Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-206

Proposal Title: Graphene Oxide Nanofiltration Membranes for Water Remediation

Project Manager Information

Name: Traian Dumitrica

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Graphene-based membranes for removing inorganic and organic contaminants, including PFAS, from water will be developed through nanofiltration molecular-level modeling and experimental advancements in membrane processing and testing.

ENRTF Funds Requested: $838,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Water (B)

Project Location

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

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.

Contamination of run-off water, groundwater, and lakes by salts and per- and polyfluoroalkyl substances (PFAS) is a widespread problem in many regions of Minnesota. The salts include high nitrate and phosphate levels from agriculture and failing septic systems, chloride from de-icing salt and water softeners, as well as sulfate and metal ions from mine tailings. The PFAS contamination is primarily due to industrial discharge.

Commercial cleanup methods are energy intensive and have high capital costs. In water treatment plants, heavy metals and salts are removed by membrane filtration. Reverse osmosis is currently the most energy-efficient desalination technique. It utilizes polymeric membrane filters with relatively low permeability, which restricts the volume of contaminated water that can be treated within a given timeframe. Better membranes are needed to improve flux and rejection of ionic compounds and PFAS. Recently, it was demonstrated that graphene or graphene oxide-based membranes can provide 4–10 times higher water flux than most commercial nanofiltration membranes with high retention of organic dyes and moderate retention of ions from salts and PFAS, though with limited mechanical stability. Optimization is needed to improve their robustness and control interactions between the membrane and specific contaminants for better selectivity before greater commercialization.

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.

We propose to conduct fundamental and applied research to develop graphene or graphene oxide (GO)-based membranes for more efficient water purification, facilitating their commercialization and integration into water treatment plants across Minnesota. Guided by molecular modeling, the experimental research will address the following objectives:

- improve robustness of GO-based membranes by interconnecting GO sheets via gamma irradiation or chemical coupling
- enhance water flux by tuning water permeability through modification of GO sheet surfaces
- improve contaminant rejection by tuning pore structure, surface interactions, and interlayer spacings
- evaluate effectiveness of removing anions relevant to agricultural and mining contaminants (phosphate, nitrate, sulfate) and PFAS (PFOA - an 8-carbon-chain PFAS found in water)

We will build on our prior experience with GO for polymer composites (Stein), membrane separations (Li), and modeling (Dumitrica).

Preparation of GO-based membranes is scalable, given that amounts as small as 34 milligrams of graphene derivative suffice to make a square meter of nanofiltration membrane with a thickness of ~50 nm. One of the major novel approaches in our research is to employ gamma irradiation to improve mechanical properties and porosity. This technique is widely used for sterilization of food, pharmaceuticals and medical equipment and is easily adapted to the membranes.

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?

This project develops graphene-based membranes for efficient water purification, targeting salt and PFAS contaminants in Minnesota's water. By enhancing filtration performance and durability, these membranes provide a sustainable, energy-efficient alternative to conventional filters. The research addresses runoff and contaminant impacts on surface and groundwater, offering a scalable solution for long-term protection. It also creates educational opportunities for students and researchers in water remediation technologies. Potential implementation in treatment plants will support conservation efforts, safeguarding public health and promoting environmental stewardship, aligning with Minnesota's commitment to clean water for communities and future generations.

Activities and Milestones

Activity 1: Membrane Fabrication

Activity Budget: $248,500

Activity Description:

1a. Simple graphene oxide (GO) membranes: GO will be prepared in-house from graphite by the Hummer's method. It may be chemically treated by base washing or converted to reduced GO to modify surface interactions. Membranes will be prepared in freestanding form or on porous supports.
1b. Methods of controlling layer spacing between GO sheets and water transport will be investigated. This includes intercalating layers with ions of different sizes or with nanoparticles to produce pillared structures (e.g., GO/TiO2).
1c. GO membranes will be treated by gamma-irradiation to control porosity and cross-linking of the GO. Porosity may be tuned through the dosage of the gamma-ray flux. The advantage of this method over alternative methods is that it can be done in the bulk; it is currently done on large scales for medical equipment, food, pharmaceuticals, etc.
1d. Surfaces of the membranes will be functionalized to interconnect the sheets (as an alternative and for comparison to gamma-irradiation) and to alter interactions with different contaminants to tune water permeation and rejection rates of salts (nitrates, phosphates, sulfates, chlorides) or PFOA.

Activity Milestones:

Description	Approximate Completion Date
Fabricate Non-functionalized membranes.	December 31, 2026
Gamma-irradiated membranes.	June 30, 2027
Ion-exchanged membranes.	December 31, 2027
Functionalized membranes.	June 30, 2028
Optimized Membranes for Salt and PFAS separation from water.	June 30, 2029

Activity 2: Modelling of transport through membranes

Activity Budget: $249,000

Activity Description:

Molecular dynamics (MD) allows for the observation of the impact of hydrogen bonding, electrostatic, and van der Waals forces that influence water and solute movement.
2a. For single-layer GO, MD will determine the optimal nanopore diameter for rejecting specific contaminants (salts or PFOA), where even sub-nanometer variations can significantly affect the ability to allow their passage. We will examine the collective effects of salt ions on the rejection performance.
2b. MD can help identify the most effective surface functionalization strategies, allowing for computational testing of modifications with hydroxyl, carboxyl, or amine groups to improve hydrophilicity and selectivity.
2c. For multilayer GO, MD will trace the movement of water molecules, providing a detailed understanding of how water permeates the material. This includes identifying the primary pathway, whether water passes through individual pores, through interlayer spaces, or along defect sites. Simulations will also give information about the mechanical resilience.
2d. The interlayer distance is crucial because it defines channels available for water and solute transport. MD will predict how changes in the interlayer distance affect water permeability, as well as the ion or contaminant rejection. Thus. MD will provide insights into the optimal spacing needed for efficient water permeation while blocking undesirable

Activity Milestones:

Description	Approximate Completion Date
Understanding Water and Solute Transport.	June 30, 2027

Impact of Irradiation (porosity & cross-linking).	December 31, 2027
Tunning Interlayer Spacing.	June 30, 2028
Modeling Surface Functionalization	December 31, 2028
Modeling Optimized Membranes for Salt and PFAS separation.	June 30, 2029

Activity 3: Membrane characterization

Activity Budget: $100,000

Activity Description:

3a. Structural and compositional characterization using electron microscopy (TEM, SEM) and surface probe microscopy (AFM) to determine the membrane structure; Raman spectroscopy, bulk chemical analysis, and surface chemical analysis (XPS, EDS) to determine the membrane composition; and gas sorption analysis to determine membrane porosity.

Activity Milestones:

Description	Approximate Completion Date
3a. Membrane characterization: Years 1–3 (ongoing and parallel with membrane preparation).	June 30, 2029

Activity 4: Membrane testing

Activity Budget: $240,500

Activity Description:

We will build an in-house membrane filtration test bench to evaluate the performance of the membranes fabricated in the aforementioned activities. We will conduct membrane flux and contaminant rejection tests on our membranes. The contaminants include the salts and PFOA as introduced in Activity 1. The concentrations of feed, permeate, and retentate solutions will be measured. The concentration of salts will be measured by a conductivity meter, while a UV-vis spectrometer will measure the concentration of PFOA. The performance of the membrane will be quantified by the rejection (R) property, defined as $R=(1-C_p/C_r)\times100\%$, where C_p and C_r are the concentrations of contaminants in the permeate and retentate solutions, respectively. We will also conduct mechanical testing on our membranes, including tensile testing and dynamic mechanical analysis (DMA).

In addition, we are aware that the Environmental Laboratory at the Minnesota Department of Health (MDH) Public Health Laboratory provides PFAS analysis services for water samples. We plan to use that as a third-party service.

Activity Milestones:

Description	Approximate Completion Date
4a Building membrane flux test bench for membrane permeation.	March 31, 2027
4b Mechanical testing of the membranes fabricated in Activity 1.	January 31, 2029
4c Flux and rejection testing of membranes fabricated in Activity 1.	June 30, 2029
4d Third-party tests for PFAS at the MDH Public Health Laboratory.	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jun Li	University of Minnesota	co-PI. Prof. Li will lead the membrane testing activity and co-lead the membrane characterization activity. His research focuses on polymer and surface sciences for anti-icing and carbon capture applications. At UMN, he studies membrane materials for carbon capture.	Yes
Andreas Stein	University of Minnesota	co-PI. Professor Stein's expertise includes zeolite and MOF syntheses, zeolite membranes, and functionalization of delaminated clay or graphene oxide materials for polymer nanocomposite fabrication with improved structural and barrier properties. He will lead the membrane fabrication activity and the membrane characterization activity.	Yes
Shane Olund	Environmental Laboratory Section, Public Health Laboratory Minnesota Department of Health	Collaborator. Mr. Olund supervises the Emerging Contaminants Unit of the Environmental Laboratory Section and oversees the analysis of PFAS compounds in aqueous matrices and fish tissues. The laboratory is ISO 17025 accredited for the analysis of PFAS in drinking water by EPA 533 as well as PFAS in non-potable waters.	No
QingHui Yuan	Donaldson Corporation	Donaldson will collaborate with us as an industrial partner, providing valuable industry insights throughout the project and a strategic perspective on commercializing our research findings.	No

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 of this project will be implemented through collaboration with water treatment facilities, regulatory agencies, and industry partners (Donaldson Company) to integrate our graphene-based membranes into existing purification systems. Testing will be conducted to validate performance under real-world conditions at those municipal and industrial water treatment plants. If further refinements or testing are needed, partnerships with Minnesota-based water utilities and research institutions will provide continued support. Findings will be shared through technical reports, academic publications, and stakeholder workshops to promote knowledge transfer and commercialization opportunities.

Project Manager and Organization Qualifications

Project Manager Name: Traian Dumitrica

Job Title: Professor

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

Dumitrică earned a PhD in Chemical Physics and brings a distinctive blend of technical expertise, leadership, and strategic insight. A professor at the University of Minnesota since 2005, he has built a strong research portfolio in computational materials science and nanotechnology, with a particular focus on carbon-based materials such as graphene, carbon nanotubes, and fullerenes. With over 100 peer-reviewed publications, Dumitrică has made significant contributions to understanding the mechanical and electronic properties of nanostructures. His work has been supported by major funding agencies, reflecting his success in securing competitive grants and leading high-impact projects. Beyond research, Dumitrică is committed to mentoring students and postdoctoral scholars, fostering the next generation of scientists. He collaborates with industry and interdisciplinary teams to translate fundamental discoveries into real-world applications. His expertise in advanced carbon materials has broad implications.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota is the main research and graduate teaching institution in the state of Minnesota. The Department of Mechanical Engineering is building on the past, responding to the present, and leading the way to the future by driving innovative research with significant real-world impact through our five impact areas: Environment & Sustainability, Energy Transition, Human Health, Next-Gen Manufacturing, and Robotics & Mobility. For Environment & Sustainability, from the atmosphere to ground water and everything in between, mechanical engineering is essential in the advancement of environment and sustainability studies. Researchers in the Department of Mechanical Engineering work on air and water pollution, seawater desalination, engine efficiency, alternative fuels, biodegradables, and more to combat climate change and work toward a greener future.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Traian Dumitrica		PI			26.79%	0.15		$46,339
Jun Li		co-PI			26.79%	0.15		$38,770
Andreas Stein		co-PI			26.79%	0.15		$58,533
ME Research Assistants		Research Assistants			43.02%	3		$373,460
Chem Research Assistants		Research Assistant			42.93%	1.5		$187,403
							Sub Total	**$704,505**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Equipment	Millipore Amicon 8050 stirred cell.Quantity:1	Build-up of membrane filtration test bench					$1,750
	Equipment	Omega PX series absolute pressure transducer. Quantity: 2.	uild-up of membrane filtration test bench					$3,470
	Equipment	Fisherbrand feed solution pump. Quantity: 1.	Build-up of membrane filtration test bench					$2,500
	Equipment	Swagelok Diaphragm Valves. Quantity: 1.	Build-up of membrane filtration test bench					$600
	Equipment	Thermo Scientific Accumet Excel XL30 conductivity meter. Quantity: 1.	Measure salt concentration					$2,850
	Equipment	NI cDAQ-9178 Chassis. Quantity: 1.	Build-up of membrane filtration test bench					$2,100
	Equipment	NI C Series, NI-9252 Voltage Input Module. Quantity: 2.	Build-up of membrane filtration test bench					$3,400
	Equipment	NI C Series, NI-9212 Temperature Input Module. Quantity: 1.	Build-up of membrane filtration test bench					$1,800

	Tools and Supplies	Chemicals and general laboratory supplies and consumables. Quantity: N/A	GO membrane fabrication					$20,495
	Equipment	HP Computers: Quantity 3.	Dedicated system for MD simulations					$2,000
	Equipment	Vacuum rotary pump. Quantity 1.	Pump for the filtration process.					$4,530
							Sub Total	**$45,495**
Capital Expenditures								
		Micro Motion ELITE mass flow meter. Quantity: 1.	Build-up of membrane filtration test bench	X				$8,100
		Micro Motion ELITE transmitter. Quantity: 1.	Build-up of membrane filtration test bench	X				$8,900
		UV-vis spectrophotometer. Quantity: 1	Measuring PFOA concentration	X				$8,000
							Sub Total	**$25,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	1 trip/year travel to conference (3 people). 1 trip/year travel to gamma-ray facility (1 student)	Present research results at profession conferences and execute the gamma-ray irradiation component of the proposal.	X				$18,000
							Sub Total	**$18,000**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Scientific Services. Quantity: N/A	Characterization of materials synthesized in this project at the UMN					$45,000

			Characterization Facility; UMN Polymer Characterization and Processing Facility; Gamma-ray irradiation.					
							Sub Total	**$45,000**
							Grand Total	**$838,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Micro Motion ELITE mass flow meter. Quantity: 1.	This is a critical equiment for carying out the flow measuerment. **Additional Explanation :** The equipment will be preserved and actively used to support the ongoing expansion of the current program.
Capital Expenditures		Micro Motion ELITE transmitter. Quantity: 1.	The test bench is critical for setting up the experimental testing. **Additional Explanation :** The equipment will be preserved and actively used to support the ongoing expansion of the current program.
Capital Expenditures		UV-vis spectrophotometer. Quantity: 1	This is a critical equiment for carying out the contaminat measuerment. **Additional Explanation :** The equipment will be preserved and actively used to support the ongoing expansion of the current program.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	1 trip/year travel to conference (3 people). 1 trip/year travel to gamma-ray facility (1 student)	Travel outside Minnesota (within USA) is needed to perform irradiation experiments. The main scientific conferences (such as the Materials Research Society Conference) for presenting our results are also located outside Minnesota.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A calculated at 54% MTDC	Support of ME facilities where research will be conducted.	Secured	$348,877
			Non State Sub Total	**$348,877**
			Funds Total	**$348,877**

Total Project Cost: $1,186,877

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7b02ece6-a83.pdf

Alternate Text for Visual Component

The visual describes the concept of the proposal and the work proposed to fabricate optimized membranes for water remediation....

Supplemental Attachments

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

Title	File
Letter from University of Minnesota	314ad0f3-c81.pdf
Area impacted by the proposal	eb5ed1c4-5f0.pdf
Letter of Collaboration with MDH	73bae276-f86.pdf
Letter of Support from Donaldson Corporation	0fe1f96a-85b.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?

Yes, I understand the UMN Policy on travel applies.

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:

Victoria Troxler, Sponsored Projects Administration, University of Minnesota

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