Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-276

Proposal Title: A Cheap Portable Sensor for PFAS Detection

Project Manager Information

Name: Tianhong Cui

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: We propose to develop a cheap, accurate, and easy-to-use sensor for detection of PFAS in water. It can be used for natural water monitoring and drinking water detection of PFAS.

ENRTF Funds Requested: $250,000

Proposed Project Completion: June 30, 2027

LCCMR Funding Category: Small Projects (H)

Secondary Category: Water Resources (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?

During the Project and In the Future

Narrative

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

The proposal addresses the critical need for cheap and portable detectors to evaluate per- and polyfluoroalkyl substances (PFAS) in water bodies, including natural sources and drinking supplies. PFAS, commonly found in industrial and consumer products for their water- and oil-repellent properties, persist in the environment and pose health risks to humans, affecting growth, reproduction, thyroid function, immune system, and liver health. Current PFAS detection methods are costly and time-consuming, limiting accessibility in resource-constrained settings or for on-site monitoring. Portable sensors offer a promising solution, providing rapid on-site detection at low cost. This proposal emphasizes the importance of detecting PFAS contamination in natural water bodies to assess environmental impacts and guide remediation efforts. Ensuring the safety of drinking water supplies is crucial for public health, necessitating efficient detection methods to promptly identify PFAS contamination. By developing a low-cost, portable sensor for PFAS detection, this proposal aims to bridge the gap in current detection capabilities, enabling more widespread and timely assessments of PFAS contamination in both natural water sources and drinking systems. This innovation has the potential to enhance environmental stewardship and safeguard public health by facilitating early detection and mitigation of PFAS pollution.

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 to the aforementioned challenge involves the utilization of graphene field-effect transistor (FET) sensors to detect PFAS in water. Graphene is a monolayer of carbon atoms. To achieve selective detection of PFAS, the molecularly imprinted polymers (MIPs) will be applied to modify the sensors. The ion concentration polarization technique will be introduced to enrich the PFAS, considering the extremely low concentrations of PFAS in water. Three parts will be integrated into a testing kit capable of rapid and accurate detection of PFAS. We emphasize the importance of field tests to validate the effectiveness and reliability of the sensor in real-world environments. Following successful field tests, our next steps involve scale-up production to ensure widespread availability of the sensor and collaboration with regulatory agencies and environmental organizations to incorporate it into their detection protocols. Furthermore, ongoing research will focus on optimizing the sensor's sensitivity, selectivity, and durability to meet evolving needs in PFAS detection and environmental monitoring. Overall, the requested funding will support the development, characterization, and deployment of this new sensor technology, offering a cost-effective and portable solution to address the critical issue of PFAS contamination in water bodies and safeguard public health and environmental quality.

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 outcomes contribute to protecting, conserving, preserving, and enhancing the state's natural resources by improving detection capabilities for PFAS in water. Through the development of cheap, sensitive, accurate and easy-to-use PFAS testing kits, this project enables quick and accurate detection of PFAS contamination. This enhances the state's capability to detect and mitigate pollution in Minnesota water bodies, promoting environmental stewardship. Additionally, the accessibility of low-cost, portable sensors empowers communities to actively engage in monitoring efforts, while timely identification of PFAS pollution safeguards public health and ensures the preservation of safe drinking water resources for communities.

Activities and Milestones

Activity 1: Design, fabrication, and characterization of a cheap, accurate, and easy-to-use sensor for detection of PFAS in water at laboratory

Activity Budget: $122,199

Activity Description:
This activity encompasses a multifaceted approach to the development of an innovative sensor tailored for detecting PFAS in water. The proposed sensor incorporates three main features: (1) Molecularly imprinted polymers (MIPs) for selective detection of different types of PFAS. By imprinting specific molecular structures into the polymer matrix, the sensor can differentiate different PFAS compounds with high precision and accuracy; (2) Ion concentration polarization will be employed to enrich PFAS in water samples, thereby amplifying sensor sensitivity and enabling the detection of ultra-low concentrations that are characteristic of PFAS contamination. This technique enhances the sensor's performance, ensuring reliable detection even in challenging environmental conditions.; (3) All sensor components will be seamlessly integrated into a microfluidic system, streamlining the detection process and facilitating user-friendly operation. This "sample in and answer out" design will enable non-specialist users to perform PFAS detection with ease, making the sensor accessible for widespread use in diverse settings. This laboratory-based testing phase will rigorously assess the sensor performance across a range of PFAS concentrations and water matrices, ensuring its accuracy, reliability, and practicality for real-world applications. Specifically, different PFAS will be tested to validate the efficacy of MIPs for accurately detecting and distinguishing between various PFAS compounds.

Activity Milestones:

Description	Approximate Completion Date
Design, synthesis, and assessment of the molecularly printed polymers for detection of different PFAS	December 31, 2025
Design, fabrication, and testing of portable PFAS sensors with coating of molecularly imprinted polymers	June 30, 2026
Characterization, evaluation, improvement, and optimization of the portable PFAS sensors in laboratory	June 30, 2026

Activity 2: Field tests, improvement, and optimization of the portable PFAS sensor in real-word environments in Minnesota lakes and rivers

Activity Budget: $127,801

Activity Description:
This critical phase involves deploying the PFAS sensor into real-world environments, such as Minnesota's rivers, lakes, and drinking water sources, for comprehensive field tests. These tests are essential for validating the sensor performance under authentic conditions, assessing its accuracy, reliability, and sensitivity in detecting PFAS contamination across diverse water compositions and potential interferences. Iterative optimization will be driven by feedback gathered from end users, environmental experts, and regulatory agencies during field tests. This feedback loop aims to enhance the sensor performance with existing monitoring practice. Insights from end users regarding ease of operation and maintenance will inform adjustments to the sensor design and functionality. In addition, stakeholder engagement plays a pivotal role in this activity. Collaboration with environmental agencies, regulatory bodies, and local communities through workshops, seminars, and participatory forums will facilitate our knowledge exchange. This collaborative approach empowers stakeholders to contribute to refining the sensor performance, ensuring alignment with regulatory standards and community needs. By combining real-world field tests, iterative optimization, and stakeholder engagement, this activity aims to validate the effectiveness of the PFAS sensor as a robust and practical tool

for environmental monitoring, contributing significantly to the protection and preservation of water resources and public health.

Activity Milestones:

Description	Approximate Completion Date
Field tests of the PFAS sensor in real-world environments including lakes and rivers in Minnesota	December 31, 2026
Iterative optimization of the sensor design and fabrication for field tests in Minnesota waters	December 31, 2026
Data analysis and system evaluation of the PFAS sensors with stakeholders in Minnesota real-word waters	June 30, 2027

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?

As the product of this project, testing kits for PFAS detection in water will be developed. Patents based on the developed prototypes will be applied for commercialization. The University of Minnesota and Cui are partners on a large Regional Innovation Engine funded by the National Science Foundation, initially for 2 years at $15M, with the potential for additional investments of up to $145M total over 8 subsequent years. This Innovation Engine focuses on water technology, sensing, and data science applications in water. This effort will be leveraged across work at UMN and in Cui's laboratory on water technology.

Project Manager and Organization Qualifications

Project Manager Name: Tianhong Cui

Job Title: Professor

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

Dr. Tianhong Cui is a Distinguished McKnight University Professor at the University of Minnesota. He is a Professor in Department of Mechanical Engineering and an Affiliate Senior Member of the graduate faculty in Department of Electrical and Computer Engineering. He joined the faculty of the University of Minnesota in 2003. He is a Fellow of the American Society of Mechanical Engineering. He is also a member of European Academy of Sciences and Arts. Dr. Cui is an international leading expert on micro sensors and advanced manufacturing. He has 380 archived publications in scientific journals and prestigious conferences and 10 US patents. He is the founding Executive Editor-in-Chief for a Nature journal, Microsystems & Nanoengineering. He has received awards including the STA & NEDO Fellowships in Japan, the Alexander von Humboldt Fellowship in Germany, the Richard & Barbara Endowed Chair and the Distinguished McKnight University Professorship from the University of Minnesota, the Blaise Pascal Chair Visiting Professorship in France (named after famous French scientist Blaise Pascal), the Distinguished Visiting Fellowship from the Royal Academy of Engineering and the Global Chair at the University of Bath in UK, a recent JSPS faculty fellowship at the University of Tokyo, and numerous best paper awards. Most recently Dr. Cui has received two NSF grants on micro chemical sensors for detection of water pollutants.

Dr. Cui will serve as the PI and project manager, responsible for overseeing the project, all reports, and deliverables. He will supervise one postdoc to work on design, fabrication, and characterization of the proposed sensors for detection of PFAS in water. He will hold weekly meetings and daily technical discussions with his advisee to ensure good progress of this proposed work. Dr. Cui and his postdoc will also be responsible for field tests and assessment of the proposed PFAS sensor.

Organization: U of MN - College of Science and Engineering

Organization Description:

All programs in the College of Science and Engineering at the University of Minnesota were ranked in the top 25 in the nation by U.S. News. The Department of Mechanical Engineering at the University of Minnesota is one of the foremost programs in the United States, serving the state and nation as a leading center of education, research, and innovation.

This work will be performed at the University of Minnesota in the Technology Integration & Advanced Nano/Microsystems Laboratory (TIAN Lab), located in the Mechanical Engineering Building. Professor Cui is the director of TIAN Lab equipped with the state-of-the-art instrument and facility to conduct the proposed research, with a variety of fabrication and characterization equipment and tools, sufficient for Professor Cui and his postdoc to design, fabricate,

characterize, and analyze the proposed sensors to detect PFAS in water. Some fabrication work will be done in Minnesota Nano Center, a state-of-the-art facility for research in nanoscience and applied nanotechnology. Minnesota Nano Center well maintains these systems, keeps safe operating procedures, and trains students. State support, support from NSF through NNCI, and industry usage allows the Center to offer academic rates, normally less than half of the actual cost of operation.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Tianhong Cui		Principal Investigator, Responsible for all activities of this project			27.06%	0.24		$58,026
Post Doctoral Associate		Post Doctoral Associate, Responsible for design, fabrication, and testing of the PFAS sensor			21.32%	2		$167,708
							Sub Total	**$225,734**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Silicon wafers, polymer substrates, graphene, chemicals, and components for testing set-up	Materials and supplies for various items required to fabricate and characterize the PFAS sensor					$11,266
							Sub Total	**$11,266**
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								
		Scientific Servicescientific services at the University of Minnesota's Minnesota Nano Center and Characterization facility	Fabrication and characterization costs of the PFAS sensors in central facilities					$13,000
							Sub Total	**$13,000**
							Grand Total	**$250,000**

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				
In-Kind	unrecovered F&A calculated at 55% MTDC	Support of ME facilities where research will be conducted.	Secured	$137,500
			Non State Sub Total	**$137,500**
			Funds Total	**$137,500**

Total Project Cost: $387,500

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7161a3fe-38f.pdf

Alternate Text for Visual Component

Comparision of the current and proposed technologies...

Supplemental Attachments

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

Title	File
University Supporting Letter	ad0f756a-c49.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes

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

Yes

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

No

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:

Alexandra Sullivan <sull1129@umn.edu>