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Microbial Remediation of Halogenated Compounds via Microbial Chain Elongation

-Chlorinated solvents (e.g., tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-cis-dichloroethene (cis-DCE) are widespread legacy groundwater pollutants. The most common groundwater treatment for bioremediation of PCE and TCE is in situ anaerobic reductive dechlorination by Dehalococcoides mccartyi. Hydrogen (H2) is a crucial electron donor in this process, and is typically generated by fermentative bacteria through conversion of organic substrates to H2. However, factors such as rapid substrate consumption, competition for H2, unfavorable thermodynamics, and clogging can result in H2 limitations and subsequent slow rates of dechlorination. While repeated intervention and addition of excessive substrate may provide enough H2 for reductive dechlorination, it can lead to additional complications, such as loss of H2 to production of methane (a greenhouse gas) and generation of unfavorable conditions for reductive dechlorination.

Researchers at the Biodesign Institute of Arizona State University and collaborators have developed a novel biotechnology for in situ bioremediation of chlorinated solvents, including PCE and TCE, using an H2-producing process called microbial chain elongation (MCE). They have achieved complete reductive dechlorination of TCE and cis-DCE to ethene through chain elongation of acetate and ethanol, and maintained reductive dechlorinating conditions through the subsequent fermentation of the MCE end-products. By employing chain elongation, reductive dechlorination can be improved at sites where dechlorination rates are impeded by difficulty in forming sustained H2 in situ, high microbial competition for H2, and high concentrations of electron acceptors.

The use of MCE in groundwater bioremediation schemes offers an alternative and possibly a more cost-effective approach for addressing slow reductive dechlorination rates.

Potential Applications

- Microbial anaerobic remediation of halogenated compounds in groundwater and soil
  - Including PCE, TCE, cis-DCE and vinyl chloride

Benefits and Advantages

- MCE generates thermodynamically favorable conditions for reductive dechlorination in groundwater and soil:
  - Innately produces H2
  - Does not result in net production of carbon dioxide/bicarbonate
  - Maintains groundwater pH within a favorable range (near neutral pH)
- MCE achieves complete and sustained reductive dechlorination:
  - Abundant H2 production overcomes demand from competing electron acceptors (i.e., nitrate and sulfate)
  - Inhibits or minimizes methanogenesis
  - MCE end-products (i.e., butyrate, butanol, and caproate) can become in situ source of slow-release H2
  - Field relevant chain elongation substrate dosages ~1 g L-1 drive
- MCE substrates could improve footage treatment by avoiding well and pore space clogging caused by traditional substrates

For more information about this opportunity, please see

Robles – Thesis – 2019

Robles et al – Environ Sci Technol - 2021

For more information about the inventor(s) and their research, please see

Dr. Delgado's departmental webpage

Dr. Delgado’s laboratory webpage