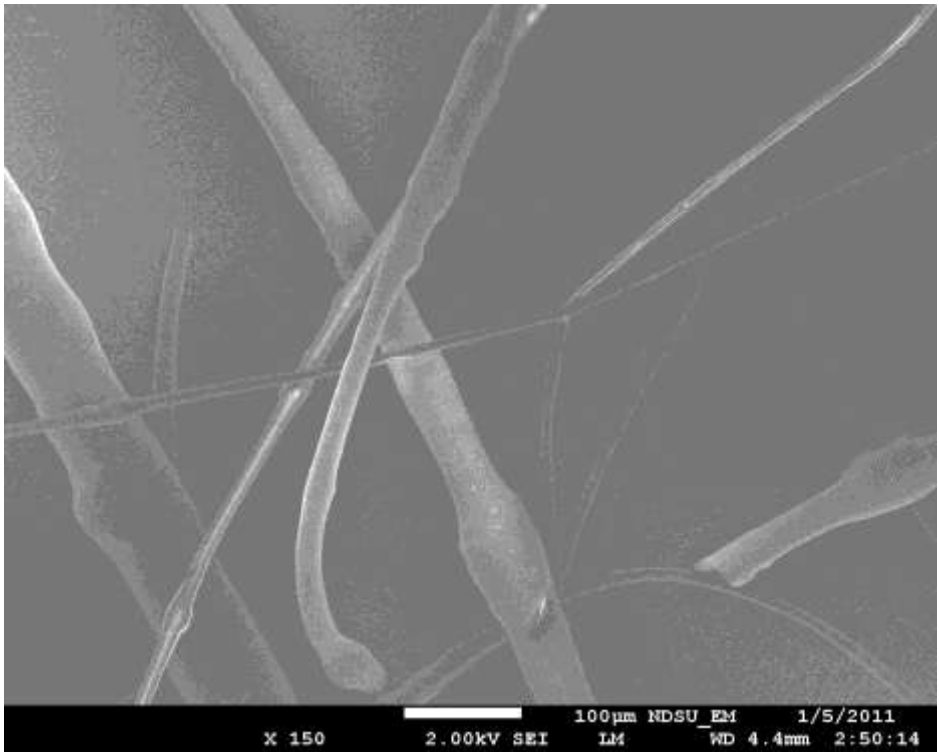
1. The current emphasis is to conduct investigations that will analyze key material properties to support the overall benefit and performance of biocomposites.
2. We are developing novel material combinations and investigating applicability of usage in biocomposite systems, such as the Epoxidized Sucrose Soyate for predominantly-renewable, hemp-fiber-reinforced biocomposites.
   - ESS-based composites using hemp fibers as reinforcements.
   - The effects of epoxy to anhydride stoichiometry, cure time, and cure temperature on the performance properties of coatings and films.
3. Effect of Extrusion Screw Speeds on Thermo-mechanical Properties of Polypropylene-based Biocomposites
4. Utilization of Agricultural Co-products as Reinforcements and Fillers in ABS Plastic.
   - The UV blocking properties of lignin component of natural fibers were analyzed as additives in a natural ABS grade and were compared to an ABS grade compounded with a commercial UV inhibitor, carbon black.

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

Renewable High Purity Carbon Products

Technology is being developed to convert heavy tars and coke produced during the cracking reaction into high value carbon by-products.

1. High purity granulated carbon for nanotubes, cathode posts, etc.
2. Mesophase pitch for carbon fibers



SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites
Facilities and Resources

- Chemical Process development: an extensive suite of lab and bench scale facilities and supporting instrumentation to generate, isolate, and purify renewable chemicals including GC-FID/GC-MS, LCMS
- Polymer and composite characterization:
  - DSC, FTIR, GPC, DMA, NMR, UV-VIS, TGA, Stress Rheometer
  - 4.5, 30, 50, 250 kN mechanical load frames
  - Bose fatigue tester (up to 200 Hz), Dynatup impact tester
  - TEM, SEM (with EDS)
- Coatings formulation and testing:
  - UV-VIS-NIR (w/ Diffuse Reflectance)
  - Accelerated Weathering (UV-A/B, xenon arc, salt spray)
  - AFM, EIS, Surface tension instruments

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

Five types of Private Sector Partners:

1. Feedstock Suppliers
2. Collaborative Technology Providers
3. Associated Preferred Service Providers for Licensors
4. Licensees – processing companies
5. Product end users

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

Feedstock Suppliers

1. Bayer Crop Science: canola oil, non edible high erucic brassica oil
2. Global Agricultural Solutions: jatropha oil
3. Central By-Products: animal fats
4. Jalisco Jojoba: jojoba oil
5. Sustainable Oils/Great Plains: camelina oil

Collaborative Technology Providers

1. Menon & Associates: conversion of biomass to fatty acid oils
2. Aquatic Energy: production of fatty acid oils from algae

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

Associated Preferred Service Providers for Licensors

1. Karges-Faulconbridge: process design and procurement
2. Kadrmas, Lee, & Jackson: logistics and infrastructure

Licensees – processing companies

1. Chemera: Canadian renewable fuels and chemicals
2. Global Agriculture Solutions: African/Asian renewable fuels and chemicals
3. Heartland Corn Products: corn oil from ethanol DDG

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

Product end users

1. Bayer Material Science: monomers for polyurethane
2. Marvin Windows: composite resins
3. LM Wind Energy: composite resins, gelcoats
4. Composite Innovations: composite resins
5. Advanced Ceramic Manufacturing: carbon fibers

SUNRISE BioProducts Center of Excellence
Biobased Chemicals, Polymers, and Composites

State funding with commercial matching funds: 2009-2011

Originating or participating in an existing NSF I/UCRC is a natural next step to continue our Center's activities

The two research universities, UND and NDSU would both join so that existing collaborations can continue

Is CICI the right fit?