Advancing Bio-Based Chemicals and Next-Generation Fuels from Montana's Agricultural Crops

Second Quarterly Report

Submitted by:

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Montana State University - Northern
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CITY COLLEGE
MONTANA STATE UNIVERSITY BILLINGS

Introduction

With the steady decline of manufacturing employment in Montana and as the search for alternative energy sources continues, industrial oilseed crops pose a unique opportunity in addressing these issues. This collaborative research effort between Advanced Fuels Center, Montana State University-Northern (AFC-MSUN) and Montana State University Billings (MSUB) aims at establishing and maintaining a biorefinery utilizing Montana-grown industrial oilseed crops. If a local facility can process industrial oilseeds, such as camelina and carinata, and is able to pay producers a competitive price, there is potential for an oilseed-based biorefinery that will boost Montana's manufacturing employment and will meet industries' greener portfolio. The establishment of this biorefinery will provide sustainable growth in Montana's agriculture and manufacturing industry in two ways: [a] the research is expected to generate numerous Montana jobs and will allow the investment to be leveraged by attracting businesses and [b] the research can address the federal government's thrust of utilizing alternative energy sources to achieve a cleaner environment. This report covers all activities performed until February 29, 2016.

Personnel Recruitment and Employment

Three (3) undergraduate research assistants were hired to assist the leads with their respective tasks. An Energy Corps through the AmeriCorps Program was appointed to help the leads in outreach and education.

Equipment Purchased

Billings City College is currently seeking bids for a pelletizer. MSU-Northern is not buying any equipment with MREDI funding.

Progress Towards Meeting Milestones

Task 1: Life Cycle Analysis (LCA) and Techno-Economic Assessment of Green Diesel and Bio-jet Fuel (Lead: E.P. Resurreccion, eleazer.resurreccion@msun.edu). Evaluate the environmental life cycle analysis (LCA) impacts and techno-economic feasibility of green diesel and bio-jet fuel (next-generation fuels) and high-value added chemicals (bio-based chemicals).

Key Milestones

a) Development of a thorough unit process analysis and life cycle inventory of the entire camelina-to-next-generation fuels/bio-based chemicals process chain. (Timeline: July 1, 2015 to July 2016)

b) Comparative assessment of "cradle-to-gate" life cycle impacts of camelina-to-next-generation fuels/bio-based chemicals. (Timeline: July 1, 2016 to January 1, 2017)

c) Evaluation of tech-economic feasibility of camelina-to-next generation fuels/bio-based chemicals via life cycle costing (LCC). (Timeline: January 1 to July 1, 2017)

Activities to Date

With the purchase of the LCA software SimaPro and financial modeling software Crystal Ball, the lead and undergraduate research assistants have performed goal and scoping, life cycle inventory, and determination of impacts using the EcoInvent™ database. The LCA and cost models have been generated for the production of synthetic paraffinic kerosene (SPK), hydroprocessed esters and fatty acids (HEFA), and MSUN's patented process for converting plants oils to jet fuels. Coordination with MSU Billings has generated industrial economic data for the establishment of the biorefinery. These data are critical inputs that will ensure the models will generate reasonable and reliable life cycle estimates and profitability indices.

The results of this modeling will be presented at the American Center for Life Cycle Assessment (ACLCA) on September 2016 in Charleston, SC. Additionally, a proposal has been submitted to the National Science

Foundation-Innovations at the Nexus of Food, Energy, and Water Systems (NSF-INFEWS) on March 2016. This proposal is a collaboration between MSUN and Old Dominion University (ODU), Norfolk, VA.

Task 2: Production of Camelina-Derived Alkylated Aromatics as a Blend Component to Aviation Gasoline (Lead: R.L. Maglinao, randy.maglinao@msun.edu). Propose and validate the mechanism of producing high-octane number chemicals (e.g., alkylated aromatics) from camelina.

Key Milestones

a) Validation of the mechanism of producing high-octane number chemicals from camelina. (Timeline: July 1 to December 1, 2015)

b) Optimum ratio of camelina-derived alkylated aromatics and unleaded avgas with desired anti-knock value identified. (Timeline: December 1, 2015 to October 1, 2016)

c) Certification of the newly-formulated unleaded avgas. (October 1, 2016 to June 30, 2017)

Activities to Date

A cryogenic (CO2) cooling system has been added to the Center's GC/MS instrument. This allowed us to validate the composition of desired products. The proposed mechanism of converting camelina to high-octane chemicals has been successfully validated through various laboratory experiments (Figure 1). A 12-mL Fisher-Porter reactor has been purchased in performing the reactions (Figure 2). The results of the team's research has been selected to be presented at the 107th American Oil Chemists' Society Annual Meeting & Expo in Salt Lake City, UT this coming May. The team has been continuously progressing in the write-up of the paper to be submitted to ACS journal pending the final results of the experiment. This action will not affect the subsequent tasks.

Figure 1. Validation of compounds in the product using FTIR-ATR.

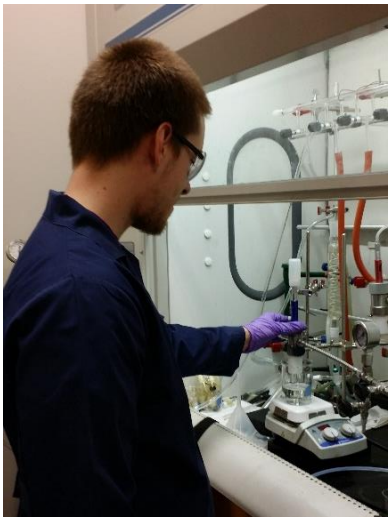

Figure 2. The 12-mL Fisher-Porter used in this task.

Task 3: Development of Heterogeneous Grubbs Catalyst for Biomass Conversion (Lead: M.J. Abedin, md.abedin@msun.edu). Develop a novel and robust heterogeneous Grubbs catalyst that achieves efficient conversion of natural oils to next-generation fuels and bio-based chemicals.

Key Milestones

a) Synthesis of a silica-supported polymeric Grubbs catalyst for olefin metathesis of natural oils. (Timeline: July 1, 2015 to June 30, 2016)

b) Synthesis of a novel silica-supported Grubbs catalyst for olefin metathesis of natural oils. (Timeline: July 1 to December 31, 2016)

c) Comparative analysis of the two heterogeneous Grubbs catalysts. (January 1 to June 30, 2017)

Activities to Date

The polymeric catalyst has been successfully synthesized and characterization is still in progress. Solvent distillation set has been purchased to assist in drying the chemicals used in the catalyst synthesis.

Task 4: Design of an Optimum Process Configuration and Economic Analysis for Medium- and Large-Scale Pelletizing Plants for Camelina Meal (Lead: A. Sullivan, andrew.sullivan3@msubillings.edu). Develop and prepare a design study documenting an optimum process configuration and economic analysis for medium- and large-scale pelletizing plants for camelina meal (next-generation fuels).

Key Milestones

a) Development of an optimized process for fuel pellet production from camelina meal and manufacture a range of pellet compositions to verify producibility. (Timeline: Summer 2016)

b) Testing of products in a range of commercially-available multi-fuel pellet stoves and identification of potential markets to determine product price including a fish food for export. (Timeline: Winter 2016)

c) Preparation of study design for 40,000 to 500,000 ton per year pelletizing plant with economic analysis. (Timeline: Summer 2017)

Activities to Date

Collected 400 lbs of dry grass clippings that will be used for the project. Additional sources of grass clippings has been also identified. Started student research on optimizing oil extraction from camelina seeds using screw presses. The team at MSUN has met with A. Sullivan to discuss camelina meal marketability and has discussed pertinent cultivation details with Northern Agricultural Research Center lead by D. Boss and P. Lamb.

Expenditures

MSU Northern	**Expenditures to Date**
Personnel Services	$221,995.57
Operations	$41,606.64
Equipment	$0.00
MSU Billings	
Personnel Services	$0.00
Operations	$0.00
Equipment	$24,982.00
TOTAL	**$288,584.21**