



## 2021 ACS GCI Oilfield Chemistry Roundtable Research Grant for Friction and High Viscosity Friction Reducers

[The ACS Green Chemistry Institute Oilfield Chemistry Roundtable \(GCI OCR\)](#) is a partnership between the ACS Green Chemistry Institute® and Oilfield Chemistry-related corporations united by a shared commitment to integrate the principles of green and sustainable chemistry and engineering into the business of oilfield development and production. Current members are BASF, Brenntag, CES Energy Solutions, International Flavor and Fragrances, Locus Bio-Energy Solutions, NexTier, Rockwater Energy Solutions, and Shell.

The ACS GCI OCR is seeking a one-year R&D commitment to assist the Roundtable's discovery of more sustainable friction reducers and high-viscosity friction reducers. The focus of the R&D will be in finding alternatives to current polyacrylamide polymers used in hydraulic fracturing. Proposals are invited from public and private institutions of higher education worldwide. This project is intended for a student within the selected Principal Investigator's research group. One grant is planned to be awarded, and the total award is limited to \$50,000 with no institutional overhead charges applied for a grant period of 12 months. Interested PIs are required to provide a written proposal describing the investigator's capability to carry out the Roundtable's proposed research. The deadline for receipt of proposals is **31 October 2021 at 5 p.m. EDT**. Proposals must be received by the deadline to be considered. Submissions must be a single PDF file submitted to [gciroundtables@acs.org](mailto:gciroundtables@acs.org) with the subject headline **GCI OCR Proposal Submission**. GCI OCR will notify the selected PI by **31 December 2021**. It is expected that research will commence in the Principal Investigator's lab by **January 2022** and last approximately 12 months.

### Requirements for Submission

Proposals will be accepted from public and private institutions of higher education. The grant is not limited to institutions in the United States. Proposals must be submitted through the appropriate institutional office for external funding. For international submissions, if there is no comparable office, submit a pdf of a letter signed by an appropriate university official recognizing the terms of the grant. This grant is seen as a seed grant and PIs are encouraged to apply for additional money from local/regional/national funders.

### Detailed Project Description

This call for grant proposals is intended to look at friction reducers and high viscosity friction reducers (FR and HVFR) for use in non-conventional oil and gas development operations. FRs are chemical compounds that "slick the water" to minimize friction losses and reduce surface treating pressures at the wellhead. At present, FRs are the single most widely used fracturing chemical additive. Only water and sand are used in greater volume/weight, and these are not typically regarded as "chemical" additives. Slickwater fluids are typically used in horizontal well applications and produce fracturing fluids that are considerably less viscous than guar-based fluids. In the absence of high viscosity, Slickwater fractures require high pump rates (often 2 to 5 times greater than pump rates used in classic vertical-well fracturing) to suspend the proppant during the fracturing treatment. As a result of the need for higher fluid velocity to suspend the proppant, any reduction in the amount of friction pressure created

means the surface treating pressure and the attending horsepower required to pump the fracturing treatment are substantially reduced. Pumping at higher rates allows fracturing fluids to carry more sand into the fractures making them wider and more conductive, which in turn, stimulates the production of more oil and gas.

*Key Considerations:*

Performance:

- when added to water, the chemical should reduce pressure drop due to friction by approximately 70-80% at a Reynolds number of a magnitude approaching  $1 \times 10^6$ . This is the maximum reduction possible as outlined by Virk's asymptote. Evaluation of the chemistries will be performed at a Reynolds number approaching  $1 \times 10^5$ .
- when added to water in some circumstances it is useful to impart viscosity to the fluid, 1-10 cP as measured at  $511 \text{ s}^{-1}$  using an R1 B1 rotor geometry (Fann 35 or equivalent)
- Functional in fluids containing high concentrations of total dissolved solids (TDS) characteristic of oilfield brines. Examples of regional differences in brines are as follows:

. 10K

ions	ppm
Sodium	2,739
Calcium	766.6
Magnesium	218.1
Strontium	12.4
Iron*	1.76
Barium	2.0
Chlorides	4,492.2
Sulfate	2,252
Bicarbonates	296.3

112k

ions	ppm
Sodium	35,597
Calcium	5,743
Magnesium	709.9
Strontium	1,503
Iron*	52.08
Barium	10.9
Chlorides	68,000
Sulfate	187.4
Bicarbonates	475.8

50k

ions	ppm
Sodium	16,965
Calcium	1,372
Magnesium	367.4
Strontium	334.9
Iron*	1.3
Barium	1.0
Chlorides	30,000
Sulfate	1,131
Bicarbonates	244

234K

ions	ppm
Sodium	63,450
Calcium	18,350
Magnesium	1482
Strontium	1,503
Iron*	301
Barium	3656
Chlorides	141,586
Sulfate	0
Bicarbonates	48.8

\*Fe present as Fe(II) with pH < 6.0 to inhibit precipitation



- Tolerant to the presence of hardness ions (Ca, Mg, Sr, Ba) and iron (Fe).
- Should not impair conductivity of the created fracture – retained conductivity. API-19B
- Readily biodegradable (as defined by OECD 301 or equivalent), products of degradation are non-toxic.
- Not persistent or bioaccumulative ( $\log D_{ow} < 3.5$  at pH 4.5 – 8).
- Minimal or no toxicity. See OSPAR; [www.ospar.org/work-areas/oic/chemicals](http://www.ospar.org/work-areas/oic/chemicals) or similar guidance.
- Cannot contain labile sulfur.
- New Synthetic Technologies: Addressing engineering, screening, and scale-up challenges are considered to be within the scope of this RFP.
- Solvents in Manufacture: Judicious selection of solvents and reagents based on the principles of green and sustainable chemistry is highly encouraged (see below). Green solvents and reagents should be explored in order to remove reliance on unsustainable compounds including dichloromethane, dioxane, NMP, and DMF. Reactions operating under high concentration or neat conditions, as well as the usage of non-traditional solvent systems such as supercritical carbon dioxide are considered within the scope of this RFP. Additionally, consideration should be paid to the handling of solids or slurries in flow where relevant—especially under high brine concentration conditions. For further guidance, please see the ACS GCIPR [solvent selection tool](#).
- Scale-up: Establishing line-of-sight to larger scales (kilograms) often informs considerations down the road beyond chemical development (for example, life cycle considerations), and can facilitate crucial discussions for future manufacturing.
- Substrates and Reactions: The oilfield chemistry industry prominently features chemicals used to make polyacrylamides and wishes to investigate alternate chemistries. Raw materials and reactions should be selected based on relevance to the hydraulic fracturing industry.
- Processing: Use of standard relevant operations such as high flow rate friction reduction in an aqueous environment should inform design of new chemicals. Consideration should be given to understanding, improving, and generalizing methodologies to obtain isolated materials with appropriate physical properties (i.e., etc.) upon scale-up.
- Life Cycle Considerations: Advances concerning raw materials, manufacture, distribution, use and disposal of waste as non-hazardous are also within the scope of this grant. In the case of water recovery or reuse, demonstration of the reusability of the recovered fluid is a key concern. Quantitative evaluation of the advantages of a newly developed system or method (e.g., through formal calculations such as life cycle analysis, process mass intensity, etc.) should be included.
- Greenness: To ensure that the proposed chemistry remains at the frontier of sustainability, applications should be reflective of the key research areas described by the ACSGCI OCR:
  - <https://dx.doi.org/10.1021/acs.energyfuels.0c00933>

And of the design principles for sustainable and green chemistry and engineering:

- <https://www.acs.org/content/acs/en/greenchemistry/principles/design-principles-booklet.html>

Additional selected recent review perspectives/reviews include:

1. Reza Barati and J. T. Liang “A Review of Fracturing Fluid Systems Used for Hydraulic Fracturing of Oil and Gas Wells,” J. Appl. Polym. Sci., 2014, 40735, 1-11.
2. Michael A. Reynolds, “A Technical Playbook for Chemicals and Additives Used in the Hydraulic Fracturing of Shales”, Energy Fuels 2020, 34, 15106–15125.
3. SPE-189537- MS, (2018) Methodology for Evaluating Drag Reduction Characteristics of Friction Reducer; Shah, S., Asadi, M., Wheeler, R., Bannon, H., Kakadjian, S., Ainley, B., Chen, Y., McElfresh, P., Ghalambor, A., Kaufman, P., Archacki, D.
4. ACS Webinar: *Grand Challenges and Opportunities for Greener Alternatives within the Oil and Gas Industry*; <https://www.acs.org/content/acs/en/acs-webinars/technology-innovation/greener-oil-alternatives.html>. Accessed 26 August, 2021.

## **Project Goal**

Promote innovation at the interface of chemistry and engineering to develop practical, cost-effective alternatives to acrylamide copolymers for use as friction and high viscosity friction reducers.

## **Project Timeline**

It is anticipated that one year of research support will be sufficient to provide progress toward intended goals.

## **Proposal Format** (Maximum 3 pages as described below + CVs)

All of the information below must be submitted as a single PDF file. All components described in sections A, B, and C must be included in the same PDF file to assure the proposal is reviewed in its entirety.

### A) Title Page (1 page, 12 pt font, 1-inch margins)

1. Project Title:
2. Principal Investigator:
3. Title / Position(s):
4. Telephone Number(s):
5. Fax Number(s):
6. Postal Mailing Address:

7. Email Address:
8. Research Group website:

B) Proposed Plan of Work (*2 pages, 12 pt font, 1-inch margins*)

1. Summarize the student's (undergraduate, graduate student and /or postdoc) capabilities to perform the Roundtable's proposed work.
2. Brief description of the PI's research facilities.
3. Proposed milestone deliveries (primary project and side project) with brief description of the manner in which the researcher intends to achieve them.
4. The PI should list any existing background intellectual property and/or collaborations they are aware of that might limit the freedom to operationalize any of the results arising from all research funded by ACS GCI OCR. The priority of the Roundtable is to encourage research utilizing conditions that are commercially available with the freedom to use.
5. References (does not count toward your page limit).

C) Detailed Estimated Budget: The total amount requested would include all direct costs, student assistantships, etc. The total award is limited to \$50,000 for a grant period of up to 12 months. This does not count toward your page limit.

1. Institutional overhead costs (indirect costs) must not be applied.
2. Post-doctoral associate salary and benefits are supported.
3. Student stipend and benefits are supported. Proposals for support of advanced graduate students are highly favored.
4. PI salary supplements will not be supported.
5. Laboratory supplies and instrument use charges are supported.
6. No funds may be allocated for travel, equipment purchase or repair, or administrative support.

D) Curriculum Vitae of Project Team Members: Please submit a curriculum vitae of each project team member (two pages per team member). Note that this does not count toward your page limit.

### **Report Requirements**

- Progress reports are due on a quarterly basis from initiation of research and discussed in arranged monthly teleconferences.
- Reports are to include research milestones/significant outcomes, summary of progress to date noting any deviations from the proposal, and research plans for upcoming months.
- A final comprehensive report is due one month after the end of the grant period.
- Reports must be submitted as a PDF document electronically to [gciroundtables@acs.org](mailto:gciroundtables@acs.org). Reports will be shared with the member companies of the Roundtable. In addition, the content of the report will be targeted for publication in a peer-reviewed technical journal. The paper will be co-authored by the principal investigator and student (s) performing the work with the guidance of member companies of the ACS GCIPR.

### **Intellectual Property, Publication Acknowledgement, and Terms of the Grant**

- The primary purpose of this grant is the public dissemination of research through publication.

- Every patent, United States or foreign, that results from research funded (in part or in its entirety) by the ACS GCI OCR Research Grant shall be immediately dedicated to the public, royalty free.
- Publication of results is expected within 6 months of work completion.
- Each publication prepared in connection with the ACS GCI OCR Research Grant shall make acknowledgement in the following manner: “This manuscript was developed with the support of the American Chemical Society Green Chemistry Institute Oilfield Chemistry Roundtable (<https://www.acs.org/content/acs/en/greenchemistry/industry-roundtables/oilfield-fracturing.html> ). The ACS GCI is a not-for-profit organization whose mission is to catalyze and enable the implementation of green and sustainable chemistry and engineering throughout the global chemistry enterprise and across the Society. The ACS GCI Oilfield Chemistry Roundtable is composed of leading companies in the Oilfield Chemistry value chain and was established to encourage innovation while catalyzing the integration of green chemistry and green engineering in the industry. The activities of the Roundtable reflect its members’ shared belief that the pursuit of green chemistry and engineering is imperative for business and environmental sustainability.”
- Acceptance of a Roundtable Grant will be conditional upon agreement by the grantee institution that in the event the Principal Investigator is unable for any reason to conduct the research proposed, the funds, if previously paid by the Roundtable, shall, upon demand, be returned in full to the Roundtable, and further, that in the event the PI is unable for any reason to continue with the research after it has commenced, this grant shall be terminated forthwith and the unexpended and unencumbered balance of any funds theretofore advanced shall be returned to the Roundtable.
- The grantee institution, by acceptance of this grant, provides assurance that support normally provided by the institution for research of the faculty member will not be diminished.
- Applicants may have only one research grant with the ACS GCI OCR at a time. In order to close a grant, the ACS GCI OCR must receive and approve the required reports.

**For additional information:**

Website: <https://www.acs.org/content/acs/en/greenchemistry/industry-roundtables/oilfield-fracturing.html>

Email: [gciroundtables@acs.org](mailto:gciroundtables@acs.org)