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# Microbially-Driven Fenton Reaction for Degradation of Oil Spill Contaminants

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**Background/Objectives.** Hazardous contaminants of heightened concern in the Gulf of Mexico (GoM) water column, coastal marine sediments, and beach sands impacted by the *Deepwater Horizon* (DWH) Macondo oil spill include a range of saturated, aromatic, and polar hydrocarbons, including n-alkanes, branched alkanes, monochromatic hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs). Recent concern over oil contamination is driven by several factors, including harmful effects on natural GoM ecosystems, human health concerns, and adverse effects on tourism and the fishing industry. Current physical, chemical, and biological remediation technologies are unable to effectively remove recalcitrant oil components, which subsequently accumulate to toxic levels. PAHs are especially problematic since PAH degradation rates may be exceedingly slow. Here we describe the development of alternative oil and gas remediation technologies based on microbially-driven Fenton reactions.

**Approach/Activities.** Our research team has successfully designed a microbially-driven Fenton reaction that autocatalytically generates hydroxyl ($HO^{--}$) radicals and degrades pentachlorophenol (PCP), 1,4-dioxane, trichloroethene (TCE), tetrachloroethene (PCE), and oil spill components including the PAHs pyrene and anthracene. In comparison to conventional (purely abiotic) Fenton reactions, the microbially-driven Fenton reaction operates at circumneutral pH and does not require addition of exogenous $H_2O_2$ or UV irradiation to regenerate Fe(II) as Fenton reagents. The contaminant degradation process is driven by the Fe(III)-reducing facultative anaerobe *Shewanella oneidensis.* Batch cultures amended with lactate, Fe(III), and contaminant were subsequently exposed to alternating aerobic and anaerobic conditions. During the aerobic period *S. oneidensis* produced $H_2O_2$ via microbial aerobic respiration, while during the anaerobic period *S. oneidensis* produced Fe(II) via microbial Fe(III) reduction. During the transition from aerobic-to-anaerobic conditions, $H_2O_2$ and Fe(II) interacted chemically via the Fenton reaction to produce $HO^{?}$ radicals that completely degraded PCP, 1,4-dioxane, TCE, PCE, and as described here, pyrene, and anthracene with optimal aerobic-anaerobic cycling frequencies of 3 h. The microbially-driven Fenton reaction thus provides the foundation for further development of alternative *ex situ* and *in situ* remediation technologies to degrade hazardous oil and gas components such as those released during catastrophic events of the DWH oil spill.

**Results/Lessons Learned.** Generation of reactive hydroxyl radicals via the microbially-driven Fenton reaction effectively degraded pyrene and anthracene. This system is currently being optimized to improve rates of co-contaminant degradation by examining effects of varying bacterial cell density, the concentrations of Fe(III), oxygen, and the co-contaminants in fed-batch reactor configurations.