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Soil Washing and Biodegradation Potentials of Amphiphilic Polyurethane(APU) Nano-network Particles

Young-Bum Kim · Shin-A Jang · Ju Young Kim[1] · Eun-Ki Kim*
Dept. of Biological Engineering, Inha University
Dept. of Materials Engineering, Samchuck Nat'l University[1]
Tel (032)872-2978, Fex (032)875-0827

ABSTRACT

Amphiphilic polyurethane(APU) particle is a polymeric surfactant, and could increase the solubility of 2-methylnaphthalene significantly. 2-Methylnaphthalene was recovered by the precipitation of APU particles and was degraded by *Acinetobacter* sp. K2-2. APU particle was recovered and reused after treatment of triethylamine.

INTRODUCTION

Soil pollution by organic chemicals such as pesticides, industrial solvents and petroleum products has emerged as one of the major environmental problems.

Contaminated subsurface environments have become great problems, because many countries including Korea rely on groundwater resources for drinking water supply. In any case, there are numerous contaminated sites dangerous to man and other life forms.

The use of soil washing is a common method in remediation of soil. However, some sites contaminated with hydrophobic organic compounds(HOCs) can not use this technology because of the slow rate of HOCs' desorption from soil. The rate of hydrocarbon biodegradation therefore depends upon the bioavailability of organic compounds.

Some surfactants have disadvantages such as micelle breakage, and high degree of adsorption to soil. These disadvantages result in high cost.

Amphiphilic polyurethane(APU) nano-network particles have hydrophilic carboxylic groups on the surface and a hydrophobic backbone in their core. Therefore they can act like surfactants in soil washing.

APU particles have advantages that do not break up which was observed in surfactant micelles and remain intact due to its low adsorption to soil. They can be recovered after soil washing and reused.

The purposes of this study were to investigate APU particles' potential of soil washing and to find the recovery and reuse conditions after soil washing.

In addition, the ability of HOCs to be solubilized and transported by APU particles into bacterial cells was enhanced.

MATERIALS AND METHODS

Materials

Amphiphilic ionomer networks were synthesized from polyurethane acrylate anionomer(UAA) precursors(Song et. al., 1996; Kim et. al., 1997). 2-methylnaphthalene(Aldrich, 98%) was used as a model contaminant.

Surface Tension and Solubility Experiments

Surface tension of APU solutions were measured using a Fisher surface tensiomat. Aqueous solubility experiments were performed in 20mL vials using surfactant solutions(10000-40000ppm) in the presence of excess quantities of 2-methylnaphthalene (24h, 25℃). Samples were equilibrated for about 48h, and the supernatant was extracted and analyzed by GC(Shimadzu).

Recovery of APU particles.

The effects of temperature, $CaCl_2$ and pH on the precipitation APU particles were evaluated. All experiments were performed with 25℃, 80000ppm APU, pH 6.5 and 0.8N $CaCl_2$.

Flushing of 2-methylnaphthalene by APU particles

Model pollutant, 2-methylnaphthalene, which had the concentration below MSR value was added to 10000ppm APU solution, and shaked for 20hrs. APU was recovered by filtering after precipitation by using of 0.5N CaCl2.

2-Methylnaphthalene inside the APU particles was extracted by hexane.

Initial and final concentration of 2-methylnaphthalene were compared by Gas Chromatography(GC, Shimadzu)

Biodegradation Experiments

Microorganism *Acinetobacter* sp. K2-2 was obtained from Korea Ocean Research and Development Institute(KORDI)

2 Times concentrated MS medium which contained 2-methylnaphthalene, and different concentration of APU solution which also 2times concentrated were mixed and autoclved, then contained for 20hrs in shaking incubator until the pollutant and APU were equalization. At equilibrium, pre-incubated *Acinetobacter* sp. K2-2 was innoculated and cultivated at 37℃, 200rpm for 3days.

Same volume of hexane was added to extract 2-methylnaphthalene and the emulsion was remved by centrifugation at 10000rpm for 10min, and the concentration of contaminant in the hexane was analyzed by GC(Shimadzu)

RESULTS AND DISCUSSIONS

For surfactants, a fundamental and important property is critical micelle concentration(CMC). However APU particles didn't have CMC(Fig. 1), because they already formed a micelle. However, surface tension continue being decreased by increasing the APU concentration.

In figure 2. APU particles increased the solubility of 2-methylnaphthalene significantly. Molar solubilization ratio(MSR) was 0.38 and solubility of 2-methylnaphthalene in 10,000mg/L APU particles increased about one hundred times more that in water.

The optimum condition for APU precipitation is very important, because they can be reused after soil washing. $CaCl_2$ concentration influenced the precipitation significantly(Fig. 3), but pH and temperature should no effect. Over 0.1N $CaCl_2$ concentration precipitated APU particles instantly. However at low concentration(0.6N), no precipitation was observed.

These results showed that APU particles could be employed in soil washing and the use of them could be very economical due to the recovery and re-use of APU particle.

In figure 4. 2-methylnaphthalene was recovered by the precipitation of APU, that had recovery rate of 92% at 500ppm, In addition, the ability of HOCs to be solubilized and transported by APU particles into bacterial cells was enhanced(Fig. 5).

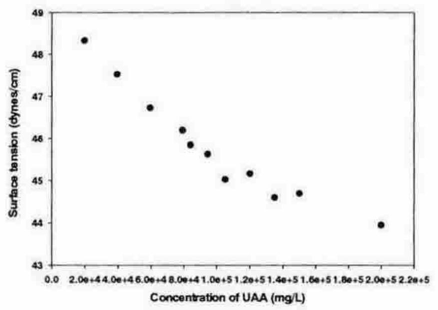


Figure. 1. Surface tension of APU particles

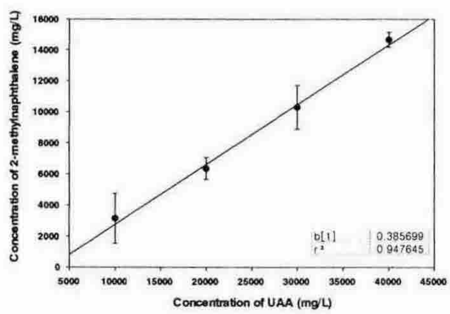
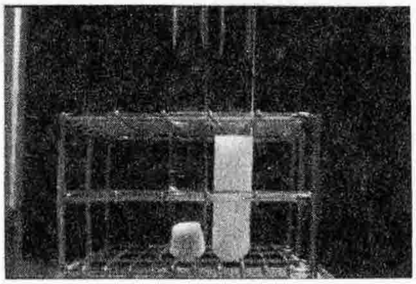


Figure 3. Effect of AUP particles on the solubility of 2-methylnaphthalene.



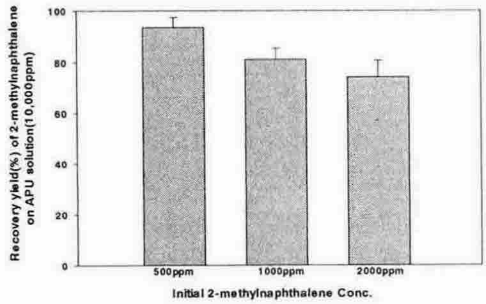


Figure 3. The precipitation of APU
Figure 4. Recovery of 2-methylnaphthalene particles with $CaCl_2$
by APU particles

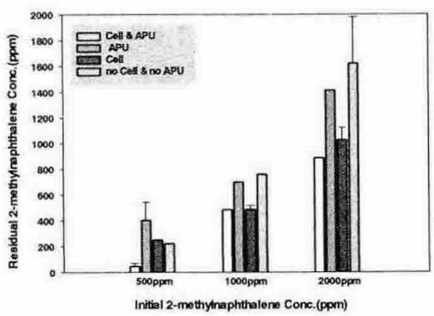


Figure 5. Effect of APU particles on the degrading of HOCs by *Acinetobacter* sp. K2-2.

REFERENCES

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