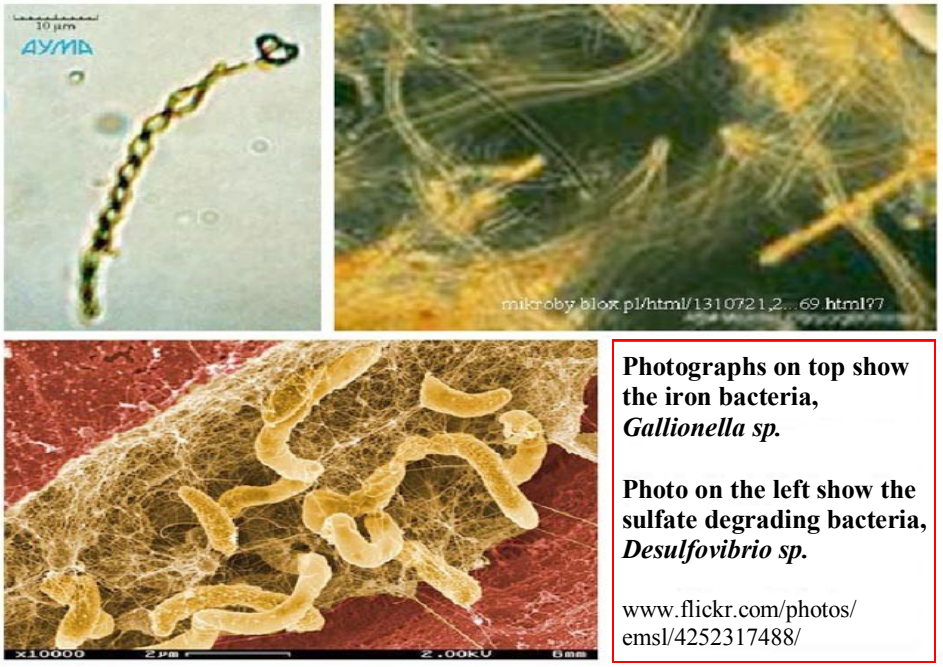
Non-leaching, ecofriendly biocidal technology for use in hydraulic fracturing fluids

a Poseidon Sciences-Selenium Ltd Project

Hydraulic Fracturing

The Marcellus Shale Formation, a geologic feature located between New York State and West Virginia, holds an estimated 262 trillion cubic feet of extractable natural gas reserves. Although this resource is known for a century, the Marcellus shale deposit became important in the last two decades because of the depletion of other easily accessible reserves, the increasing price of oil and the development of the hydraulic fracturing technology by Halliburton that made it feasible to extract natural gas. Hydraulic fracturing is a process wherein fluid containing sand is pushed at high pressure through a well bore deep into the shale formation to create man-made fractures. The hydraulic fracturing process is followed by injection of proppants, typically ceramic beads that are lodged inside the shale to keep the fracture open. The fractured shale allows free flow of natural gas and oil into the pipeline that brings them to the surface for collection. Over a million wells have been drilled in the Marcellus shale through hydraulic fracturing.



Photographs on top show the iron bacteria, *Gallionella sp.*

Photo on the left show the sulfate degrading bacteria, *Desulfovibrio sp.*

www.flickr.com/photos/emsl/4252317488/

Environmental issues associated with hydraulic fracturing

The Problem

Anaerobic iron and sulfate degrading bacteria rapidly proliferate in the fracturing fluids, causing corrosion of the pipes and clogging of the proppants. Inevitably biocides had to be included in the fracturing fluid to inhibit bacterial growth. However, in recent years, there has been a tremendous public concern about the environmental issues associated with hydraulic fracturing and, in particular, the possible contamination of the aquifer and nearby streams by biocides and other chemicals present in the fracturing fluid. This triggered the current search for more environmentally benign options to keep such anaerobic organisms from proliferating. Considering the economic and strategic value of extracting US oil-gas reserves, an alternative technology needs to be developed as soon as possible to solve this environmental concern.

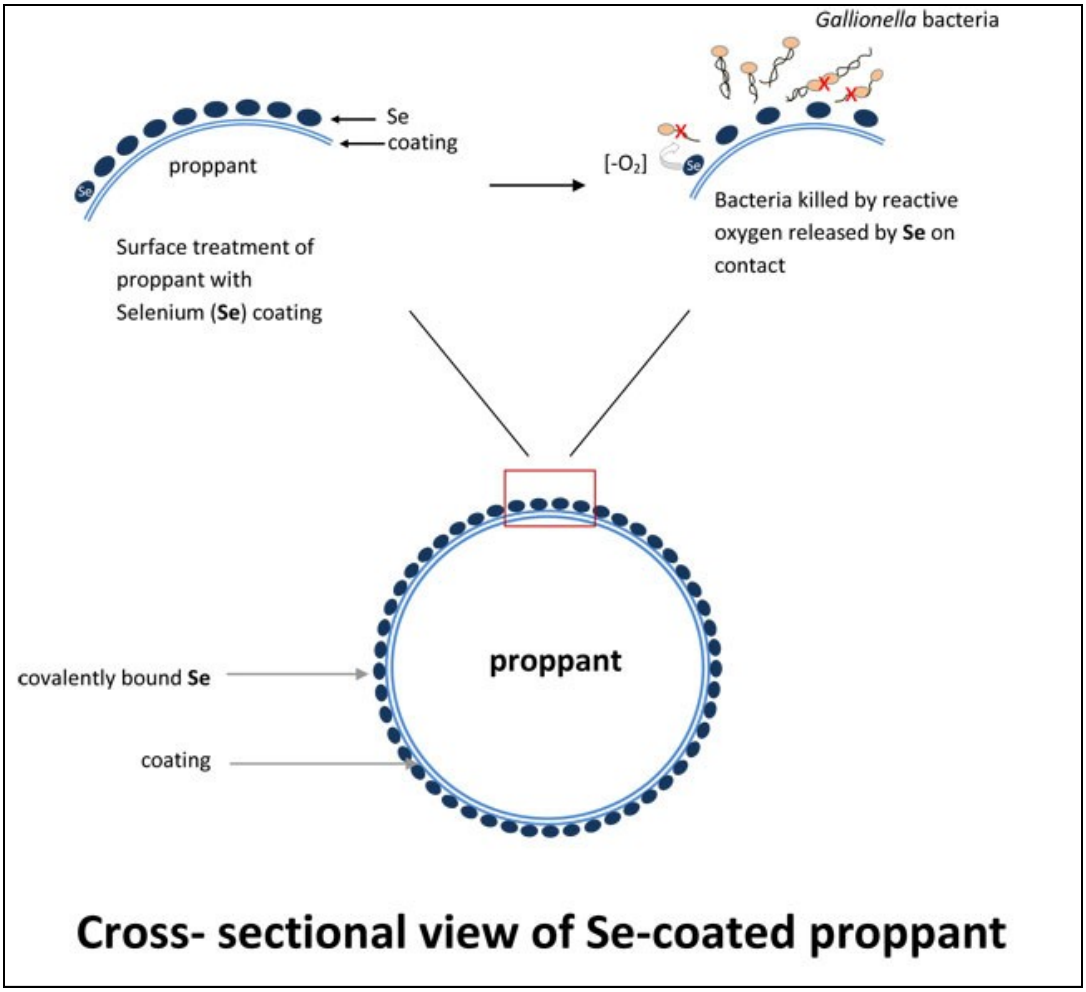
Solving the problem

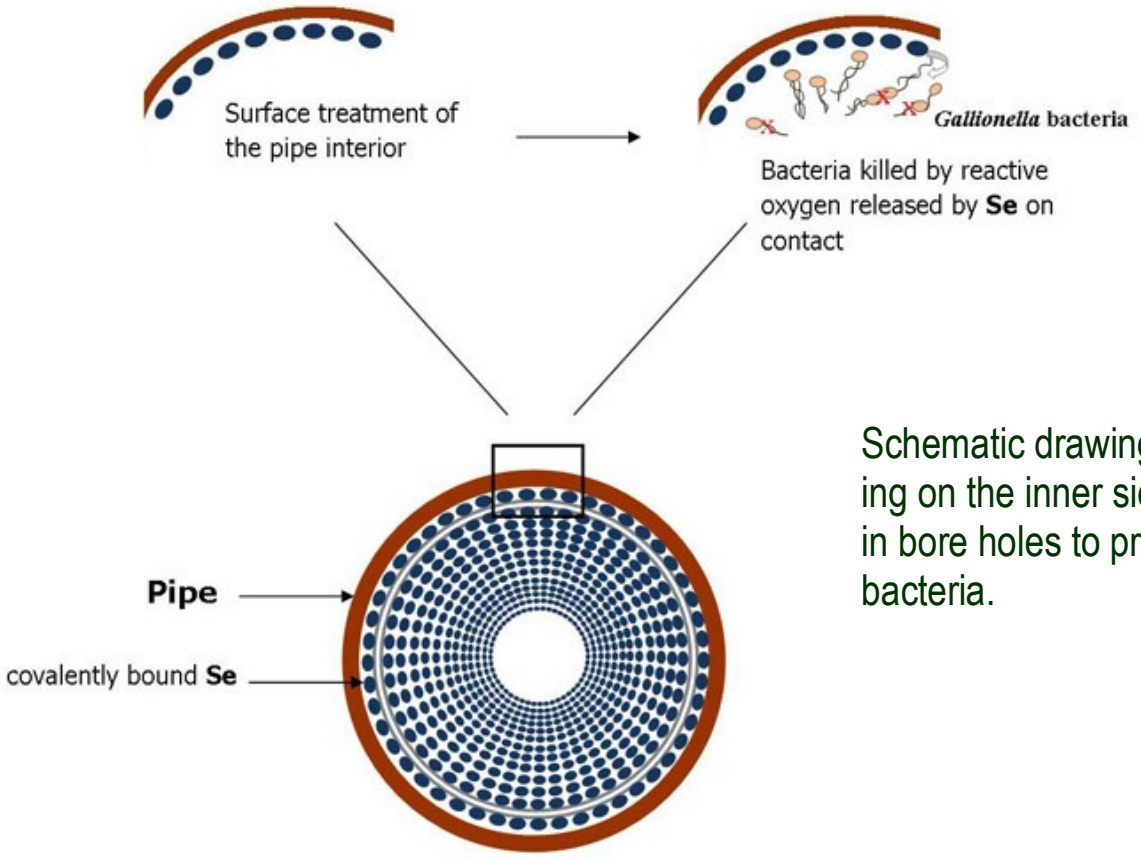
At the risk of stopping all natural gas extraction and exploration, it is imperative that a solution be developed soon to prevent bacterial overgrowth in fracturing wells. Because it takes only a small amount of bacteria to contaminate the well, introduction of bacteria-free fluids or other technologies proposed to date have marginal impact on the overall problem. A biocidal approach is still the best method. However, the biocidal material should be environmentally friendly and must not freely diffuse away from the bore hole. These are daunting challenges to overcome.

Technological advances often times are not at same pace with the response necessary to negate environmental issues that result. The case in point is the BP Deepwater Horizon oil spill in the Gulf of Mexico. For this reason Poseidon has embarked on an ambitious program, called ***Nereus Project***, to develop technologies that help ameliorate environmental problems associated with technological advances. While developing technologies for oil spill cleanup, the Nereus Project has also been looking at alternative options that would prevent biocidal actives from leaching out to the environment from fracturing fluids.

Recently, Poseidon Sciences and Selenium, Ltd entered into a strategic partnership to develop coatings containing covalently bound selenium (Se). Se is approved by the FDA as a nutritional supplement and possesses anti-bacterial properties through the release of reactive oxygen species, such hydrogen peroxide. Upon contact with the Se-treated surface, the reactive oxygen released by Se kills the bacteria on contact, thereby preventing biofilm formation. This patented technology is called Selenium's SeLECT technology. Because it is bound permanently to the coating and yet remains bioactive, Se does not have to leave the surface to exert its antimicrobial action. Thus, leaching of Se to the environment is prevented. This technology will find use in the industry as a coating on proppants, sand and other materials used in hydraulic fracturing and as coatings on the iron pipes used in boreholes. Covalently bound Se on the surface of ceramic proppants for an example will be the next generation of non-leaching, environmentally-friendly biocidal technology. For more information about this technology, please see this link:

http://www.selenbio.com/technology/index.html#coatings





Schematic drawing of the Se coating on the inner side of pipes used in bore holes to prevent adhesion of bacteria.

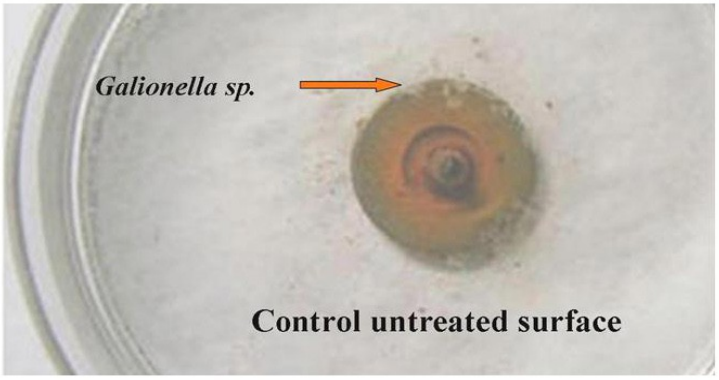
Selenium, Ltd.

About Selenium, Ltd. Selenium, Ltd. was founded in 2004 based on discoveries made by Co-Chief Scientists Julian Spallholz, Ph.D. and Ted Reid, Ph.D., professors within the Texas Tech University System. Their work revealed that certain organo-selenium molecules are catalytic and produce super oxide radicals, resulting in a lethal, but short-range toxicity to surrounding cells. Thus, selenium-coated surfaces act as an impenetrable barrier to microbes and other cells, and selenium-armed molecules will selectively destroy targeted cells. Selenium, Ltd. is an Emergent Technologies Inc. (ETI) portfolio company, and ETI provides all management services. For more information, visit the company website www.selenbio.com.

Selenium's Green Technology - Natural Antimicrobial Solutions Engineered For Specific Applications.

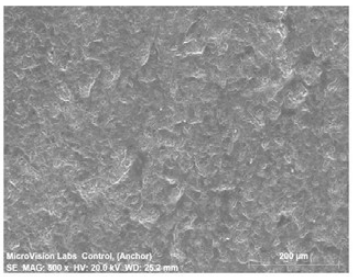
Selenium's SeLECT™ technology was originally developed within the Texas Tech University System by Dr. Ted Reid and Dr. Julian Spallholz, Co-Chief Scientists of Selenium and TTU professors. A "green technology," Selenium Ltd.'s proprietary chemistry is able to inhibit microbial growth on surfaces through a natural, safe catalytic reaction that does not leach chemicals or toxins into the surrounding environment. Target markets for SeLECT technology are medical device coatings and industrial coatings.

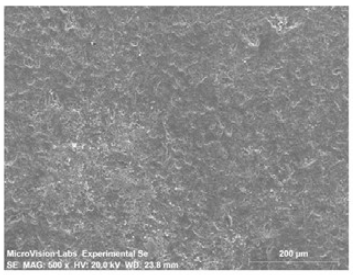
PROOF OF CONCEPT. Although the concept has been proven for orthodontics applications, it is yet to be demonstrated as a useful approach against bacteria associated with fluids from hydraulic fracturing operations. The culture of the iron bacteria, *Gallionella sp.,* was undertaken at Poseidon Sciences' facilities, thereby making it possible to develop a bioassay to evaluate the performance of SeGuardTM . In this method,



CONTROL

SeGuard



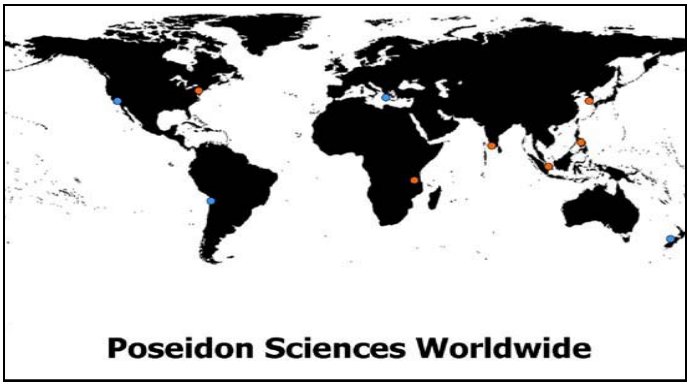


titanium washers were coated with Se and placed in a petri dish. Titanium is typically used in medical applications because of resistance to corrosion and used in these studies as interim substrate to test this concept. In the middle of the open area of the washer was a piece of iron to serve as nutrient source for the added *Gallionella sp*. Controls consisted of titanium washers that were not treated with Se. After immersion of the washers in a *Gallionella* rich environment for 9 days, the results show that Se-treatment prevented the migration of *Gallionella* over the surface of the Se-treated washer. A second experiment was conducted in which Se-treated and untreated washers were immersed in a *Gallionella* rich culture for a period of 14 days at 30 oC under anaerobic conditions. The results show that the control washers demonstrate the beginnings of corrosion compared to the Se-coated surfaces.

Poseidon Sciences is a research and development company focusing on a diverse portfolio of technologies with applictions in the marine and freshwater systems. The company also has a broad range of interest in alternative technologies to prevent biofouling, coatings research, oil spill response, mariculture, malaria control, natural products and subsea technologies. Poseidon conducts research through its facilities located in tropical regions. For more information, please visit our website at www.poseidonsciences.com.

For more information about collaborating in this applied research program, please contact:

Jonathan R. Matias, *Executive Director*
POSEIDON SCIENCES GROUP
122 East 42nd Street, Suite 1700, NY, NY 10168
www.poseidonsciences.com
+1 646 341 7714
jrmatias@poseidonsciences.com, poseidonnova@aol.com



Poseidon Sciences Worldwide