Adsorption of Phenanthrene on Kaolinite Clay

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Abstract

The adsorption of phenanthrene by kaolinite clay was investigated in batch reactors at a liquid-to-solid ratio of 5. The adsorption isotherms were linear at the concentration ranges investigated. The presence of SDS, an anionic surfactant, affected the adsorption of phenanthrene. When SDS concentrations were less than its CMC, the presence of SDS enhanced the adsorption of phenanthrene to around 10 L/kg from 5 L/kg.. When SDS concentrations were above its CMC, the presence of SDS reduced the adsorption of phenanthrene to around 1 L/kg..

1. Introduction

Surfactants have been proposed to be used to enhance the remediation of hydrophobic organic compounds (HOCs) contaminated soils1. Surfactants enhance remediation in three ways: increasing contaminant mobility and solubility to improve pump-and-treat performance; decreasing the mobility of contaminants to prevent their migration; speeding the rate of biodegradation of contaminants2. The effects of surfactants come from the fact that the hydrophobic organic contaminants can be incorporated into the hydrophobic cores of surfactant micelles. Micelles are aggregates of surfactant molecules. When surfactant concentration reaches the CMC, micelles start to form3.

When a surfactant is applied to a soil-aqueous system, the surfactant molecules can also get sorbed on the soil, together with the monomers and micelles in aqueous phase. Molecules of hydrophobic contaminants (such as phenanthrene) in such a system can dissolved in aqueous solution, solubilized in surfactant micelles, sorbed directly on the soil, or sorbed on the sorbed surfactant molecules4. If there is no micelles in the system or the solubilization by micelles is less than the adsorption on sorbed surfactants, more hydrophobic compounds will be adsorbed on the solid phase.

In this research, the adsorption of phenanthrene on kaolinite clay was investigated. SDS was chosen as a representative anionic surfactant.

2. Test Methods

2.1 Solubilization Test

A series of solutions of different SDS concentrations (up to 10 g/L) was prepared by dissolving known amount of SDS in DI (deionized) water. Solid phenanthrene was added into the solutions at a total concentration of 200 mg/L. After 48-hour shaking, samples were taken and centrifuged at 4000g for 10 min. The supernatant was analyzed for phenanthrene concentration using a UV spectrophotometer at 248 nm. Up to 60 mg/L phenanthrene was solubilized in 10 g/L SDS solution.

2.2 Adsorption Test

Adsorption study was done in batch slurry reactors. A liquid to solid ratio of five was used. After at least one day equilibration, samples were taken and centrifuged at 4000g for 1 hour. Supernatant was analyzed for phenanthrene concentration with the UV spectrophotometer. Adsorption was calculated with mass balance equation.

3. Results and Discussion

3.1 Solubilization of Phenanthrene

At SDS concentrations below its CMC, phenanthrene concentrations in the solution were the same as its water solubility (1.28 ppm at 25_ C). This is because the surfactant monomers does not have much effect on the dissolution of phenanthrene. When SDS concentrations were above its CMC, phenanthrene concentrations shown linear increase with SDS concentration. The increase in phenanthrene solubilization was caused by the incorporation of phenanthrene molecules into the micelles. The higher the SDS concentration is, the more the micelles are, and the more phenanthrene get solubilized.

3.2 Adsorption of Phenanthrene

The adsorption of phenanthrene on kaolinite clay had a linear isotherm. The soil-water partition coefficient (Kd) was calculated according to the equation below.

where qs is phenanthrene concentration in the solid phase (mg phenanthrene / kg clay) and Ce is the equilibrium liquid concentration. The adsorption of phenanthrene first increased with SDS concentration in

the system, reached peak values around CMC, and decreased after SDS concentration was above its CMC.

4. Conclusion

Surfactants (such as SDS) can enhance the solubilization of hydrophobic organic compounds (such as phenanthrene). This property can be used to enhance the remediation of contaminated soils by enhancing solubilization of free residual contaminants and the desorption of sorbed contaminants on soil. To be effective, surfactant concentrations have to be above surfactant CMC. The adsorption of surfactants also needs to be considered because the sorbed surfactant molecules act as a sorbent for the contaminants.

5. Acknowledgment

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6. References

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