Biochemical Engineering Journal 103 (2015) 158–169

Contents lists available at ScienceDirect

Biochemical Engineering Journal

journal homepage: www.elsevier.com/locate/bej

Review

Applications of a lipopeptide biosurfactant, surfactin, produced by microorganisms

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ARTICLE INFO

Article history:
Received 8 April 2015
Received in revised form 30 June 2015
Accepted 11 July 2015
Available online 21 July 2015

Keywords:
Surfactin
Biodegradation
Bioremediation
Bioseparations
Environmental preservation
Global environment
Microbial production system

ABSTRACT

Surfactin, one of the most powerful biosurfactants, is a lipopeptide-type biosurfactant that is generated by the gram-positive, endospore-producing, microorganism, *Bacillus subtilis*. The chemical structure of surfactin is composed of seven amino acids that are bonded to the carboxyl and hydroxy groups on long chain fatty acids (C_{13}–C_{15}). The potential applications of surfactin are therapeutic applications, and environmental applications. However, the high cost of surfactin production and its low yields limit its range of commercial applications. This work therefore develops the natural production a surface active agent by microorganisms and evaluates the microbial production system, the purification process, the identification process and the potential applications of surfactin.

Contents

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http://dx.doi.org/10.1016/j.bej.2015.07.009
1369-703X/

1. Introduction

Endocrine disruptors (persistent organic pollutants, POPs) have been demonstrated to interfere with the hormone systems of animals, including humans, causing such symptoms as tumors, birth defects and other developmental disorders, because they accumulate in the natural environment and the human body [1,2]. Only a few microorganisms can digest these POPs owing to their high surface tension and low solubility in water or hydrophobia [3,4]. The United Nations Environment Programme has sought the control of these POPs following negotiations at the Stockholm Convention on 23 May 2001 [5]. To solve problems of pollution by POPs, surfactants are utilized owing to their interfacial rheological behavior [6]. Various industrial applications of surfactants, including foam formation [7], stabilization in food processing [8], bioremediation of water-insoluble pollutants [9] and their use as detergents are all based on this property.

Numerous commercially available surfactants can be classified by origin as either chemical synthetic (Table 1) or natural surfactants that are derived from organisms, called biosurfactants [21]. However, some synthetic surfactants, such as methylene-blue active substances and nonylphenol polyethoxylate, are detrimental to environmental ecology [22]. Biosurfactants have been attracted much attention from industry in recent years because they have the owing following advantages over chemical synthetic surfactants. Examples include lower toxicity, higher biodegradability, better environmental compatibility, specific activity under extreme conditions (of temperature, pH, and salinity) and the ability to be synthesized from renewable feedstocks [23,24]. Biosurfactants that are generated by microorganisms are amphiphilic compounds with hydrophilic heads and hydrophobic tails normally hydrocarbon chains that reduce the surface tension between liquid phases such as at oil–water and air–water interfaces [23,25]. Surfactant are typically categorized into four broad classes according to their polar hydrophilic head group. The classes are (i) anionic, (ii) cationic, (iii) nonionic and (iv) zwitterionic (Table 1) [23]. Biosurfactants are classified into five classes based on their natural chemical structure and microbial origin. These classes are (i) glycolipids (ii) phospholipids and fatty acids (iii) lipopeptides or lipoproteins (iv) polymeric surfactants and (v) particulate surfactants. (Table 2).

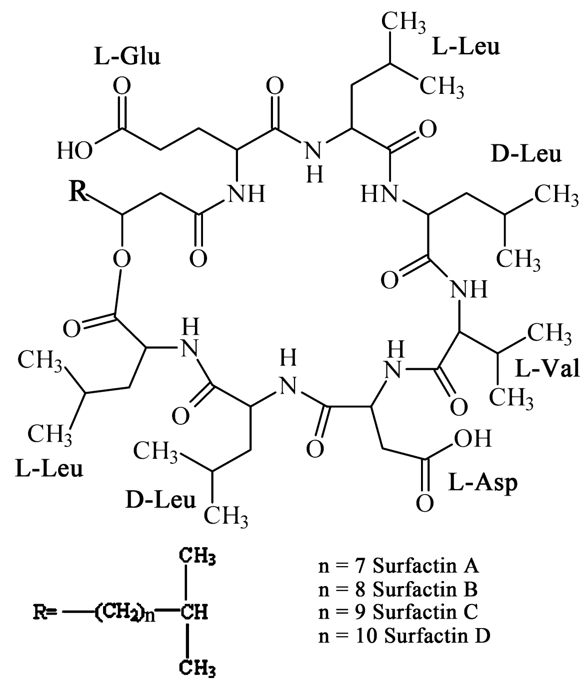

Fig. 1. Chemical structures of surfactins [33].

Surfactin, one of the most powerful biosurfactants, is a lipopeptide-type biosurfactant that is formed by various strains of the gram-positive, endospore-producing, microorganism, *Bacillus subtilis* [23,35,36]. Surfactin as a secondary metabolite was first found in a cultivation broth of *B. subtilis* in 1968 and consists of four isomers (Surfactin A–D) and exhibits various physiological activities, including as an inhibitor of fibrin clotting and as a cell lysate agent [46]. The chemical structure of surfactin has a common peptide loop of seven amino acids (L-asparagine, L-leucine, glutamic acid, L-leucine, L-valine and two D-leucines) with a long hydrophobic fatty acid chain, as displayed in Fig. 1 [47]. Surfactin at a concentration of 20 μM decreases the surface tension of water from 72 to 27 mN/m, which is considerably lower than the surface tensions of most biosurfactants in the literature [23,35,36]. In addition, surfactin with far below the critical micelle concentration of 23 mg/L is in water [23]. In recent years, surfactin has been characterized as anti-bacterial, anti-viral, anti-fungal, anti-mycoplasma and hemolytic meaning that it exhibits cation-carrier and pore-forming effects) [47–51].

The recent annual increase in the production of surfactants is 2–4% [24]. The surfactant market is expected to grow robustly. However, the high production cost of biosurfactants has become a great issue in industry and hindered their development. Although biosurfactants have to compete with chemical synthetic surfactants in terms of cost, biosurfacants must still be utilized in some high-priced products in, for example, cosmetics and medicine. Increasing the environmental biocompatibility of industrial applications has become increasingly important. The commercial of biosurfactants reflects this fact. In this work, the natural production of a lipopeptide biosurfactant by *B. subtilis* will be developed and the microbial production system, fermentation strategies, purification and identification processes will be elucidated. Finally, the potential applications of surfactin will be considered.