Biosurfactant: Pharmaceutical Perspective

Abstract

Biosurfactants (BS) are amphiphilic compounds of microbial origin that have an advantage of biodegradability, low toxicity, better surface and interfacial activity over conventional surfactants. They have several applications in agriculture, industry, petroleum and medicine. Due to its antimicrobial activity and low toxicity, BS has considerable pharmaceutical applications.

Keywords: Biosurfactant; Surface tension; Biodegradability; Industrial applications; Petroleum; Medicine; Agriculture; Amphiphilic compounds; Biodegradability; Low toxicity; Microbial; Better surface; Interfacial activity; Surfactants; Pharmaceutical

Mini Review

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Introduction

Surfactants are amphipathic compounds having both lipophilic and hydrophilic structural moieties in its molecule. They are mostly produced on microbial surfaces or excreted extracellular hydrophobic and hydrophilic moieties. Due to such nature, solubility of hydrophilic molecules is increased along-with reductions in surface and interfacial tensions at the oil/water interface [1]. Surfactants are the active ingredients found in soaps and detergents with the ability to concentrate at the air- water interface, because they are able to increase aqueous solubility of Non- Aqueous Phase Liquids (NAPLS) by reducing their surface/ interfacial tension at air–water and water–oil interfaces [2]. Surfactants are widely used in many industries, particularly pharmaceuticals. However, there is an inherent risk of environmental pollution and toxicological hazards associated with its usage. Pertaining to such concerns, of late, surface active molecules of microbial origin, referred to as 'Biosurfactants' (BS), have gained considerable interest [3].

BS are surface-active molecules with unique chemical structures. Structural polymorphism exists, and may range from being glycolipids, lipoproteins, fatty acids or neutral lipids [4]. Higher environmental sustainability, better foaming properties and stable activity at extremes of pH, salinity and temperature mark their superiority over conventional surfactants [5]. Moreover, manufacturing encompasses microbial fermentation processes using cheaper agro-based substrates and waste materials, hence lower costs [6].

Microbial surface-active compounds are mainly of two types:

a. Those that reduce surface tension at the air-water interface or 'Biosurfactants'; and

b. Those that reduce the interfacial tension between immiscible liquids, or at the solid-liquid interface or 'Bioemulsifiers' [7] BS usually exhibit emulsifying capacity but bioemulsifiers do not necessarily reduce surface tension [8].

BS increases the bioavailability of hydrophobic water-insoluble substrates, heavy metal binding bacterial pathogenesis and bio-film formation. They are used as surface-active agents for emulsion, polymerization, wetting, foaming, phase dispersion, emulsification and de-emulsification in various industries [9]. Owing to their antimicrobial properties, they are of considerable therapeutic and biomedical interest, as they are known to exhibit anti-adhesive action against several pathogenic microorganisms [10]. BS have also received much attention in the field of nano-biotechnology [11].

Classification

BS are small moderately large molecules, generally ranging from 500 to 1500 Da [12,13]. BS are generally categorized by their microbial origin and chemical composition, as follows:

Glycolipids

Rhamnolipids congeners and its homologues are produced at different concentrations by species of Pseudomonas [14]. *Sophorolipids* are produced by different strains of the yeast, *Torulopsis* [15,16]. *Trehalolipids* are produced by species of Mycobacterium, Nocardia and Corynebacterium [17]. Those produced from *Arthrobacter* spp. and *Rhodococcus erythropolis* are able to lower surface and interfacial tensions in culture broth to 25-40 and 1-5mN/m, respectively [18].

Phospholipids & fatty acids

Different bacteria and yeasts produce large amounts of fatty acids and phospholipid surfactants during growth on n-alkanes. Phosphatidyl ethanolamine-rich vesicles are produced from *Acinetobacter spp*. and form optically clear microemulsions of alkanes in water [19].

Polymeric BS

Emulsan, lipomanan, alasan, liposan and other polysaccharide protein complexes constitute the polymeric biosurfactants.

Emulsan is an emulsifier for hydrocarbons in water at concentrations as low as 0.001% to 0.01% [20]. *Liposan* is an extracellular water soluble emulsifier synthesized by *C. lipolytica* and is made up of 83% carbohydrates and 17% proteins [21].

Particulate BS

Particulate biosurfactants, particularly those derived of Acinetobacter species, partition extracellular membrane vesicles to form a micro-emulsion that exerts an influence on alkane uptake in microbial cells [21].

Pharmaceutical perspective

BS have a wide range of applications in pharmaceutical industry

Gene delivery: Gene transfection and lipofection using cationic liposomes is considered to be a promising way to deliver foreign gene to the target cells without adverse effects [22]. The method is used in *in-vitro* synthesis pulmonary surfactants, used in therapeutics of premature babies.

Immunological adjuvants: Bacterial lipopeptides constitute potent non-toxic and non-pyrogenic immunological adjuvants when mixed with conventional antigens. They also have a role stimulating stem fibroblast metabolism and immunomodulatory action [23].

Extraction of intracellular products: Surfactants have also been used to permeabilise cells after fermentation as part of the protocol for recovery of intracellular products. Biosurfactants facilitate reverse micelle solutions directed towards selective permeabilization of Escherichia coli in extraction of penicillin acylase [24].

Antimicrobials: Structural diversity of biosurfactants confers a unique antimicrobial property i.e. toxicity on the cell membrane permeability resembling detergent like effect. [25-28].

Cosmetics: Many biosurfactant properties such as emulsification and de-emulsification, foaming, water binding capacity, spreading and wetting properties effect on viscosity find use in the cosmetic industry. These surfactants are used as emulsifiers, foaming agents, solubilizers, wetting agents, cleansers, antimicrobial agents, mediators of enzyme action in production of bath products, acne pads, anti dandruff products, contact lens solutions, baby products, mascara, lipsticks, toothpaste, dentine cleansers [29,30].

Conclusion

Pharmaceutical interest in BS has been steadily increasing in recent years due to their diversity, environmentally friendly nature, possibility of large-scale production, selectivity, performance under extreme conditions, and potential applications in environmental protection.

References

1. Schramm LL, Stasiuk EN, Marangoni DG (2003). Surfactants and their applications. Ann Rep Program Chem Sec 99: 3-48.
2. Makkar RS, Rockne KJ (2003) Comparison of synthetic surfactants and biosurfactants in enhancing biodegradation of polycyclic aromatic hydrocarbons. Environ Toxicol Chem 22(10): 2280-2292.
3. Desai JD, Banat IM (1997) Microbial production of surfactants and their commercial potential. Microbiol Mol Biol Rev 61(1): 47-64.
4. Pacwa-Płociniczak M, Płaza GA, Piotrowska-Seget Z, Cameotra SS (2011) Environmental applications of biosurfactants: recent advances. Int J Mol Sci 12(1): 633-654.
5. Mukherjee S, Das P, Sen R (2006) Towards commercial production of microbial surfactants. TRENDS in Biotechnology 24(11): 509-515.
6. Muthusamy K, Gopalakrishnan S, Ravi TK, Sivachidambaram P (2008) Biosurfactants: properties, commercial production and application. Current Science 94(6).
7. Batista SB, Mounteer AH, Amorim FR, Totola MR (2006) Isolation and characterization of biosurfactant/bioemulsifier-producing bacteria from petroleum contaminated sites. Bioresour Technol 97(6): 868-875.
8. Willumsen PA, Karlson U (1996) Screening of bacteria, isolated from PAH-contaminated soils, for production of biosurfactants and bioemulsifiers. Biodegradation 7(5): 415-423.
9. Helmy Q, Kardena E, Funamizu N, Wisjnuprapto (2011) Strategies toward commercial scale of biosurfactant production as potential substitute for it's chemically counterparts. International Journal of Biotechnology 12(1-2): 66-86.
10. Ron EZ, Rosenberg E (2001) Natural roles of biosurfactants. Environ microbiol 3(4): 229-236.
11. Kumar CG, Mamidyala SK, Das B, Sridhar B, Devi GS, et al. (2010) Synthesis of biosurfactant-based silver nanoparticles with purified rhamnolipids isolated from Pseudomonas aeruginosa BS-161R. J Microbiol Biotechnol 20(7): 1061-1068.
12. Cameotra SS, Makkar RS (1998) Synthesis of biosurfactants in extreme conditions. Appl Microbiol Biotechnol 50(5): 520-529.
13. Bognolo G (1991) Biossurfactants as emulsifying agents for hydrocarbons. Colloids and Surfaces A: Physicochemical and Engineering Aspects 152(1-2): 41-52.
14. Chrzanowski Ł, Ławniczak Ł, Czaczyk K (2012) Why do microorganisms produce rhamnolipids? World J Microbiol Biotechnol 28(2): 401-419.
15. Cortés-Sánchez AJ, Sánchez HH, Jaramillo-Flores ME (2013) Biological activity of glycolipids produced by microorganisms: New trends and possible therapeutic alternatives. Microbiol Res 168(1): 22-32.
16. Hu Y, Ju LK (2001) Purification of lactonic sophorolipids by crystallization. J Biotechnol 87(3): 263-272.
17. Lang S (2002) Biological amphiphiles (microbial biosurfactants). Current Opinion in Colloid & Interface Science 7(1-2): 12-20.
18. Vijayakumar S, Saravanan V (2015) Biosurfactants-types, sources and applications. Res J Microbiol 10: 181-192.
19. Gautam KK, Tyagi VK (2005) Microbial Surfactants: A review. J Oleo Sci 55: 155-166.
20. Marchant R, Banat IM (2012) Microbial biosurfactants: challenges

and opportunities for future exploitation. Trends Biotechnol 30(11): 558-565.

21. Chakrabarti S (2012) Bacterial Biosurfactant: Characterization, Antimicrobial and Metal Remediation Properties. National Institute of Technology, Surat, India.

22. Inoh Y, Kitamoto D, Hirashima N, Nakanishi M (2004) Biosurfactant MEL: A dramatically increases gene transfection via membrane fusion. J Control Release 94(2-3): 423-431.

23. Rodrigues LR, Teixeira JA, Oliveira R (2006) Low cost fermentative medium for biosurfactant production by probiotic bacteria. Biochemical Engineering Journal 32(3): 135-142.

24. Singh P, Cameotra SS (2004) Potential applications of microbial surfactants in biomedical sciences. Trends Biotechnol 22(3): 142-146.

25. Rahman MS, Ano T (2009) Production characteristics of lipopeptide antibiotics in biofilm fermentation of *Bacillus subtilis*. J Environ Sci 21(1): s36-s39.

26. Tabatabaee A, Mazaheri MA, Noohi AA, Sajadian VA (2005) Isolation of biosurfactant producing bacteria from oil reservoirs. Iranian J Env Health Sci Eng 2(1): 6-12.

27. Tahzibi A, Kamal F, Assadi MM (2004) Improved production of rhamnolipids by a *Pseudomonas aeruginosa* mutant. Iran Biomed J 8: 25-31.

28. Techaoei S, Leelapornpisid P, Santiarwarn D, Lumyong S (2007) Preleminary screening of biosurfactant producing microorganisms isolated from hot spring and garages in Noetheren Thailand. KMITL Sci Tech J 7: 38-43.

29. Tugrul T, Cansunar E (2005) Detecting surfactant-producing microorganisms by the drop-collapse test. World Journal of Microbiology and Biotechnology 21(6): 851-853.

30. Tuleva BK, Ivanov GR, Christova NE (2002) Biosurfactant production by a new *Pseudomonas putida* strain. Z Naturforsch C 57(3-4): 356-360.