# *Hydrophobic Membrane for the Removal of Organic Impurities in Production Water*

## FWP FEW106

### Program

This project was selected in response to DOE's Natural Gas and Oil Technology Partnership Upstream Environmental Program FY 2003 call for proposals on produced water treatment.

### Project Goal

The project goal is to develop hydrophobic aerogel technology to remove organic compounds from drilling and production waters on oil production platforms. This technology will be available for use on drilling platforms but also will be suitable for land-based production and/or refinery applications, as well as contaminated water issues in other industries.

### Performer

*Lawrence Livermore National Laboratory (LLNL)*
*Berkeley, CA*

### Project Results

Hydrophobic aerogel formulations have been developed that optimize the removal of organics contained in produced water waste streams. Intrinsic adsorption characteristics of these materials have been investigated under batch and dynamic conditions. Bench-scale treatment systems for granular filter and membrane configurations are under development.

### Benefits

Adsorption and membrane technologies using advanced materials show newly realized capability for waste treatment because of the variety and flexibility of newly developing materials. Such materials can be tailored to target specific contaminant, such as removal of free oil, dissolved organics, or specific metals. Extreme adsorption affinity permits efficient removal utilizing a smaller system footprint and/or higher waste flow rates.

### Background

Offshore oil production in the U.S. faces environmental regulations dealing with disposal of drilling and production waters. A high percentage of these waters cannot be returned directly into the surrounding environment because of their high concentrations of free oil, dissolved organics, and metals from components in crude oil and drilling fluids. Treatment technology is available that removes the free oil, but it is slow and inefficient. New methods that are more efficient, have less space demands, and better address dissolved organics are necessary because of the high volume of the produced water and current cost of disposal on offshore platforms.

Silica aerogel material that can be modified for contaminant removal. (Photo from http://www.building-green.com/auth/image.cfm?imageName=images/1107/strewnpiles6-18-02.jpg&fileName=110708a.xml)

Produced water is an integral part of oil production. Worldwide daily production is more than triple the volume of oil produced. About 50% of the water is reinjected, and the rest is discharged. Most discharged water requires treatment because of the concentrations of free oil, heavy metals, and dissolved organics (such as BTX [benzene, toluene, and xylene], carboxylic acids, and polynuclear aromatics). Treatment and disposal in the U.S. is estimated to cost $0.60/bbl. Unless treatment can reduce the content of organics to an environmentally acceptable level, the water cannot be disposed of into the ocean and must be transported from the platform.

### Project Summary

The aim of this project is to develop a commercially viable adsorbing or membrane material that can be used in remediation and removal of organic materials, such as dissolved organics, in high ion-content aqueous media, rendering a water stream reusable or releasable. LLNL will provide the membrane technology, and the Industrial Partner (an unidentified major oil company) will provide scale-up and large-scale testing leading toward commercial application. The end result should be a cost-effective technology that allows for direct treatment of contaminated water at the source.

The approach is to use membranes or adsorbants to do the separation and use them in a continuous flow system that can be installed at a remote location, such as a drilling platform. The materials to be used for this are inorganic/organic composites known as hydrophobic sol-gels, or aerogels. These materials already have been shown in laboratory testing to be effective for separation of oil and organics from water. The challenge here is to bring this material technology to commercial use as membranes or adsorbants in real, remote applications, such as ocean drilling platforms.

The researchers envision that the aerogel material will be in direct contact with the wastewater and used as a granular filter bed or as a cross-flow filtration membrane to remove the targeted organic compounds, yielding water that can be disposed of easily, economically, and in compliance with environmental regulations. The aerogel will be designed in such a way that the organics can be extracted, allowing reuse of the aerogel.

### Current Status (August 2005)

Project researchers are currently pursuing:

- Testing of the effectiveness of selected membrane designs for separation.
- Synthesis of granular hydrophobic aerogels for bench testing .
- Scale-up design of a column or membrane separation bench system.
- Construction of a separation bench system for flow configuration validation.
- Bench system testing of hydrophobic aerogels.
- Development of aerogel synthesis with an outside company.
- Design plans for potential pilot-scale aerogel-based water treatment facility for offshore use.

Offshore oil platforms require a small footprint for produced water treatment technology. (Photo from http://www.mms.gov/mmskids/explore/q1s.jpg)

**Publications**

Love, A.H., Hanna, M.L., Coronado, P.R., and Reynolds, J.G., Engineering Surface Functions Groups on Silica Aerogel for Enhanced Cleanup of Organics from Produced Water, Separation Science, 40:311-320 (2005).

**Project Start:** April 22, 2003
**Project End:** April 21, 2006

**Anticipated DOE Contribution:** $770,000
**Performer Contribution:** $0

**Contact Information**

*NETL* – Rhonda Jacobs (rhonda.jacobs@netl.doe.gov or 918-699-2037)
*LLNL* – John G. Reynolds (reynolds3@llnl.gov or 925-422-6028)