BP Biosciences 2018 Call for Academic Proposals

The following is a list of the proposals from the BP Biosciences Center for funding beginning January 1, 2019.

All proposals (including proposed budgets) are due to the EBI no later than 12:00 p.m. (Pacific Time) on Friday, August 10, 2018. Decisions will be made by September 28, 2018.

Submit proposals electronically to:
Shelley Brozenick, EBI Program Manager
sbrozenick@berkeley.edu

Applicants are encouraged to reach out to the BP tags for further information, if needed.

Proposal 1: Development of Low pH Production Hosts

BSC Tags: Ling Li (ling.li@bp.com), Fernando Valle (fernando.valle@bp.com)

Funding Available: 1 Postdoctoral Researcher, 2-3 years

Bio-refineries have been proposed as a solution to replace oil-derived products with more sustainable biotechnologies, which are based on the use of renewable resources for the commercial production of chemicals and other products. In 2004 the DOE identified 15 platform chemical compounds that could be produced from carbohydrates. Importantly, ten of these platform compounds were organic acids. Since then, using a variety of production hosts, numerous fermentation technologies have been developed for the production of these 10 organic acids. In most of these processes, 50%-80% of processing costs are typically due to product recovery and purification. The primary factor for this cost is that most production hosts need a neutral pH for optimal performance. However, as the organic acids are accumulated in the culture media, pH decreases and the organic acid has to be neutralized by the addition of a base; leading to the formation of the organic acid salt. Subsequent applications of the organic acids normally use the acid form, and the neutralizing cation has to be removed, disposed or recycled.

Given that the pKa values for most organic acids are typically between 3 and 5, using production hosts that could produce organic acids efficiently below pH 4.0, would decrease or eliminate the formation of organic acid salts. There is therefore a need to develop new production hosts that have an optimum pH below 4.0.

The BSC is seeking proposals for the development of alternative production microorganisms that could be used for low pH (below 4.0) fermentation processes.

Specifically, proposals should be directed to the development of new (or improve existing) genetic tools for the genetic manipulation of the proposed host. It is expected that the proposed host has already shown to have an optimum pH for growth below 4.0, and that its genome has been sequenced. Proposals considering the creation of novel microorganisms that can thrive at pH below 4.0, by combining traits of closely related species will be also considered.

Some of the goals of a proposal could be:

- Development / Improvement of electroporation or other transformation methods.
- Construction of transposon libraries.
- Implementation of a CRISPR system.
- Establish efficient gene knockout / replacement by homologous recombination, using markers and regions of homology of different lengths.
- Development of stable cloning and expression systems.
- Construction and Characterization of promoter libraries.
- Improvement of targeted gene knockout/replacement methods.

Proposal 2: Characterization of Microbial Communities in Oil Reservoirs

BSC Tags: Tom Goldman (Thomas.Goldman@bp.com), Fernando Valle

Funding Available: 1 Postdoctoral Researcher, 2-3 years

Microbial communities play crucial roles in many geochemical processes, human health and in a variety of industries. For example in the oil & gas industry, microbial activities participate in oil souring, corrosion, and fouling. These activities compromise operation safety, as well as cause significant economic losses. The oil industry has studied microbiology of reservoirs for almost 100 years and recently has incorporated DNA sequencing as a way to better understand the microbes present in reservoirs, how they may affect operations, and to improve risk analysis and mitigation strategies. Despite the continuous decrease in DNA sequencing costs, it remains prohibitively expensive to sequence whole genomes (“shotgun” sequence) from the hundreds of samples that are normally needed to properly characterize an oil extraction process. As a result, the most common method today is the use of targeted sequencing, focused on 16S rDNA and a few marker genes. This allows the identification of microbes with different levels of accuracy, and provides the ability to infer a limited amount of metabolic pathway information present within a population. Because of these limitations, new tools and approaches are needed to characterize microbial communities, including the potential metabolism and dynamics.

The BSC is seeking proposals for novel approaches for the characterization of microbial communities present in samples from oil extraction processes, or sand-packed columns that serve as proxies for oil reservoirs. Specifically, proposals should be directed to the development of new approaches and/or improvements to current methods to characterize microbial communities based on limited DNA sequencing data. This characterization should provide a plausible metabolic model that explains measured physicochemical parameters. The development of databases that include microbial species, full metabolic pathways, and individual enzymatic reactions, suitable to study oil extraction processes will also be considered.

Proposal 3: Improving management of reservoir souring

BSC Tags: Reinhard Dirmeier (Reinhard.Dirmeier@bp.com), Liguang Wang (Liguang.Wang@bp.com)

Funding Available: 2 Postdoctoral Researchers (1 for each Area), 2-3 years each

Waterflooding, the injection of water into a reservoir to support the production of hydrocarbons, can stimulate conditions favorable to microbial formation of H_2S (reservoir souring or biosouring). Where these organisms establish a foothold - expected to be primarily in the form of biofilm - and continue to grow, they enrich reservoir fluids with H_2S. After transport through the reservoir this will eventually appear at the point of production. H_2S can present a significant hazard to the safety of personnel, integrity of infrastructure and consequently a risk to the environment.

To pro-actively mitigate souring risk, preventative barriers are applied. Industry relies on the addition of either calcium nitrate to the injection water, or on the removal of sulfate from the injection water. Calcium nitrate is the most widely used option due to its lower cost and greater technical simplicity. Its role is to stimulate nitrate reducing organisms in the reservoir, which may out-compete sulfate reducing organisms for essential resources and thus prevent sulfide production. Where preventive barriers are not in place or inefficient, chemical scavengers may be applied to remove H_2S from the produced hydrocarbons.

The likelihood of souring occurring in a given reservoir is better understood in relation to some factors more so than others. For example, the impact of injection water chemistry and microbial metabolic preferences have long been described, whereas the role of temperature is broadly defined and continues to be refined. These parameters are components of existing models used to predict the potential occurrence and magnitude of biosouring, and are used in tandem with reservoir models to couple predicted H_2S production with oil and water flow rates and directions.

The influence of parameters such as crude oil composition, mineralogy and geological microstructures are not well defined, and there is limited understanding of how these factors may impact the ability of sulfate reducing organisms to thrive or not.

Currently, there is no routine method to determine if the water flood process has triggered the onset of microbial sulfate reduction, nor the ability to confirm the success or failure of any preventative barrier until changes in the concentration of H_2S can be detected in the produced fluids. The ability to determine the establishment of microbial activity that will lead to the onset and development of reservoir souring, and ideally, quantification of the maximum mass of H_2S which might be anticipated in produced fluids, would greatly improve our ability to mitigate the safety hazards and operational risk associated with H_2S production.

To enable more effective management of souring risk in water flooded reservoirs the BSC seeks to fund research activities on the following two topics:

Area 1: <u>Develop novel methodologies for the early detection and quantification of microbial H_2S formation in water flooded reservoirs ahead of its appearance during production</u>

The ability to determine the establishment of microbial activity that will lead to the onset and development of reservoir souring, and ideally, quantification of the maximum mass of H_2S which might be anticipated in produced fluids would greatly improve our ability to mitigate the safety hazards and operational risk associated with H_2S production.

The point at which H_2S is detected in produced fluids is not congruent with the production of the water in which the H_2S was generated. The lag between the arrival/detection of these two phases is created by multiple processes including geochemical reactions of H_2S within the reservoir, partitioning of H_2S between residual hydrocarbon and aqueous phases, and the sensitivity with which we are able to detect changes in H_2S concentrations in the produced fluids.

A leading indicator of reservoir souring could offer a means to monitor the performance of any preventative barrier applied and help predict the occurrence of H_2S during production. The ability to monitor the degree of H_2S formation with any sensitivity would further allow for either changes to the barrier application to restore performance, or for improved confidence in mitigation decisions to manage adequate H_2S performance.

Proposed goal

Identify & develop a methodology for the detection of active biological H_2S formation in hydrocarbon reservoirs and demonstrate proof of concept at lab scale applying current or novel experimental approaches to mimic oil reservoirs.

- Demonstrate the early detection of souring activity before the appearance of H_2S itself via indirect detection of microbial activity related to sulfate reduction, or any approaches which may utilize H_2S directly, e.g. reporter chemistries that react with it.
- Demonstrate the ability of quantitative or semi-quantitative predictions for the extent of souring activity to describe changes in souring activity over time e.g. in response to applications of a barrier chemistry.

Area 2: Define the impact of reservoir geology on biofilm formation and souring behavior, and/or its mitigation with nitrate

Currently the industry has only a limited understanding of how to account for variations in the geological characteristics of a reservoir and their impact on the processes involved in biosouring. It is anticipated that a mechanistic understanding of factors such as permeability, porosity, and mineralogy on biofilm formation, and its propensity to support souring and community changes due to nitrate treatment will enhance our capacity to understand biosouring risk, and optimize our strategies to mitigate it.

Proposed goal

Experimentally define what aspects of reservoir geology & geochemistry play a significant role in biosouring and establish a fundamental understanding of the role the various factors play in one or more of the following areas:

- Interplay between relevant mineralogical and textural parameters and biofilm formation and behavior.
- Impact of this relationship on the efficacy of chemical treatments intended to mitigate souring, e.g. calcium nitrate.
- Develop applicable kinetics that can accurately represent these relationships.

Proposal Instructions

The proposal submission deadline is **Friday, August 10, 2018** with the expectation of funding decisions being completed by September 28, 2018. The completed proposal should be submitted electronically as a single PDF file to Shelley Brozenick (sbrozenick@berkeley.edu) by 12 p.m. (Pacific Time) using the subject line ***"EBI-BP Full Proposal."*** Please only use Arial or Times, a minimum font size of 11, and leave a 1 inch margin around the document. In addition to the PDF file, please additionally submit the budget as a separate Excel spreadsheet using the attached template. For scientific questions related to the project please contact the BP tags identified in the call, and for logistical questions Shelley Brozenick. The proposals should be broken down in the following four sections.

A. Executive Summary (1 page):

Provide a synopsis of the proposed project.

B. Background (2 pages max)

C. Technical Plan (5 pages max):

Outline and address technical challenges inherent in the approach and possible solutions for overcoming potential problems.

D. Appendices

- Budget (use Excel template attached)
- Budget Justification
- Images (unlimited)
- References (unlimited)
- 2 page NSF style Bio sketches required for all PIs