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Reuse of Surfactants in Soil Washing Process by Selective Removal of Contaminants

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are among the most common organic pollutants founds in air, water, soil and sediment. These compounds bring environmental concerns, due to their carcinogenic and mutagenic properties. PAHs have extremely low water solubility and are strongly sorbed to soil. Soil washing is one of the recommended technologies for remediation of contaminated soils with PAHs. While the use of surfactants significantly enhances the performance of soil remediation, operation costs are increased as surfactant dosages are increased. Thus, it is necessary to develop the surfactant reuse processes for cost effective soil washing. Current approaches to reduce surfactant usage include ultrafiltration, precipitation, foam fractionation, and photochemical treatment. However, these methods are limited since the fluxes are decreased by gel-layer formation or ineffectiveness above critical micelle concentration (CMC). In this study, selective adsorption of contaminants by activated carbon is proposed to separate surfactant from washed solution. The effectiveness of selective adsorption using various nonionic surfactants was investigated. Charcoal-based GAC (Darco 20~40 mesh) was used as adsorbents and phenanthrene as a representative PAH. Selective adsorption tests were performed using five different surfactants (Triton X-100, Tween 40, Tween 80, Brij 30 and Brij 35) at various concentrations. Phenanthrene and surfactant were analyzed after filtering (0.45㎛) by using HPLC (Dionex) with an UV detector and TOC analyzer (SHIMAZU TOC-5000A).

The selectivity, the ratio of partition coefficient of phenanthrene to that of surfactant, represents how effective the conditions are for selective adsorption. Fig. 1 shows the selectivity obtained from batch adsorption tests at various concentrations of surfactants with a fixed phenanthrene concentration.

Table 1. The selected properties of various surfactants used in this study

	Triton X-100	Tween 40	Tween 80	Brij 30	Brij 35
Mol formula	$C_8H_{17}C_6H_4O$	$C_{16}H_{33}S_6$[b]	$C_{18}H_{37}$ S_6[b]	$C_{12}H_{25}$	$C_{12}H_{25}$
(average)	$E^a{}_{9.5}H$	$E^a{}_{20}OH$	$E^a{}_{20}OH$	$E^a{}_4OH$	$E^a{}_{23}OH$
Mw[c] (g/mol)	625	1282	1310	363	1200
CMC (g/L)	1.06×10^{-1}	1.67×10^{-2}	2.27×10^{-2}	1.27×10^{-2}	3.96×10^{-2}
HLB[d] (-)	13.5	15.6	15.0	9.7	16.9
WSR[e]	0.0266	0.0298	0.0296	0.0683	0.0209

[a]: ethylene (CH_2CH_2O), [b]: sorbitan ring ($C_6H_9O_5$), [c]: molecular weight, [d]: hydrophile-lipophile balance, [e]: weight solubilization ratio (g-phenanthrene/g-surfactant)

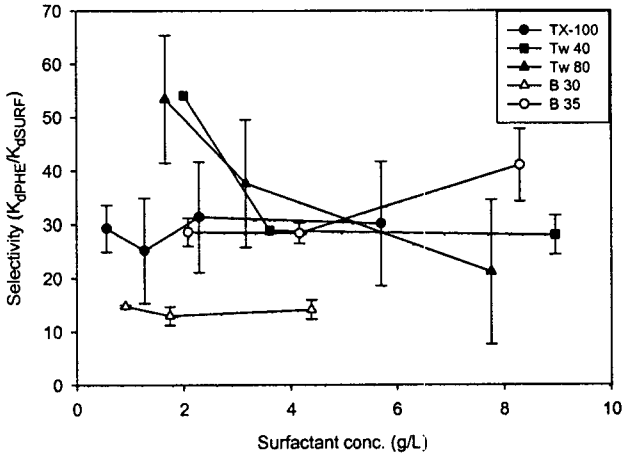

Fig. 1. Effect of initial surfactant concentrations on selectivity at 10 mg phenanthrene/L.

In all cases, the selectivity for phenanthrene to surfactant was larger than 1, suggesting that adsorption by using the GAC is an effective method to reuse the surfactants. The patterns on selectivity on surfactant concentration are very complicated as seen in Fig.1, since the value depends on partitioning of both surfactant and phenanthrene. The selectivity of Brij 30 was low (around 15) in whole ranges of surfactant concentrations. The highest selectivity (around 55) was obtained with Tween 40 and Tween 80 at low concentrations of the surfactants, suggesting that these are more effective than others from the viewpoint of surfactant reuse. The results demonstrate that the selective adsorption is potentially effective to reuse surfactants in a soil-washing process for the remediation of contaminated soils

Key words: GAC, PAH, selective adsorption, soil washing, surfactant reuse