Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-215

Proposal Title: Advanced Pour Point Depressants from Waste Cooking Oil

Project Manager Information

Name: Prasanth Kumar Sasidharan Pillai

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: This project transforms waste cooking oil into a novel pour point depressant that prevents Minnesota biodiesel from crystallizing at temperatures between -30°C and -40°C.

ENRTF Funds Requested: $500,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro, SE, SW,

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota, a leader in biodiesel production with an annual output of 85.5 million gallons, faces a significant challenge in cold-weather performance. Fatty Acid Methyl Esters (FAMEs), the primary component of biodiesel, tend to crystallize at extreme temperatures (-30°C to -40°C), leading to fuel gelling, clogged pipelines, and operational failures in transportation, agriculture, and industrial sectors. This issue increases maintenance costs and limits the adoption of biodiesel, posing a major setback for renewable energy advancements in cold climates.

To address this, we propose valorizing waste cooking oil, an abundant yet underutilized resource in Minnesota. Events like the Minnesota State Fair alone generate 125,000 to 150,000 pounds of used cooking oil annually, and much of this waste remains underutilized or incurs high disposal costs. By developing a novel, cost-effective pour point depressant (PPD) using a unique chemistry platform, this project will transform waste cooking oil into a high-value biodiesel additive that prevents crystallization, ensuring reliable cold-weather fuel performance. This solution not only eliminates reliance on petroleum-based additives but also enhances waste management efficiency, reduces industry costs, and strengthens Minnesota's circular economy. By turning a waste stream into a critical industry solution, this innovation directly benefits energy sustainability,

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Our proposed solution leverages an innovative metathesis platform to transform waste cooking oil (WCO) into high-performance pour point depressants (PPD), addressing biodiesel crystallization issues in extreme cold temperatures (-40°C). Metathesis, a powerful catalytic process, enables the selective restructuring of lipid molecules, optimizing their molecular weight, branching, and polarity to enhance cold-flow properties. By applying this platform to WCO, we aim to create novel, cost-effective PPDs that improve biodiesel fluidity and stability, ensuring reliable performance in cold climates. We will explore two pathways: (1) Trans-esterified Metathesis, where WCO is first converted into fatty acid methyl esters before metathesis to control branching and chain length, and (2) Non-Transesterified Metathesis, which applies metathesis directly to triglycerides, creating branched and shorter-chain derivatives, reducing processing complexity and cost. Since WCO is highly heterogeneous, we will analyze its composition to develop an optimal metathesis strategy. Additionally, we propose a 50:50 blend of WCO with natural oils to ensure consistent processing efficiency and superior PPD performance. To execute this project, we seek $500,000 in funding, supporting two Master's students, laboratory research, catalyst development, and pilot-scale validation. This scalable, industry-feasible approach offers a sustainable, cost-effective solution to enhance biodiesel cold flow properties while valorizing waste

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The project promotes the protection, preservation, and enhancement of natural resources by advancing biodiesel sustainability. By incorporating modified waste cooking oil as a pour point depressant (PPD), the research improves biodiesel's cold flow properties, enabling its use in colder climates and reducing reliance on fossil fuels. This innovation lowers emissions, mitigates environmental impact, and enhances renewable energy adoption in a technoeconomic way. Additionally, it supports waste valorization, utilizing agricultural byproducts efficiently. By extending biodiesel's usability and promoting sustainable fuel solutions, the project contributes to conservation efforts, reducing pollution and fostering eco-friendly energy alternatives.

Activities and Milestones

Activity 1: Characterize and understand the composition waste cooking oil (WCO)

Activity Budget: $60,000

Activity Description:
The characterization of waste cooking oil (WCO) is a critical step in determining its suitability as a pour point depressant (PPD) for biodiesel applications. WCO undergoes chemical and physical analysis to assess its fatty acid composition, oxidative stability, free fatty acid (FFA) content, moisture levels, and impurity profile. Gas chromatography (GC) is used to analyze saturated, monounsaturated, and polyunsaturated fatty acids, which influence the oil's cold flow properties. Fourier-transform infrared (FTIR) spectroscopy detects oxidation by-products and polymerized compounds, ensuring fuel stability. Additionally, nuclear magnetic resonance (NMR) spectroscopy is employed to assess triglyceride integrity and detect degradation levels. Differential scanning calorimetry (DSC) is used to analyze the thermal behavior and crystallization onset temperature (Ton), providing insights into WCO's potential as a cold flow improver (CFI). Viscosity and density measurements further determine its impact on fuel performance. Contaminant screening, including heavy metals, water content, and polymerized residues, ensures WCO meets fuel-grade standards after purification. This detailed characterization allows for the optimization of fractionation, purification, and modification processes, ensuring that WCO-derived additives effectively enhance biodiesel's cold flow properties and prevent crystallization, promoting sustainable fuel solutions while reducing waste.

Activity Milestones:

Description	Approximate Completion Date
Collection and preprocessing of waste cooking oil (WCO)	October 31, 2026
Comprehensive chemical and physical characterization of WCO	December 31, 2026
Triglyceride integrity and degradation analysis using NMR	December 31, 2026
Thermal behavior, crystallization analysis, viscosity and density measurements for WCO	December 31, 2026
Fatty acid profile analysis using GC and oxidative stability assessment (FTIR spectroscopy)	December 31, 2026

Activity 2: Fractionation of WCO via chromatography, and dry and solvent mediated crystallization procedure

Activity Budget: $70,000

Activity Description:
To obtain ideal fractions for further processing into pour point depressants (PPD) as cold flow improvers (CFI), a strategic chromatography and/or crystallization fractionation approach is employed. Dry crystallization selectively crystallizes high-melting components through controlled cooling, followed by filtration or sedimentation, making it a cost-effective method. However, its efficiency is constrained by higher viscosity, which can limit purity. Solvent-mediated crystallization, in contrast, utilizes an organic solvent to reduce viscosity, enabling more precise separation and a higher purity yield of the desired liquid fraction. The fractionated segments are characterized to ensure suitability for biodiesel applications. Gas chromatography (GC) is employed to analyze the fatty acid profile, identifying saturated, monounsaturated, and polyunsaturated fractions that influence cold flow properties. Fourier-transform infrared spectroscopy (FTIR) is used to detect oxidation by-products, while nuclear magnetic resonance (NMR) spectroscopy assesses triglyceride integrity and molecular structure. Differential scanning calorimetry (DSC) provides insights into crystallization onset temperature, essential for predicting performance in biodiesel blends. By optimizing these fractionation parameters, the resulting liquid fraction is enriched with unsaturated, low-melting components, making it ideal for further processing into PPDs that effectively enhance biodiesel's cold flow properties, ensuring superior low-temperature performance.

Activity Milestones:

Description	Approximate Completion Date
Fractionation Optimization for Ideal Cold Flow Improvers (CFI) (Chromatography, Dry and solvent crystallization)	June 30, 2027
Compositional Analysis of Fractionated Segments to determine fatty acid profile and structural integrity	June 30, 2027
Understanding the thermal and rheology properties of fractionated WCO	June 30, 2027

Activity 3: Blending the fractionated/non-fractionated WCO with soyabean oil to enhance their unsaturation

Activity Budget: $45,000

Activity Description:
This activity focuses on blending waste cooking oil (WCO) with 10%, 20%, 30%, 40%, and 50% soybean oil to enhance its unsaturation levels, thereby improving its suitability for metathesis modification. The goal is to optimize the fatty acid composition, ensuring the resulting blend possesses the desired structural characteristics to function effectively as a pour point depressant (PPD) for biodiesel. To evaluate the impact of blending, the modified oil will undergo comprehensive characterization. Chemical analysis will include gas chromatography (GC) to determine fatty acid composition and Fourier-transform infrared spectroscopy (FTIR) to detect functional group modifications. Physical characterization will assess viscosity, density, oxidative stability, and cold flow properties to determine performance improvements. Structural characterization using nuclear magnetic resonance (NMR) spectroscopy will further analyze molecular interactions and triglyceride integrity post-blending. Additionally, differential scanning calorimetry (DSC) will be used to study thermal behavior, particularly crystallization and melting transitions, which directly impact biodiesel's cold flow properties. By systematically evaluating these blends, the most effective formulation will be selected for metathesis modification, enhancing its functionality as a PPD. This study will provide critical insights into optimizing biodiesel performance, improving its low-temperature operability, and ensuring greater sustainability in fuel applications.

Activity Milestones:

Description	Approximate Completion Date
Optimization of WCO-Soybean Oil Blends (10-50% soybean oil) to enhance unsaturation of the mixture	September 30, 2027
Analyzing fatty acid composition, structural integrity and purity	September 30, 2027
Thermal, flow and other physical characterization of the WCO blends	September 30, 2027

Activity 4: Cross and Self-Metathesis Modification of WCO-Soybean Oil Blends for High-Performance Pour Point Depressants (PPDs)

Activity Budget: $150,000

Activity Description:
To achieve a highly effective pour point depressant (PPD), the chemistry of cross and self-metathesis of waste cooking oil (WCO) blended with soybean oil (SBO) will be systematically optimized. The self-metathesis reaction will be fine-tuned to maximize the formation of symmetrical and asymmetrical metathesized products, ensuring a balance of cis/trans isomers and a targeted molecular weight distribution that enhances cold flow properties. For cross-metathesis, different olefin co-reactants will be screened, including short-chain alkenes to disrupt long-chain fatty acid crystallization and create branched or modified lipid structures. The catalyst selection and reaction conditions (temperature, pressure, reaction time) will be optimized to achieve high metathesis efficiency while maintaining product stability and economic

feasibility. Grubbs catalysts will be evaluated for their selectivity and turnover efficiency, ensuring high yields of functionalized metathesized WCO-SBO derivatives. The modified PPD formulations will be tested for crystallization onset temperature (Ton), pour point (PP), and cold filter plugging point (CFPP) in biodiesel blends. This chemistry-driven approach will ensure a cost-effective, scalable, and high-performance PPD solution, enabling enhanced biodiesel operability in cold climates while promoting waste valorization and renewable energy advancements.

Activity Milestones:

Description	Approximate Completion Date
Optimize the self/cross-metathesis reaction parameters to maximize symmetrical and asymmetrical metathesized products CFI	June 30, 2028
Screening Olefin Co-Reactants for Cross-Metathesis modify fatty acid crystallization and enhance cold flow properties	June 30, 2028
Catalyst Selection and Reaction Optimization for efficiency, stability, and high-yield metathesis of WCO-SBO derivatives.	June 30, 2028
Physicochemical and Thermal Characterization of the different metathesized waste cooking oils (MWCO)	June 30, 2028
Compare and contrast the properties of the different MWCO to select few best for biodeseltrials	June 30, 2028

Activity 5: Performance optimization and validation of MWCO using commercial biodiesel

Activity Budget: $150,000

Activity Description:
This activity focuses on the systematic optimization and performance evaluation of metathesized waste cooking oil (MWCO)-derived cold flow improvers (CFIs) for biodiesel applications. MWCO undergoes self- and cross-metathesis to modify its fatty acid composition, breaking down long-chain saturated compounds and introducing branched structures that enhance fuel fluidity and reduce crystallization in cold conditions. To determine the most effective MWCO fraction, biodiesel formulations containing various MWCO-derived CFIs will be subjected to differential scanning calorimetry (DSC) and ASTM-standard cold flow tests, including cloud point (CP), crystallization onset temperature (Ton), pour point (PP), and cold filter plugging point (CFPP). The goal is to lower the crystallization temperature, prevent wax formation, and improve fuel flow performance in cold climates. The most effective MWCO-derived CFI will be integrated into commercial biodiesel production and validated through semi-pilot scale trials to ensure batch-to-batch consistency and economic feasibility. Advanced analytical techniques such as GC-MS, NMR, and FTIR will characterize the structural and functional properties of the optimized additive. By refining MWCO-based CFI formulations, this initiative aims to enhance biodiesel operability in cold weather, reduce dependency on petroleum-based additives, and support sustainable fuel innovations through waste valorization.

Activity Milestones:

Description	Approximate Completion Date
Optimization of MWCO Metathesis for Cold Flow Enhancement	December 31, 2028
Biodiesel Blending and Performance Testing: Incorporating MWCO-based PPDs into B100, B20, and B10 blends	December 31, 2028
Assessing crystallization behavior using DSC and measuring viscosity changes	December 31, 2028

Activity 6: Technoeconomic Evaluation of Processing Technology for Pour Point Depressant (PPD) Production

Activity Budget: $25,000

Activity Description:

The Agricultural Utilization Research Institute (AURI) will conduct a technoeconomic analysis to assess the cost-effectiveness and scalability of MWCO-derived pour point depressants (PPDs) for biodiesel applications. This study will evaluate processing efficiency, raw material sourcing, production costs, and market feasibility to ensure economic viability.

Activity Milestones:

Description	Approximate Completion Date
Develop scalability models and industry adoption strategies for biodiesel producers in Minnesota	March 31, 2029
Evaluate metathesis efficiency, raw material costs, and energy consumption to determine production feasibility.	June 30, 2029
Analyze capital and operational costs, supply chain logistics, and market competitiveness of MWCO-based PPDs	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Agricultural Utilization Research Institute	Non-profit Organization	AURI supports the techno-economic analysis (TEA) of MWCO-derived CFIs by evaluating cost-effectiveness, scalability, and market feasibility. Their expertise ensures a comprehensive assessment of production costs, commercialization potential, and competitive positioning, enabling the successful transition of MWCO-based cold flow improvers from pilot-scale validation to large-scale biodiesel industry adoption.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

The results will be implemented through collaborations with industry partners, policymakers, and researchers to integrate findings into renewable fuel formulations and cold flow improver (PPD) applications. Knowledge transfer will occur via publications, presentations, and outreach programs. Ongoing efforts will seek additional funding from federal and state grants (USDA, DOE, NSF), industry partnerships, and private investments. Post-project, findings will guide commercialization strategies for biodiesel additives, with further optimization supported through pilot-scale trials and technology transfer initiatives. If additional work is needed, future grants, research collaborations, and stakeholder investments will ensure continued development and sustainable implementation.

Project Manager and Organization Qualifications

Project Manager Name: Prasanth Kumar Sasidharan Pillai

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Prasanth K.S. Pillai is a newly appointed Assistant Professor at the Food Science and Nutrition Department, University of Minnesota, where he leads research in the bioconversion and upcycling of food and agricultural byproducts into functional and high-value food ingredients, materials, and sustainable chemicals. With a Ph.D. in Materials Science from Trent University and postdoctoral experience in lipid chemistry, plant protein utilization, and hydrocolloid chemistry at Trent University and the University of Saskatchewan, Dr. Pillai has developed deep expertise in understanding the molecular interactions of different materials and their impact on fine-tuning these materials for advanced applications. Dr. Pillai's career spans over a decade, including six years in the biotech and food industry with companies such as Louis Dreyfus Company, Noblegen Inc., and Mane Kancor. During this time, he spearheaded the development of novel extraction, modification, and microbial fermentation technologies that convert agricultural and industrial byproducts into functional food ingredients, sustainable polymers, and bio-based materials. His expertise in lipid modification and structuring has led to advancements in biodegradable polymers, material applications, and pour point depressants—critical for lubricant performance at low temperatures. Through strategic lipid engineering, he has developed innovative methods to enhance cold flow properties of bio-based lubricants, offering sustainable alternatives to petroleum-based additives. Dr. Pillai has authored several research articles, holds 20+ U.S. patents, and has developed multiple trade secrets shaping industry practices. At the University of Minnesota, his research focuses on bioconversion, upcycling, and sustainable material innovation, transforming food waste and agri-byproducts into value added materials. Committed to sustainability and the circular economy, he aims to reduce environmental impact while enhancing food safety, nutrition, and material performance.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

The College of Food, Agricultural and Natural Resource Sciences (CFANS) at the University of Minnesota is a leader in sustainable innovation, driving research and education in food, agriculture, and environmental sciences. CFANS is committed to advancing climate-smart agriculture, circular economy solutions, and regenerative land management to tackle global challenges in food security and sustainability. Researchers are pioneering alternative proteins, plant-based food innovations, and fermentation-derived ingredients to reduce reliance on traditional food systems. Through waste upcycling, CFANS transforms agricultural byproducts and food waste into high-value ingredients, biodegradable materials, and renewable energy sources. Efforts in soil health, precision agriculture, and water conservation ensure resilient farming practices that enhance productivity while minimizing environmental impact. The development of climate-resilient crops and sustainable livestock systems supports biodiversity and strengthens food supply chains. By integrating cutting-edge science, industry partnerships, and community outreach, CFANS fosters real-world solutions that promote a greener, more sustainable future while shaping the next generation of scientists and industry leaders.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Assistant Professor (Principal Investigator)		Lead the project and completion of deliverables			26%	0.15		$24,883
Co-Principal Investigator		Characterization of WCO and MWCO samples			26%	0.1		$17,161
Assistant Professor (Co-Principal Investigator)		Leading the application study of MWCO with biodiesel			26%	0.05		$8,701
Postdoctoral Associate		MWCO development			21%	1.3		$104,924
Postdoctoral Associate		Characterization or WCO and MWCO			21%	0.8		$64,569
Postdoctoral Associate		Blending of MWCO with Biodiesel and the impact study			21%	0.5		$41,571
Graduate Student		Development of MWCO, Characterization and implementation in biodiesel			19%	3		$164,517
AURI (Third Party Non-Profitable Organization)		Technoeconomic evaluation			0%	1		$25,000
							Sub Total	**$451,326**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supples	For experiments related to characterization of WCO, development of WCO and for biodiesel trial					$38,674

	Tools and Supplies	Lab and medical service	Third party characterization for the biodiesel studies and other structural characterization					$10,000
							Sub Total	**$48,674**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$500,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $500,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 53a3a4b2-0e3.pdf

Alternate Text for Visual Component

Preliminary results of metathesized Soyabean Oil PPD: The LCCMR.pdf presentation investigates crystallization additives' effects on fatty acid methyl esters (biodiesel). At -5°C, biodiesel forms a monoclinic structure, shifting to orthorhombic and triclinic at -20°C. This study aids in optimizing biodiesel formulations for improved low-temperature stability and performance....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Endorsement Letter from University of Minnesota	b9bbcc3a-73b.pdf
LDC Support Letter	90ef56e6-0b9.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,

treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Not Applicable

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A