Oligomeric Surfactant-Enhanced Leaching Coupled with Bioremediation for Petroleum-Contaminated Soils

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Introduction.

Petroleum-contaminated soils are difficult to remediate due to a wide range of point/nonpoint sources of pollution and complex components. Here, the leaching process were optimized through the selection of conventional eluting agents and the development of oligomers, modified bio-based surfactants and synergists, leading to a new and efficient leaching system. From a colloid and interface chemistry perspective, remediation efficiency is governed by interfacial activity, wettability alteration, and the solubilization/emulsification of hydrophobic petroleum components at the soil-water interface. In particular, regulation of interfacial tension and wetting reversal of oil-coated soil surfaces can enhance pollutant detachment and transfer. A subsequent bioremediation step was retained to further degrade residual hydrocarbons after leaching. This study provides an economical and environmentally friendly technical route for emergency oil-spill response and historical petroleum-contaminated sites.

Experimental/methodology.

A benzene ring was used as a reaction site, and carbonyl and imino functional groups and substituted benzene were subjected to polycondensation reaction through catalysis to construct a molecular skeleton of the oligomeric surfactant. A branched structure was formed by adding dialdehyde with double reaction sites, followed by incorporation of hydrophilic groups on the benzene ring.

All raw materials required for the oligomeric surfactant are readily available. Compared with traditional single-chain surfactants, dimeric and oligomeric surfactants can self-assemble to perform various functions at much lower dosage. Such behavior is favorable for emulsification/demulsification balance, contaminant desorption from soil particles, and enhanced washing performance in porous media.

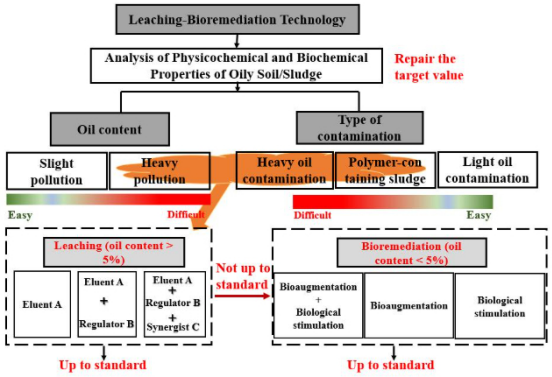
Results and discussion.

A new leaching agent system containing oligomers, green bio-based surfactant molecules, and synergists was developed to optimize soil-washing performance. The improved formulation showed advantages in interfacial activity and wetting regulation, promoting the desorption and mobilization of petroleum from soil particles. After leaching, a microbial polishing step was applied based on the characteristics of the treated soil, with screened petroleum-degrading bacteria used to remove residual heavy oil, polycyclic aromatic hydrocarbons and other pollutants.

According to the physical characteristics of different oily sludge and soil types, an economical and efficient remediation technology system and supporting implementation process were established, and finally, forming a "leaching-bioremediation" coupled treatment process. After treatment, the PHs content of actual contaminated soil was lower than 0.45%, and 12,000 t of contaminated soil was remediated. The results demonstrate that coupling interfacially tuned leaching with bioremediation is a practical strategy for petroleum-contaminated soils.

Keywords:

leaching, bioremediation, soil remediation, petroleum pollution, colloid and interface chemistry



Schematic diagram of the coupled leaching-bioremediation process for petroleum-contaminated soils