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Oil recovery from refinery oily sludge using a rhamnolipid biosurfactant-producing *Pseudomonas*

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ABSTRACT

In this study, a rhamnolipid biosurfactant-producing strain, *Pseudomonas aeruginosa* F-2, was used to recover oil from refinery oily sludge in laboratory and pilot-scale experiments. The optimum values of carbon to nitrogen ratio, temperature, sludge–water ratio and inoculum size for oil recovery were determined as 10, 35 °C, 1:4 and 4%, respectively. An oil recovery of up to 91.5% was obtained with the equipping of draft tubes during the field pilot-scale studies. The results showed that strain F-2 has the potential for industrial applications and may be used in oil recovery from oily sludge.

1. Introduction

Oily sludge is a complex mixture of petroleum hydrocarbons, sediments, heavy metals and water, generated during the exploration and development of oilfields and also in the petroleum refineries. The annual output of oil sludge by China's refinery industry was estimated to be about 1,000,000 tons, mainly derived from the cleaning process of oil storage tanks (Liu et al., 2011).

Oily sludge is listed as hazardous waste in Resource Conservation and Recovery Act (RCRA) (USEPA, 1989), and represents a major source of contamination for soil, air and ground water. Because of its large yield, treatment difficulties, and potential hazards to the environment, oily sludge has become as a major problem plaguing the petroleum and petrochemical industry (Chang et al., 2000).

Due to the numerous sources of oily sludge, there is no single method for oily sludge treatment. Typically, oil sludge can be handled via various physical and chemical processes such as dewatering and incineration, stabilization, solvent extraction, washing by hot water and surfactant, pyrolysis, and biodegradation (Jing et al., 2011). However, each method has its own advantages and disadvantages. In general, expensive reagents and complex equipments are needed during the oil recovery from oily sludge using physical and chemical methods, complicating the processes and increasing operating costs. In addition, secondary pollution may be caused when chemical approaches are applied. Microbial degradation of oily sludge typically saves energy, capital investment and operating costs. However, it would be inadvisable to decompose oil by microorganisms, since oily sludge is recognized as a valuable energy resource that can be recycled as fuel (Shie et al., 2000).

Synthetic surfactants that are used to enhance contaminant solubility are often toxic, representing an additional source of contamination (Banat et al., 2004). Recently, extensive studies have been conducted on the isolation and characterization of surfactant-producing microorganisms and their application in environment remediation (Lai et al., 2009; Saeki et al., 2009; Sarachat et al., 2010; Ferhat et al., 2011).

Biosurfactants can be used not only for bioremediation processes, but also for cleaning oil storage tanks, increasing flow though pipelines and enhancing oil recovery from oil reservoirs (Desai and Banat, 1997). However, studies on the application of biosurfactants for oil recovery from oily sludge are still very scarce. Pornsunthorntawee et al. (2008) reported obtaining higher oil recoveries using biosurfactants than that obtained using synthetic surfactants on a laboratory scale.

In this study, studies on oil recovery from oily sludge using the biosurfactant-producing microorganism, *Pseudomonas aeruginosa* F-2, were carried out in laboratory and pilot-scale experiments. The orthogonal experimental design was used to determine the optimum conditions for oil recovery from the oily sludge. The

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