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Research review paper

Surfactants in microbiology and biotechnology: Part 2. Application aspects

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Abstract

Surfactants are amphiphilic compounds which can reduce surface and interfacial tensions by accumulating at the interface of immiscible fluids and increase the solubility, mobility, bioavailability and subsequent biodegradation of hydrophobic or insoluble organic compounds. Chemically synthesized surfactants are commonly used in the petroleum, food and pharmaceutical industries as emulsifiers and wetting agents. Biosurfactants produced by some microorganisms are becoming important biotechnology products for industrial and medical applications due to their specific modes of action, low toxicity, relative ease of preparation and widespread applicability. They can be used as emulsifiers, de-emulsifiers, wetting and foaming agents, functional food ingredients and as detergents in petroleum, petrochemicals, environmental management, agrochemicals, foods and beverages, cosmetics and pharmaceuticals, and in the mining and metallurgical industries. Addition of a surfactant of chemical or biological origin accelerates or sometimes inhibits the bioremediation of pollutants. Surfactants also play an important role in enhanced oil recovery by increasing the apparent solubility of petroleum components and effectively reducing the interfacial tensions of oil and water in situ. However, the effects of surfactants on bioremediation cannot be predicted in the absence of empirical evidence because surfactants sometimes stimulate bioremediation and sometimes inhibit it. For medical applications, biosurfactants are useful as antimicrobial agents and immunomodulatory molecules. Beneficial applications of chemical surfactants and biosurfactants in various industries are discussed in this review.

Keywords: Biosurfactant; Chemical surfactant; Emulsification; De-emulsification; Oil recovery; Toxicity; Environmental applications

Contents

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1. Introduction

Chemical and biosurfactants are amphiphilic compounds which can reduce surface and interfacial tensions by accumulating at the interface of immiscible fluids and increase the solubility and mobility of hydrophobic or insoluble organic compounds (Prince, 1997; Ron and Rosenberg, 2002; Mulligan, 2005). However, bioavailability and biodegradation kinetics of the hydrophobic pollutants are affected variably by the surfactants. Both stimulating and inhibiting effects of surfactants on bioremediation of pollutants are known depending on the chemical characteristics of the surfactant, pollutant and physiology of the microorganism (Banat et al., 2000; Van Hamme et al., 2003). In nature, biosurfactants play a physiological role in increasing bioavailability of hydrophobic molecules, are involved in promoting the swarming motility of microorganisms and participate in cellular physiological processes of signaling and differentiation (Kearns and Losick, 2003). They are also involved in the processes of biofilm formation. Surfactants can interact with microbial proteins and can be manipulated to modify enzyme conformation in a manner that alters enzyme activity, stability and/or specificity (Kamiya et al., 2000). Chemical surfactants can mimic the latter effects of biosurfactants and have been exploited, for example, as antimicrobial agents in disease control and to improve degradation of chemical contaminants. Both chemical- and biosurfactants are potentially toxic to specific microbes and may be exploited as antimicrobial agents against plant, animal and human microbial pathogens (Colores et al., 2000; Boyette et al., 2002; Cameotra and Makkar, 2004). In Part 1 of this review the physiological roles of biosurfactants and chemical surfactants in nature were examined (Van Hamme et al., 2006). In this Review a variety of industrial, environmental and agricultural applications of surfactants are discussed. Specific uses of surfactants in biotechnological processes, including upstream and downstream processes, are also reviewed and their innovative applications in biocatalysis are described. Finally we examine the processes for production of microbial biosurfactants by fermentation and chemoenzymatic methods for synthesis of specific chemical surfactants.

2. Industrial and environmental applications

Chemical and biological surfactants play an important role in oil recovery and bioremediation of pollutants. Various applications of surfactants are shown in Table 1.