Treating TCE Solubilized in Surfactants with Chemicals Including Nano Fe

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Abstract

Using reactive media such as $FeCl_2$, $KMnO_4$, iron metal (Fe^0), and nanoscale Fe to treat trichloroethylene (TCE) solubilized in surfactants is being investigated. Surfactants used were UH biosurfactant, Rhamnolipid, Triton X-100, and sodium lauryl sulfate (SDS). The surfactants increased the solubility of TCE by several times the solubility in water (1,000 mg/L). All measurements showed that $KMnO_4$ was most effective among the testing reactive medias in treating TCE solubilized in surfactant solutions.

1. INTRODUCTION

Dense non-aqueous phase liquids (DNAPLs) are commonly detected at contaminated sites because of spills and the release of crude oil and refined petroleum-related products from petrochemical industries. A national Superfund site assessment study concluded that approximately 60% of the National Priorities List sites have medium to high level of DNAPLs. Because of their immiscibility, lower solubility, relatively slow rates of dissolution, high density, and capillary forces arising from interfacial tension between the DNAPLs and water, it is extremely difficult to remedy DNAPLs. The presence of DNAPLs represents a significant threat to soil and groundwater resources. More and more studies showed that pump-and-treat techniques were not adequate to extract DNAPLs from the subsurface. There is an emerging need to develop an innovative technique to clean up DNAPL effectively and efficiently.

2. OBJECTIVE

The overall objectives of this study are to chemically treat TCE that is solubilized in biosurfactants and chemical surfactants. Specific objectives are (1) to characterize surfactant through surface tension, critical micelle concentration (CMC), and critical micelle dilution (CMD); (2) to investigate the role of surfactant in solubilizing TCE and to quantify the molar solubilization ratio (MSR); and (3) to investigate the effectiveness of using chemicals such as $FeCl_2$, $KMnO_4$, iron metal (Fe^0), and nanoscale Fe to treat trichloroethylene (TCE) that is solubilized in surfactants.

3. TESTING PROGRAM

Surfactant. The biological and chemical surfactants under investigation were UH biosurfactant, Rhamnolipid, Triton X-100, and SDS. UH biosurfactant was produced from used vegetable oils by *Flavobacterium sp.* under nonaseptic conditions. Rhamnolipid, a biosurfactant produced from glucose by *Bacillus sp.*, was obtained from Co. Chemical surfactants of Triton X-100 and SDS were obtained form Sigma and Fisher Co., respectively. Surfactant was characterized for its surface tension, critical micelle concentration (CMC), and critical micelle dilution (CMD).

Solubilization study. Solubilization enhancement was determined by adding 2-mL of TCE in 200-mL glass vial with surfactant concentration of 2 g/L. The reactors were mixed on shaker platform at 200 rpm at room temperature.

Reactor setup. The effectiveness of using chemicals such as $FeCl_2$, $KMnO_4$, iron metal (Fe^o), and nanoscale Fe to treat TCE that solubilized in surfactants was evaluated in batch reactor. The TCE concentration was continuously monitored after mixing 10 g/L of each chemical into 40-mL TCE/surfactant solution obtained from above mentioned study on shaker platform at 200 rpm at room temperature.

TCE Analysis. A Shimadzu Gas Chromatograph (GC) equipped with a packed column and a flame ionization detector (FID) was used to analyze the concentration of TCE in the aqueous phase. The injector temperature and detector temperature were 150 ^oC and 250 ^oC, respectively. The detection time for TCE was 3.5 minutes.

4. RESULTS

Surfactants characterization. The CMC of UH biosurfactant was 0.7 g/L. The CMCs for Rhamnolipid, SDS, and Triton X-100 were 0.02, 2.3, and 0.1, g/L respectively. Surface tensions at CMC for biosurfactant, Rhamnolipid, SDS, and Triton X-100 were 28, 41, 36, and 38 dynes/cm, respectively

Solubilization of TCE. The apparent solubility of TCE was increased in the presence of surfactants. The solubility of TCE was increased by more than 3.5 times and 6 times when 5 CMC and 10 CMC of UH biosurfactant were used.

TCE removal. Among the testing chemicals, $KMnO_4$ was most effective to remove TCE solubilized in surfactants. A better performance of $FeCl_2$ and nano Fe was observed in UH biosurfactant.

5. CONCLUSIONS

(1) This study indicated that UH biosurfactant has comparable capacity to commercial Rhamnolipid and chemical surfactants such as SDS and Triton X-100.

(2) Among the testing chemicals, $KMnO_4$ was very effective in treating TCE solubilized in surfactants. Both $FeCl_2$ and nano Fe had a better performance in UH biosurfactant system.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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