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Bio-Surfactants: Its diversity of Applications

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ABSTRACT
Biosurfactants are a anatomically diverse group of surface-active constituents produced via microorganisms. The complex chemical structures and physical properties of Biosurfactants generally lead to properties capable or exceeding many artificial surfactants. The diversity of Biosurfactants makes them an attractive group of compounds for potential use in a very large choice of business and biotechnological applications. Applications of Biosurfactants are in the trade of pharmacy, beauty products, petroleum, and also in eat-able manufacturing industries. Biosurfactants are very helpful in the field of agriculture by way of Remediation of hydrocarbons, inorganic compounds and Remediation of inorganic compounds like heavy metals. The solubilisation and emulsification of toxic heavy metals with the help of Biosurfactants have been reported, helping within the recovery of such speculative materials from contaminated areas. The results can provide a sound scientific basis for developing cost effective remediation methods to treat oil refinery sludge. the long run success of Biosurfactant technology in Bioremediation initiatives is promising.

Keywords: *Remediation, sludge, biosurfactants*

INTRODUCTION
Biosurfactants are morphologically unmatched molecules which are surface stimulated compounds synthesized by a variety of microorganisms. Surfactants are amphiphilic mixes containing both hydrophobic (nonpolar) and hydrophilic (polar) moieties that present capacity to accumulate between liquid stages, for example, oil/water or air/water, lessening the surface and interfacial tensions and forming emulsions.

PROPERTIES
The physicochemical properties of biosurfactants, like a reduction in physical phenomenon, foaming capacity, emulsifying capacity, stabilizing capacity, low CMC, solubility and detergency, are vital within the evaluation of the performance & selection of microorganisms with the potential to supply these agents. Despite the range within the chemical composition and properties, varieties of characteristics are common to the bulk of biosurfactants, many of which supply advantages over conventional surfactants (Nitschke et al., 2007).

Surface and interfacial activity: Biosurfactants produce a lower surface tension at a very low concentration, showing greater effectiveness and efficiency as compared to the traditional surfactants.

Tolerance to temperature, pH and ionic strength: Many biosurfactants can be used under extreme conditions. Many biosurfactants are often used under extreme conditions. As an example, the lipopeptide from Bacillus licheniformis JF-2 is stable at temperatures around 75°C for up to 140 hours and within a pH range of 5 to 12. Biosurfactants can also resist salt concentrations up to 10%, whereas 2%

Sodium chloride is enough to inactivate conventional surfactants.

Biodegradability: The degradation of Biosurfactants is easy with the help of bacteria and other microorganisms in water/soil, which makes them suitable for bioremediation applications and waste treatment.

Low toxicity: Biosurfactants have received greater attention because of the increasing concern on the part of the population regarding the allergic effects of artificial products. Moreover, the low degree of toxicity of those compounds allows their use in food, cosmetic and pharmaceutical products.

Availability: Biosurfactants are produced from widely available raw materials and it can also be produced from industrial waste.

Specificity: As complex organic molecules with very specific functional groups linked to them, biosurfactants are specific in all of their actions, which is of considerable interest regarding the detoxification of specific pollutants additionally it has specifically applications in the food, cosmetic & pharmaceutical industries.[1]

PHYSIOLOGY

Biosurfactants are produced by a large variety of microorganisms either by the process of excretion or adhesion to cells, especially when cultivated on substrates that are insoluble in water (Tan et al., 2000).

PRODUCER MICROORGANISMS

Large forms of microorganisms are able to produce biosurfactants with different molecular structures (Deleu and Paquot, 2004). Bacteria from the genera Pseudomonas and Bacillus are described within the literature as large producers of biosurfactants. For example Rhamnolipids which are produced by Pseudomonasaeruginosa Composition whose yield depend upon the type of fermenter, pH, nutrients, substrates and temperatures employed (Mulligan, 2005). Bacillus subtilis produces lipopeptides, like surfactin, which contains seven amino acids linked to carboxyl and hydroxyl groups of C14 acid (Barrosetal., 2007; Lu et al., 2007). Concentrations of surfactin not up to 0.005% reduce physical phenomenon (surface tension) to 27 mN/m, making this compound one in every of the foremost potent biosurfactants.

CLASSIFICATION

Synthetic surfactants are classified on the basis of the polarity within the polar component of the molecule. The presence or the absence of an electrical charge classifies surfactants as anionic, cationic, non-ionic or amphoteric (Maneerat, 2005; Ron and Rosenberg, 2001). Almost biosurfactants are anionic or neutral, whereas just a few are cationic, like those who contain amine groups. The hydrophobic moiety is characterized by long chain fatty acids and also the hydrophilic moiety could also be a carbohydrate, amino acid, cyclic peptide, phosphate, carboxyl acid or alcohol (Bognolo, 1999).Biosurfactants are commonly classified on the basis of their biochemical nature or the microbial producer species. With relevance structure, these compounds are classified into five main groups (Rahman and Gakpe, 2008).

Glycolipids

The degree of polarity depends on the hydrocarbons used as substrate; examples: sophorolipids produced by species of *Candida.* & rhamnolipids produced by *Pseudomonas aeruginosa*

Lipopolysaccharides

These have a high molecular mass and are soluble in water; example: emulsan, it is an extracellular emulsifier produced from hydrocarbons by the bacteria *Acinotobacter calcoaceticus*;

Lipopeptides
Example: Surfactin produced by *Bacillus subtilis* (one of the most capable biosurfactants reported in the literature);

Phospholipids
This type of structure is common to many microorganisms; Example: biosurfactants from *Corynebacterium lepus*;

Fatty acids, neutral lipids (some categorized as glycolipids) and hydrophobic proteins.[1]

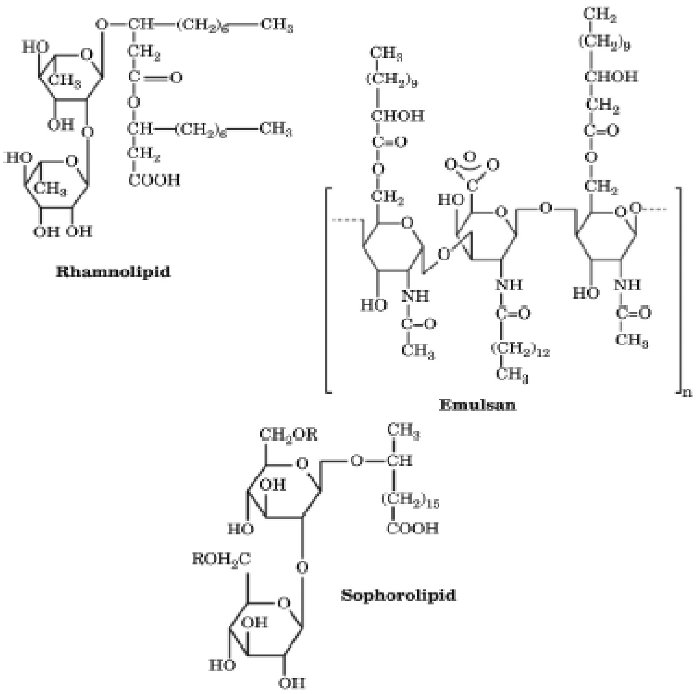

Fig. 1: *Typical Structure of Biosurfactants.*

Table 1: *Main Classes of Biosurfactants and Respective Producer Microorganisms*

Class/Type of Biosurfactant	*Microorganism*
Glycolipids	
Rhamnolipids	*Pseudomonas aeruginosa*
Sophorolipids	*Torulopsis bombicola, T. apicola*
Trehalolipids	*Rhodococcus erythropolis, Mycobacterium* sp.
Lipopeptides and lipoproteins	
Peptide–lipid	*Bacillus licheniformis*
Viscosin	*Pseudomonas fluorescens*
Serrawettin	*Serratia marcenscens*
Surfactin	*Bacillus subtilis*
Subtilisin	*Bacillus subtilis*
Gramicidin	*Bacillus brevis*
Polymyxin	*Bacillus polymyxia*
Fatty acids, neutral lipids and phospholipids	
Fatty acid	*Corynebacterium lepus*
Neutral lipids	*Nocardia erythropolis*
Phospholipids	*Thiobacillus thiooxidans*
Polymeric surfactants	
Emulsan	*Acinetobacter calcoaceticus*
Biodispersan	*Acinetobacter calcoaceticus*
Liposan	*Candida lipolytica*
Carbohydrate–lipid–protein	*Pseudomonas fluorescens*
Mannan–lipid–protein	*Candida tropicalis*
Particulate surfactant	
Vesicles	*Acinetobacter calcoaceticus*
Cells	Various bacteria

PRODUCTION OF BIOSURFACTANT

- Contrivances of fermentation and downstream recovery process.
- With the Use of less expensive and industrial wastes. Eg: Sludge, agricultural waste, corn steep-licker, molasses.[2]
- Manufacturing of extra production strains. Eg: *Rhodococcous* species, MTCC2475, *Bacillus circulans* MTTC8281.

APPLICATIONS OF BIOSURFACTANTS

Environmental Applications

Production or development of bacteria on hydrocarbons is completed with the assistance of microbial biosurfactants through expanding the surface area among water and oil by the method of emulsification and pseudo-solubilisation of hydrocarbons through distinction into micelles. Microbial biosurfactants help in remediation of hydrocarbon, inorganic compounds. It helps in re -mediation of inorganic compounds like heavy metals. Rhamnolipids stimulate the deterioration of n-hexadecane by synthesizing strain of P. aeruginosa. Concentration of rhamnolipids contrived the surface of cell hydrophobicity and also physiological state of cell.

Applications in Industries

Most commonly used rhamnolipids, lipopeptides, like surfactin, lichenysin and emulsan have the ability to extend oil recovery. Removal of oil is completed with B. subtilis. B. subtilis PT2 and P aeruginosa SP4 biosurfactants which have a tendency to recover oil more than synthetic biosurfactants. Microbial surfactants reduce surface tension and also help in detaching oil from sludge present deep down in the tank. Microbial biosurfactants helps to cut back surface-tension properties, wetting and dispersing furthermore as low toxic level and high level of biodegradability. [3] Rhamnolipids are suggested to enhance dough characteristics of bakery products; use as food ingredients of compounds obtained from pathogen P. aeruginosa isn't practically feasible. Whereas biosurfactants evolved from yeasts or Lactobacilli, are recognized as safe and are already involved in many food-processing technologies. [4]

Eg.: Microbial Enhanced Oil Recovery (MEOR)

MEOR methods are usually considered to recover oil remaining in reservoirs after completion of primary (mechanical) and secondary (physical) recovery procedures. It's a crucial tertiary process where microorganisms or their metabolites, including biosurfactants, biopolymers, biomass, acids, solvents, gases and also enzymes, are used to increase recovery of oil from depleted reservoirs. Application of biosurfactants in enhanced oil recovery is one altogether the most promising advanced methods to recover a giant proportion of the petroleum or the oil residue. The remaining oil is usually located in regions of the reservoir that are difficult to access and therefore the oil is trapped within the pores by capillary pressure.[5] Biosurfactants reduce surface tension between oil/water and oil/rock. This decreases the capillary forces thereby preventing oil from moving through rock pores. Biosurfactants also can bind tightly to the interface and form emulsion. This stabilizes −the desorbed oil in water and allows removal of oil together with the injection water.[6]

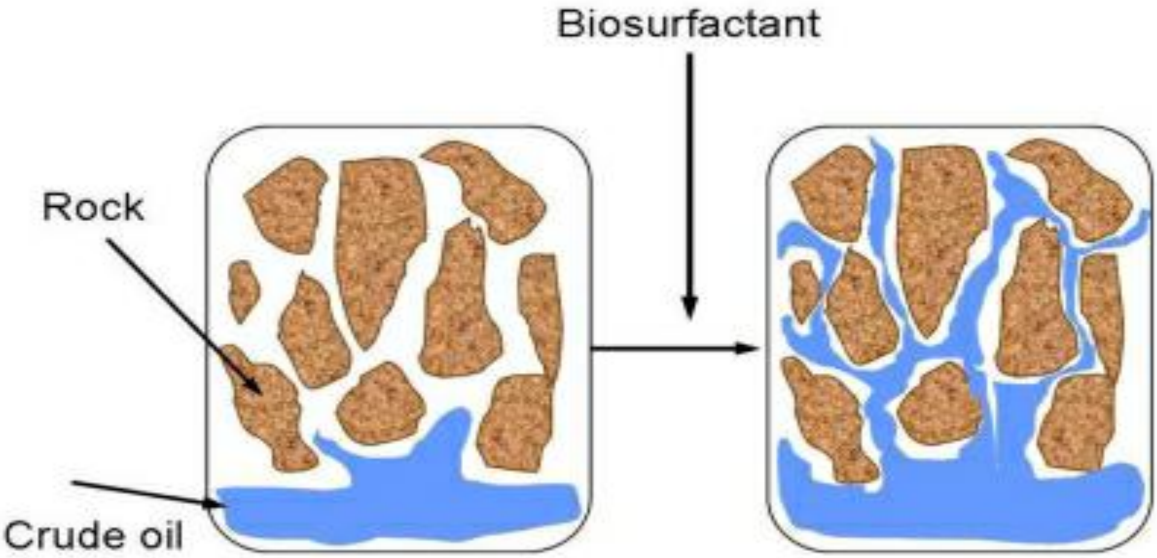

Fig. 2: *Mechanism of Enhanced Oil Recovery by Biosurfactants.*

Application in Biomedical

Surfactin formed by B. subtilis, could be a leading lipopeptide that shows antimicrobial activity. Another microbial biosurfactant having antimicrobial activities is lipopeptides viz. iturin, fengycin formed by B. subtilis. A cyclic lipopeptide derived from Streptomyces roseosporus referred to as daptomycin acts as an antimicrobial agent. Mannosylerythritol lipids (MEL-A and MEL-B) also obtained from Candida antarctica strains shows antagonistic activity for Gram-positive bacteria. In the GI tract, inhibition in growth of pathogenic microorganisms was carried through construction of antimicrobial lipopeptides by Bacillus probiotic compounds in line with Hong7. soybean oil waste are used for the production of rhamnolipid, ability to act as antimicrobial agent against many microorganisms such as Mucor miehei Bacillus cereus.Micrococcus luteus, Neurospora crassa S. aureu,. Pseudomonas sp. strain produced rhamnolipid with alginate, showed beneficial antiviral activity against herpes simplex virus types 1 and 2. Microbial biosurfactants are appropriate alternatives to man-made drugs and antimicrobial agents so biosurfactants are adequate and intact curing agents.

Applications in Agriculture

Microbial biosurfactants have capability to extend the stabilization of oil or water emulsions and extraction of hydrocarbons from soil as per the study of Franzetti3. Degradation of contamination in soil through Cd and Zn, ejection of polyaromatic hydrocarbons and removal of heavy metals from soil is carried by rhamnolipid through a recent process called foaming-surfactant technology. Microbial biosurfactants produced by microorganisms are effective for withdrawing hydrocarbons and heavy metals present in soil viz. Cd, Zn and PB etc. Degradation of certain chemical insecticides is increased with microbial biosurfactants that are present in soil of crop growing areas in excess amount 19,21. Microbial biosurfactants are very effective for removal of bulk arsenic from slime pits or contamination of soils under alkaline situations 10,20. Surfactin helps to remove pesticides from soil and also degrade chlorinated hydrocarbon through glycolipids. Biosurfactants increase the constitution of soil by removing the heavy metals from impure soil with the

assistance of Acinetobacter sp., Bacillus sp., and Pseudomonas sp. Microbial biosurfactants improve vigor of agricultural soil through soil remediation. Biosurfactants are very helpful for decomposition of pesticides.
Ex.: Removal of Metals by Biosurfactants

Since bacterial strains can produce surface active compounds that don't need to have survival ability in soil contaminated by Heavy-metals therefore the usage of biosurfactants has a lot of advantages. Also, using biosurfactants alone requires frequent addition of the foremost recent portions of those compounds.

The use of biosurfactants for bioremediation of heavy metal contaminated soil is particularly helped by their capability in forming complexes with metals. The anionic biosurfactants create complexes with metals during a very nonionic form by ionic bonds. These bonds are stronger than the metal's bonds formed between the soil and metal-biosurfactant , complexes are desorbed from the soil matrix to the soil solution due to the lowering of the interfacial surface tension . By competing for few but not all of the charged surfaces (ion exchange) the cationic biosurfactants could be replaced by the identically charged metal ions. The Biosurfactants micelles are used to remove the metallic ions from the soil surface .The polar head groups of micelles can bind metals which mobilize the metals in water.

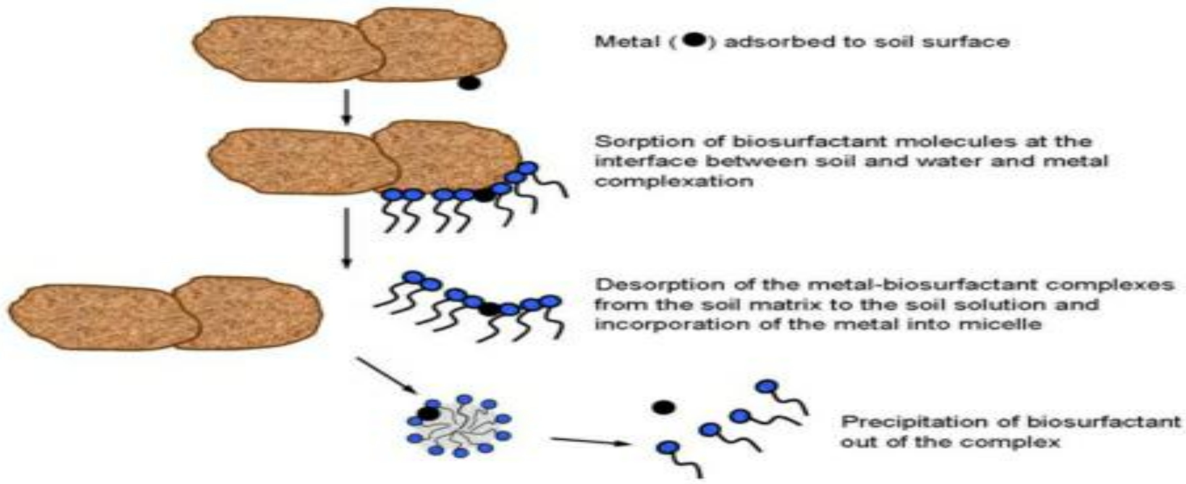

Fig. 3: *Mechanism of Biosurfactant Activity in Metal Contaminated Soil.[7]*

Application in Cosmetic Industry

Thanks to the ability of biosurfactants in emulsification, foam formation, H2O binding capacity, spreading and wetting abilities, effect on viscosity and on product consistency, biosurfactants are able to replace chemically synthesized surfactants in the cosmetic industry. These surfactants are used as emulsifiers, foaming agents, solubilizers, wetting agents, cleansers, antimicrobial agents, mediators of enzyme action, in insect repellents, antacids, bathing products, also can an acne pads, anti-dandruff products for the scalp , contact-lens solutions , baby-products , lipsticks , dentine cleansers such as toothpastes etc..,[8]

Application in Food Processing

Biosurfactants are used for various food processing applications but they mainly play a part as food formulation ingredient and anti-adhesive agents, their role as food formulation ingredient is they promote the formation and stabilization of emulsion due to their ability to decrease the surface tension. It is also used to control the agglomeration of fat globules, stabilize aerated systems, also in improving texture and shelf -life of starch-containing products, modify rheological properties(also called as the material property that includes flow of raw materials etc..,) of wheat dough and improve its consistency and texture of fat based products.[9]

Commercial Laundry Detergents

Most of the surfactants, a crucial component implemented in modern-day commercial laundry detergents, are chemically synthesized and exert toxicity to water (specially fresh water) living organisms. Growing public awareness about the environmental hazards and risks due to chemical surfactants has stimulated the need for ecofriendly, natural substitutes of chemical surfactants in laundry detergents. Biosurfactants like Cyclic Lipopeptide (CLP) are stable over a good pH range (7.0-12.0) and heating them at extreme temperature doesn't lead to any loss of their surface-active property. They have showed good emulsion formation ability with vegetable oils and demonstrated excellent compatibility and stability with commercial laundry detergents favoring their addition in laundry detergents formulation.[10]

CONCLUSION

The success of the commercialization of a biotechnological product largely depends on the economics of its processing. The costs of microbial surfactants don't seem to be currently competitive with those of synthetic tensioactive agents thanks to the high cost and low yield. It's therefore important to optimize the biological production and engineering of the method to get economically viable products. Biosurfactants are viable candidates for the replacement of synthetic surfactants, especially within the refining industry. Investments in strategies for improving the processing of those natural compounds will pave the trail to large-scale biosurfactant production. The utilization of agro industrial waste is one of the steps toward the implantation of feasible biosurfactant production on an industrial scale, Industrial waste with a high content of carbohydrates or a lipid is good to be used as substrate Nevertheless, careful and controlled use of those interesting surface active molecules will surely help within the enhanced shut down of the toxic environmental pollutants and evolve us with a clean environment.

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