

Technical Reviewers' Rating Summary

Proposal Number Application Title Submitted By
 Request For Total Project Costs

Section A. Scoring

Statement	Weighting Factor	G-41-01A	G-41-01B	G-41-01C	Average Weighted Score
1. Objectives	9	4	5	4	36
2. Achievability	7	4	4	4	28
3. Methodology	8	4	5	4	32
4. Contribution	8	4	3	4	24
5. Awareness / Background	5	5	4	4	20
6. Project Management	3	4	4	4	12
7. Equipment / Facilities	2	3	4	4	6
8. Value / Industry - Budget	4	3	4	4	12
9. Financial Match - Budget	4	2	3	4	12
Average Weighted Score		191	205	200	198

Total: 50

250 possible points

OVERALL RECOMMENDATION

FUND		X	X
FUNDING TO BE CONSIDERED	X		
DO NOT FUND			

Section B. Ratings and Comments

1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are:

The goal of producing a new technology that would enhance EOR from the Bakken oil system is consistent with improving oil and gas recovery of resources located in North Dakota. This will extend well life and the associated industry activity, create new jobs, increase economic activity and tax revenues.

- Reviewer: G-41-01A

- Rating: 4

The objectives are clearly stated along with why this project is valuable to ND. I think this project will be even a greater value in years to come, however this is a start and it is fantastic that this group is already researching and developing a method of EOR for ND. I would have liked to see some info if this technology could be of use in stimulation processes in the Bakken / Three Forks. Could nanoparticle surfactant be of use, or compatible, in the fracturing process? Regardless the Bakken Three Forks formations will need a different approach to EOR and I think this is definitely a good start.

- Reviewer: G-41-01B

- Rating: 5

This concept has great merit and is a viable potential EOR project for the Bakken and potentially other plays. The objectives and goals are clearly laid out.

- Reviewer: G-41-01C

- Rating: 4

Question 1 (from Reviewer G-41-01B): A. "If this technology could be of use in stimulation processes in the Bakken / Three Forks." B. "Could nanoparticle surfactant be of use, or compatible, in the fracking process?" Answer: A. The nanoparticles to be developed might be used in hydraulic fracturing to reduce fluid loss into the matrix rock and micro-fractures in the stimulation process. But at this moment, the focus of this work will be EOR. In the future project, we would like to investigate the possibility of applying our technology to the stimulation process. B. Surfactant is one of the historical additives for hydraulic fracturing fluids. The nanoparticle-surfactant hybrid should keep surfactant's original properties. Thus, theoretically, the nanoparticle-surfactants should be compatible with other components in the fracking fluid for Bakken/Three Forks. Detailed studies will be needed in the future.

- Applicant

2. With the approach suggested and time and budget available, the objectives are:

The testing schedule and budget seems realistic. The description of the process is quite detailed for a grant request, indicating a reasonable knowledge of the time, equipment, and monetary requirements.

- Reviewer: G-41-01A

- Rating: 4

It looks like the objectives should easily be reached within the time period stated, keeping in mind this is just the initial stage of this technology - especially in ND. I would like to see a tentative plan for what comes next after this project, as long as the results are as expected, but for this research it appears that the time is significant. The budget appears to be adequate, however I would have liked to see a little more information on the equipment and instruments that will be used and something to give a reference that they will be used correctly by personnel to ensure results in individual experiments are not skewed. Will personnel running the equipment have proper training? for the results but also safety

- Reviewer: G-41-01B

- Rating: 4

I believe this is a very achievable project within this 3 year research project. The budget is relatively inexpensive for the work being done.

- Reviewer: G-41-01C

- Rating: 4

Question 2(from Reviewer G-41-01B): A. I would like to see a tentative plan for what comes next after this project, as long as the results are as expected, but for this research it appears that the time is significant. B. I would have liked to see a little more information on the equipment and instruments that will be used and something to give a reference that they will be used correctly by personnel to ensure results in individual experiments are not skewed. Will personnel running the equipment have proper training? for the results but also safety. Answer: A. Upon the success of the proposed tasks, our next step would be seeking industrial partners to conduct a pilot test in the Bakken/Three Forks formations. The developed nanoparticles-enhanced surfactant EOR fluids would be tested in several formations to verify their effectiveness. Meanwhile, we are planning to apply for a patent. Scale-up of the nanoparticle-surfactants will be our goal as well. The long term goal of the work would be commercialization of the products. In addition, Question 1 A and B could be our future direction. B. In the nanoparticle synthesis and characterization processes, the major instruments will be used are: 1. Scanning electron microscope (SEM, Hitachi SU 8010

equipped with Oxford X-Max energy dispersive X-ray spectrometer), 2. Particle size analyzer (Malvern Zetasizer Nano ZS), 3. Surface area analyzer (Autosor-iQ-C Chemisorption with built in TCD). The three instruments are in the Co-PI's lab (Zhao) in the UND Department of Chemistry. The students and postdocs in Zhao's group have been well trained on how to operate these instruments and have published a number of research articles using the data obtained from these instruments. In addition, the group members including graduate students and postdocs have obtained safety training certificates from the UND Safety office. The characterization of rocks and fluid interaction with nanoparticle-surfactants will use the equipment in the Materials Characterization Laboratory located in the College Engineering and Mines at UND. The laboratory technical staff are full time personnel operating the equipment. The instrument using fee has been budgeted in the proposal. The scanning of rock core samples will be conducted in the Micro-CT lab at the University of Minnesota by professional staff. The lab fee has been budgeted in the proposal. The newly purchased Vinci EOR core flood system and Vinci Visual Fluid-Eval PVT system in the PI's department will be used for fluid flow study in this project. The Vinci Company technical personnel will come to the Petroleum Department at UND to train users including the PI and his students for the whole week of December 5-9, 2016. Three years contract service from the Vinci will provide the further training and customer service if needed for the proposed work.

- Applicant

3. The quality of the methodology displayed in the proposal is:

The experiment seems to be well structured to arrive at optimum surfactant type, nanoparticle, and application process. Furthermore, parallel development of the individual components should accelerate the overall selection process, providing more time for application process testing.

- Reviewer: G-41-01A

- Rating: 4

The methodology is great and very well explained. It clearly explains the conditions we have along with the challenges and goes on to explain the task that will be carried out to examine the interaction with the Bakken to evaluate the EOR results. I think one of the most important aspects of this experiment is ensuring that samples used such as cores, brine and oil correctly represent the Bakken as a whole.

- Reviewer: G-41-01B

- Rating: 5

It is apparent that this is a well thought out project and it covers all of the main aspects that are required for a project like this.

- Reviewer: G-41-01C

- Rating: 4

Question 3 (from Reviewer G-41-01B): "I think one of the most important aspects of this experiment is ensuring that samples used such as cores, brine and oil correctly represent the Bakken as a whole." Answer: We truly agree with the reviewer. The representative samples are critical for testing our method. The cores that we are currently using are from the ND Wilson M. Laird Core and Sample Library. The Library will continue providing core samples for the proposed project. The oil samples will be provided by the EOG Resources Inc. that is one of the largest operators in the North Dakota Bakken field. The oil and brine samples from different areas of Bakken Formations, such as core areas and non-core areas, will be obtained, screened and selected for the proposed study.

- Applicant

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be:

If a method to increase oil recovery from the Bakken system is found by the project, considering the low current recovery percentage of 7 to 10%, and large OOIP value of 170 Bbbl, the potential for a large increase in EUR from each well is significant. Each 1% of additional recovery, using current ND DMR OOIP estimates for the Bakken system in North Dakota, amounts to 1.7 billion barrels of additional produced oil and associated natural gas.

- Reviewer: G-41-01A

- Rating: 4

I think the contribution is significant as ND currently relies on a stimulation of the Bakken / Three Forks formations in order to produce an economical amount of oil & gas. I didn't get a good understanding of how much of a contribution this will have in Fracing here in ND as this is a project on EOR rather than stimulation, however the stimulation process is another area where this could apply potentially. I think that this technology may be effective right now in other fields or plays where a tertiary method is needed currently to make the field feasible. ND will need this EOR technology eventually and we do need to start looking at options that will work with the reservoir properties we have in the Bakken / Three Forks.

- Reviewer: G-41-01B

- Rating: 3

I do believe that if this research effort is successful, it could have far reaching benefit for the state of ND. If successful, it would provide a fluid that if applied effectively could economically enhance future oil production in the State. It does not address potential application methods specifically or the potential for success in field applications.

- Reviewer: G-41-01C

- Rating: 4

Question 4A (from Reviewer G-41-01B): "I didn't get a good understanding of how much of a contribution this will have in Fracing here in ND as this is a project on EOR rather than stimulation, however the stimulation process is another area where this could apply potentially. I think that this technology may be effective right now in other fields or plays where a tertiary method is needed currently to make the field feasible. ND will need this EOR technology eventually and we do need to start looking at options that will work with the reservoir properties we have in the Bakken / Three Forks. Answer: Nanoparticles developed in this study might be used in stimulation of the Bakken as well. Please see the above answers for Question 1 A and B. Question 4B (from Reviewer G-41-01C): "It does not address potential application methods specifically or the potential for success in field applications." Answer: Upon the success of the proposed tasks, our next step would be seeking industrial partners to conduct a pilot test in the Bakken/Three Forks formations. The developed nanoparticles-enhanced surfactant EOR fluids would be tested in several formations to verify their effectiveness.

- Applicant

5. The background of the principal investigator and the awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is:

The principal investigator has a very impressive portfolio of experience and knowledge in nanotechnology, surfactants, EOR, etc

- Reviewer: G-41-01A

- Rating: 5

The information included was very informative and it clearly shows me that the background or initial research has been conducted very thoroughly. The principal investigator is well suited for this role judging by experience, past research and articles.

- Reviewer: G-41-01B
- Rating: 4

The Professors overseeing this project appear to have great experience that is specific for this research project. Their past work references are significant but I have not interviewed any of the professors personally. I have no reason to believe their abilities would be less than "very qualified" for the work proposed.

- Reviewer: G-41-01C
- Rating: 4

6. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is:

The project is well defined in terms of management responsibilities, reporting schedule, reporting, and project timing.

- Reviewer: G-41-01A
- Rating: 4

I would recommend weekly team meetings rather than biweekly. Also I would recommend that regular project reports be done monthly or quarterly to keep the NDIC and other sponsors up to date on progress or any issues that they may encounter. Communication is in a project of this magnitude, communication between the team itself and also its sponsors. If any problems should arise they should be discussed immediately and then worked out. The timetable is clearly shown and seems very reasonable and achievable. It looks like the time needed to complete each of the 4 task can be achieved. The budget is broken down very clear and looks like the financial plan is very well laid out.

- Reviewer: G-41-01B
- Rating: 4

The entire project is very well laid out with well defined timelines that can be used to measure their successful completion of each of the research project steps.

- Reviewer: G-41-01C
- Rating: 4

Question 6 (from Reviewer G-41-01B): " I would recommend weekly team meetings rather than biweekly. Also I would recommend that regular project reports be done monthly or quarterly to keep the NDIC and other sponsors up to date on progress or any issues that they may encounter." Answer: The weekly team meeting is a good idea. We would schedule the meeting in this frequency if the project is funded. We will keep NDIC posted about our progress and submit reports in a timely manner.

- Applicant

7. The proposed purchase of equipment and the facilities available is:

Doesn't appear that equipment purchase will be a significant portion of the project cost. Equipment requirements are largely listed as part of the in kind contributions of UND and other institutions or leased for use.

- Reviewer: G-41-01A
- Rating: 3

From what I can see the equipment that will be used is justified. The oven they are requesting to purchase is needed, and the reasons why it is essential are listed in the Budget Justification. Like I said earlier I would like to see a little more information on the equipment used, more details on it. Also would like to see something stating that people running certain equipment or instruments have either training or experience on it, however this may be a given - as

individuals working on this project are most likely experienced with the lab equipment used.

- Reviewer: G-41-01B

- Rating: 4

The research team claims to have access to state of the art facilities that are both internal to UND and some are external. These are detailed in Appendix D. Lab fees and materials appear to be a small part of the project.

- Reviewer: G-41-01C

- Rating: 4

Question 7(from Reviewer G-41-01B): "I would like to see a little more information on the equipment used, more details on it. Also would like to see something stating that people running certain equipment or instruments have either training or experience on it, however this may be a given - as individuals working on this project are most likely experienced with the lab equipment used." Answer: Please see the answer for Questions 2B.

- Applicant

8. The proposed budget "value"¹ relative to the outlined work and the commitment from other sources is of:

Funding is dominated by the requested NDIC funding. A significant amount of in kind funding comes from a project partner, while a relatively minor portion is from an industry partner, in the form of oil samples. It would certainly be beneficial to the project, if there was a more robust industry contribution.

- Reviewer: G-41-01A

- Rating: 3

Other sources to contribute to this project are very good as "other sources" are contributing the use of reservoir simulation software along with training / consulting. This is a valuable contribution to the project as this software will be very much needed, and this is top of the line software in our industry. The project could take longer if this software along with help from InPetro Technologies was not available, due to training on other software from a different company not providing support of the project.

- Reviewer: G-41-01B

- Rating: 4

The potential value appears to far outweigh the costs.

- Reviewer: G-41-01C

- Rating: 4

Question 8(from Reviewer G-41-01A): "It would certainly be beneficial to the project, if there was a more robust industry contribution" Answer: We have reached out to the industry, but we were not successful in securing more cash contribution given the current petroleum downturn. Our plan is that if this project is funded, we will continue our efforts to reach out to some companies in the process of this project to obtain more support and industrial input.

- Applicant

9. The "financial commitment"² from other sources in terms of "match funding" have been identified:

All matching contributions appear to be in kind. Greater financial support from oil and gas industry partners would make this project, although a worthy scientific research project, a more attractive recipient of NDIC grant money.

- Reviewer: G-41-01A

- Rating: 2

I do not see any concerns or increased favorability with this application.

- Reviewer: G-41-01B

- Rating: 3

InPetro Technologies was identified for providing matching funds.

- Reviewer: G-41-01C

- Rating: 4

Question 9 (from Reviewer G-41-01A): Answer: Please see the answer for question 8.

- Applicant

1 "value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar. A commitment of support from industry partners equates to a higher value.

2 "financial commitment" from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application; industry partnerships equates to increased favorability.

General Comments

I like this project from a purist research point of view, and the potential benefit to the state of North Dakota economy, but it really could use greater industry support. As it stands right now, a case could be made that this is research to produce a patentable product or process, that if produced without solid industry support, is beneficial primarily to the applicants. There is a significant educational benefit, that should be considered.

- Reviewer: G-41-01A

I like the idea and purpose of this project. Overall I think it is a great start to looking at a EOR project that will be suitable for the Bakken / Three Forks. I am excited to hear about nanoparticle surfactant and chemical EOR projects, they are the future of many reservoirs, new and old, that once were not economical. The Bakken is going to take a different or "newer" form of EOR, such as nanoparticle surfactant or a chemical EOR method possibly. Normal EOR processes such as "Water Flooding" will not work in most places of the Bakken due to the amount of shale / clay minerals present that will swell shut, therefore a specialized surfactant will be required to make a chemical enhanced Water Flood or other method successful. One thing I was hoping to see in the application was something about this nanoparticle surfactant possibly having a place in stimulation processes here in North Dakota. Obviously the Bakken must be frac'd to produce a feasible amount of oil. Fracing technology has come a long way over the past 10 years and now the next step in fine tuning the stimulation process is creating a surfactant that works well in reservoirs such as the Bakken. I believe that experimenting with different EOR methods such as surfactants is extremely important for the Bakken, and I think this project is definitely a huge step towards finding a successful method, but I didn't really see anything on what the next step would be if the anticipated results are achieved. How long until operators in ND could utilize this technology. I recommend weekly team meetings among the dept working on this project. Also I suggest either monthly or quarterly progress reports to all contributors to this project. Communication is key and if any problems arise it is best they are openly discussed so that every option can be evaluated. This technology needs to be evaluated for EOR processes in the Bakken and I am all for contributing to this project. It is exciting and could greatly boost ND oil production.

- Reviewer: G-41-01B

I believe the project has great merit. The study appears to cover all aspects that would be expected to be covered in a research project like this. There are risks however. Nano-particle enriched surfactants are new and have not been proven to work on enhancing oil recoveries in very tight

rocks. The application of these fluids in highly fractured reservoirs has also not been established. Will this new fluid be effective in contact with highly saline environment found in Bakken reservoirs? Some of these risks are not even part of the research project but ultimately will be part of the success of EOR with these fluids in the Bakken. I recommend approval.

- Reviewer: G-41-01C