NATIONAL SCIENCE FOUNDATION
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NSF 22-111

Dear Colleague Letter: Critical Aspects of Sustainability (CAS): Innovative Solutions to Sustainable Chemistry (CAS-SC)

July 28, 2022

Dear Colleagues:

With this Dear Colleague Letter (DCL), the National Science Foundation (NSF) announces the establishment of the Critical Aspects of Sustainability (CAS): Innovative Solutions to Sustainable Chemistry Program (CAS-SC), under the CAS metaprogram umbrella.[1] The CAS-SC Program recognizes the importance of sustainable chemistry in addressing many societal challenges and aims to encourage the expansion of the Nation's research capacity in this topic area through submissions of research proposals. Proposals that emphasize a detailed and quantitative understanding of sustainable chemistry and include industrial partnerships are of particular interest.

The practice of sustainability, which conscientiously exploits resource and technology development in harmony to meet human needs and aspirations, benefits society in numerous ways. Meeting growing global demands for the use of sustainable chemistry in consumer and commercial products will create significant value and an economic opportunity for U.S. manufacturing. Reducing waste and maximizing the use of resources benefit the environment and contribute to mitigating climate change. NSF also provides opportunities aimed to increase the impact of discoveries through partnerships, to develop sustainable chemistry technologies into prototypes or proof of concept designs, and to learn how to develop and implement a technology development roadmap and create a business model.

NSF defines "sustainable chemistry" as efforts that seek to improve the efficiency with which resources are used to meet human needs for chemical products and materials while reducing use of hazardous substances and the generation of waste. This effort to minimize, reduce, and recycle includes the design of sustainable chemicals as well as sustainable materials, engineering process optimization, resource management (e.g., elimination or reduction of scarce and depletable resources such as rare earth elements, developing responsible, bio-based alternatives), and environmental remediation. Sustainable chemistry also addresses

the design and discovery of safe products, while promoting safe process technology that reduces or eliminates the use and generation of hazardous substances.

Advancements in fundamental research, including computational, data science, and experimental approaches, will be made to support innovative ideas related to sustainable chemistry. This includes improvements in understanding of underlying chemical and physical processes; enhancements in efficiencies of chemical reactions, separation science, and manufacturing processes at scale; upcycling and recycling of materials and chemicals, especially as related to circular technologies; as well as by developing alternative biotechnological routes, predictive synthesis methods, and alternatives for critical minerals or materials in emerging technologies, while minimizing waste products throughout the product lifecycle.

Solutions to sustainable chemistry challenges require foundational, use-inspired, and translational research, as well as creative interdisciplinary approaches. NSF strongly encourages partnerships between academic investigators and industrial experts as well as with state, local, and tribal governments to focus efforts and resources on questions relevant to innovation and current societal needs. While direct funding for industrial partners is not being offered through this DCL, industrial partners may participate in projects through established Grant Opportunities for Academic Liaison with Industry (GOALI), Industry-University Cooperative Research Centers (IUCRC), and Non-Academic Research Internships for Graduate Students (INTERN), and Partnerships for Innovation (PFI) mechanisms, other forms of collaboration, consultation/mentoring, communication, or workshops.

Training the future workforce in the principles of sustainable chemistry is another important aspect for promoting sustainable chemistry advances. Investigators are strongly encouraged to engage students at all levels in research and to develop public outreach activities that promote the benefits of sustainable chemistry. NSF welcomes proposals that include efforts to broaden participation of underrepresented groups in science, technology, engineering, and mathematics (STEM) (e.g., women, minorities, and persons with disabilities) in the development of the research agendas. Proposals from minority-serving institutions are encouraged.

Proposals in response to this DCL should be submitted to existing programs in the participating NSF divisions, adhering to the respective submission deadlines and requirements. After any solicitation or *PAPPG* specific requirements, titles should include the prefix "CAS-SC: ". **CAS-SC proposals are expected to contain a compelling, detailed, and quantitatively-supported description of how the proposed research would address sustainable chemistry**.

Suitable topics include, but are not limited to:

Chemical and Physical Building Blocks, Reactivity, and Fate

- Enhancing the efficiencies of chemical reactions, separation science, and manufacturing processes at scale
- Understanding the impact of photon, radical, and charged particle-based mechanism on chemical reactivity and kinetics
- Developing sustainable biomass-based products with enhanced and useful functionalities
- Developing products designed for reuse at end-of-life
- Understanding the environmental fate of chemicals and materials including their degradation products, and especially those that might lead to contaminants of emerging concern
- Developing enhanced methods for recycling and upcycling of chemicals and materials, especially as related to circular technologies

Sustainable Products from Alternative Processes

- Using renewable energy more efficiently to drive chemical processes
- Using electron-driven chemistry for more efficient chemical processing and synthesis
- Developing carbon-neutral or carbon-negative processes
- Developing or interfacing with alternative biotechnological routes
- Developing alternative methods for energy efficient decontamination of polluted water
- Developing alternatives for critical, strategic minerals/materials
- Developing alternative routes to sustainable polymers and elimination of plastics waste
- Developing processes with sustainable replacements or substantial reduction of rare, expensive, and/or toxic chemicals, materials, and catalysts with earth-abundant, inexpensive, and benign equivalents
- Developing more sustainable synthetic methods and processes to prepare known chemicals and materials
- Developing inherently more sustainable synthetic methods and processes to replace current functional materials with more sustainable new ones (e.g. rare earth-free compounds, or low-CO2 cement)

Advances in Measurements and Modeling

- Using predictive modeling/synthesis that leads to transformative, sustainable solutions including those that involve machine learning (ML) or artificial intelligence (AI)
- Developing mathematical/computational and experimental approaches to predict and assess the properties of novel and more sustainable catalysts, chemicals, and materials
- Designing and developing experimental probes and simulation/data analysis tools capable of characterizing chemical reactions and enabling technologies (e.g., catalysts, separation media, etc.) under realistic process conditions
- Developing novel diagnostics, databases, and models of atomic, molecular, and plasma

processes for sustainable chemistry
- Developing new chemical imaging and measurement tools for detecting and quantifying trace species to understand their environmental impacts
- Developing low-energy separation and purification approaches for chemical mixtures
- Developing new approaches for understanding how chemical reactivity differs at various time scales throughout the lifecycle of a material

Industrial, Manufacturing, and Agricultural Advances

- Enabling electrification or other forms of renewable energy in chemical manufacturing (synthesis, purification)
- Developing new procedures and processes for fine chemical (pharmaceuticals, crop protection chemicals, and other small-scale chemicals) manufacturing with improved atom economy, reduced waste, byproduct recovery and use, earth-abundant metal-based catalysts, safer solvents, and greater energy efficiency
- Developing energy- and mass- efficient routes to commodity chemicals from renewable raw materials that do not rely on fossil carbon (coal, petroleum, natural gas)
- Developing raw materials and processes that minimize the production or enhance remediation of plastic waste and/or greenhouse gases
- Developing energy-efficient processes for recovering or recycling critical minerals/materials from waste
- Developing processes for upcycling waste and end-of-life products
- Developing processes that enable modularization of formulations
- Developing alternative approaches to the application and/or production of fertilizers in agriculture

Prior to submission of a full proposal, potential research teams are required to submit a concept outline identifying the appropriate participating division (see the list below) where the primary research lies using the Program Suitability and Proposal Concept Tool (ProSPCT) webform at https://suitability.nsf.gov/s/. The webform requests a project title, list of team members, including any unfunded industrial partner(s) when appropriate, a summary of the project concept (up to 6000 characters), and a short description on how the proposed research would address sustainable chemistry as defined in this DCL. To ensure proper processing, the submitter should select "Other Proposal" from the Select Proposal Type dropdown and enter "CAS-SC" as the Other Proposal Name if none of the listed proposal types apply to your idea. Then, be sure to identify the relevant participating NSF division (see list below) as the Target Unit and enter "CAS-SC" in the Program/Funding Opportunity field. To get started, users are required to provide their Login.gov credentials to complete and submit the form. The prospective PIs will receive an email from the cognizant NSF Program Officer that specifies whether a full proposal may be submitted. A copy of the confirmation email from the targeted division must be uploaded into the Other Supplementary Documents

section of the full proposal submitted to NSF.

Participating divisions and programs with the NSF include the Divisions of Chemistry (CHE), Materials Research (DMR), Mathematical Sciences (DMS), and Physics (PHY) in the Directorate for Mathematical and Physical Sciences (MPS); Divisions of Chemical Bioengineering, Environmental, and Transport Systems (CBET) and Civil, Mechanical, and Manufacturing Innovation (CMMI) in the Directorate for Engineering (ENG); and the Partnerships for Innovation program within the Division of Translational Impacts (TI) in the Directorate for Technology, Innovation and Partnerships (TIP).

Sincerely,

Sean L. Jones, Assistant Director
MPS

Susan S. Margulies, Assistant Director
ENG

Erwin Gianchandani, Assistant Director
TIP

REFERENCES

[1]: This DCL is to establish the Sustainable Chemistry Basic Research program authorized under section 509 of the America COMPETES Reauthorization Act of 2010 (Public Law 111-358). NSF is working with the Sustainable Chemistry Strategy Team (SCST) to coordinate the interagency efforts on sustainable chemistry through its SCST representatives, SCST is an entity established under the provisions in subtitle E of title II of Public Law 116-283 by Office of Science and Technology Policy (OSTP) to coordinate Federal programs and activities in support of sustainable chemistry.