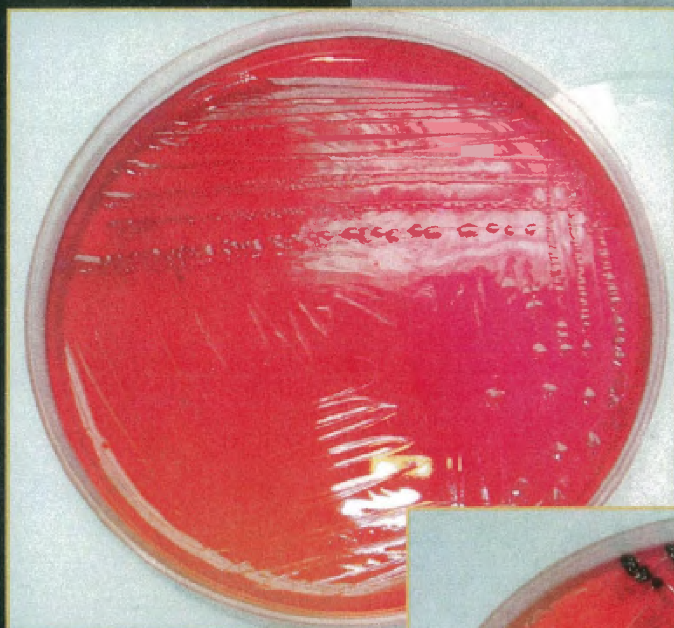
BIOSURFACTANTS

Research Trends and Applications



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6 Characterization, Production, and Applications of Lipopeptides

Catherine N. Mulligan

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INTRODUCTION

Surfactants are amphiphilic compounds that reduce the free energy of the system by replacing the bulk molecules of higher energy at an interface. They contain a hydrophobic portion with little affinity for the bulk medium and a hydrophilic group that is attracted to the bulk medium. Surfactants have been used industrially as adhesives; flocculating, wetting, and foaming agents; deemulsifiers; and penetrants (Mulligan and Gibbs, 1993). They are used for these applications based on their abilities to lower surface tensions and increase solubility, detergency power, wetting ability, and foaming capacity. Petroleum users have traditionally been the major users, as in enhanced oil removal applications by increasing the solubility of petroleum components (Falatko, 1991). They have also been used for mineral flotation and in the pharmaceutical industries. Typical desirable properties include solubility enhancement, surface tension reduction, the critical micelle concentrations (CMCs), wettability, and foaming capacity.

Surfactants are classified as cationic, anionic, zwitterionic, and nonionic and are made synthetically from hydrocarbons, lignosulfonates, or triglycerides. Some common synthetic surfactants include linear alkyl benzenesulfonates, alcohol sulfates, alcohol ether sulfates, alcohol glyceryl ether sulfonates, α-olefin sulfonates, alcohol ethoxylates, and alkylphenol ethoxylates (Layman, 1985). Surfactants have many applications industrially with multiphasic systems. Sodium dodecyl sulfate (SDS, $C_{12}H_{25}$-SO_4^- Na^+) is a widely used anionic surfactant. The effectiveness of a surfactant is determined by surface tension lowering, which is a measure of the surface free energy per unit area or the work required to bring a molecule from the bulk phase to the surface (Rosen, 1978). These amphiphilic compounds (containing hydrophobic and hydrophilic portions) concentrate at solid–liquid, liquid–liquid, or vapor–liquid interfaces. An interfacial boundary exists between two immiscible phases. The hydrophobic portion concentrates at the surface while the hydrophilic is oriented toward the solution. A good surfactant can lower the surface tension of water from 72 to 35 mN/m and the interfacial tension (tension between nonpolar and polar liquids) for water against n-hexadecane from 40 to 1 mN/m. Efficient surfactants have a low CMC (i.e., less surfactant is necessary to decrease the surface tension) as the CMC is defined as the minimum concentration necessary to initiate micelle formation (Becher, 1965). In practice, the CMC is also the maximum concentration of surfactant monomers in water and is influenced by pH, temperature, and ionic strength.

An important factor in the choice of surfactant is the product cost (Mulligan and Gibbs, 1993). In general, surfactants are used to save energy and consequently energy costs (such as the energy required for pumping or mixing). Charge type, physicochemical behavior, solubility, and adsorption behavior are some important selection criteria for surfactants.

Some surfactants, known as biosurfactants, are biologically produced from yeast or bacteria (Lin, 1996). They can be potentially as effective with some distinct advantages over the highly used synthetic surfactants due to high specificity, biodegradability, and biocompatibility (Cooper, 1986).

Biosurfactants are grouped as glycolipids, lipopeptides, phospholipids, fatty acids, and neutral lipids (Bierman et al., 1987). Most of these compounds are either anionic or neutral, with only a few cationic ones. The hydrophobic parts of the molecule are based on long-chain fatty acids, hydroxy fatty acids, or α-alkyl-β-hydroxy fatty acids. The hydrophilic portion can be a carbohydrate, amino acid, cyclic peptide, phosphate, carboxylic acid, or alcohol. A wide variety of microorganisms can produce these compounds. The CMCs of the biosurfactants generally range from 1 to 200 mg/L and their molecular weights (MWs) from 500 to 1500 amu (Lang and Wagner, 1987).

LIPOPEPTIDE BIOSURFACTANTS

Lipopeptides are produced by a variety of microorganisms, including *Bacillus*, *Lactobacillus*, *Streptomyces*, *Pseudomonas*, and *Serratia* (Cameotra and Makkar, 2004; Georgiou et al., 1992). The lipopeptides are cyclic peptides with a fatty acyl chain. Various lipopeptides include surfactin (Roongsawang et al., 2003; Youssef et al., 2007), lichenysin A (Yakimov et al., 1995) or C (Jenny et al., 1991), B (Folmsbee et al., 2006), D (Zhao et al., 2010), bacillomycin (Roongsawang et al., 2003), fengycin

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