

A Review on the Biosurfactants: Properties, Types and its Applications

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Abstract

Biosurfactants are surface-active molecules which are produced by the wide range of microbes including bacteria, fungi, and yeast. They have several advantages over the chemical surfactants such as higher biodegradability, lower toxicity, better environmental compatibility, high selectivity, higher foaming, and specific activity under extreme conditions such as temperature, pH, and salinity. All the surfactants now accessible in the market are synthetically orchestrated. As of late, consideration toward the biosurfactants was multiplied, which is basically because of their extensive variety of utilitarian properties and the assorted manufactured abilities of the microorganisms. Microbial biosurfactants are found to have an extensive variety of utilizations in ecological security, which incorporate upgrading oil recuperation, controlling oil slicks, biodegradation, and detoxification of oil-debased modern effluents and soils. Biosurfactants delivered by microorganisms have potential applications in pharmaceutical/solution, sustenance, corrective, pesticide, oil, and biodegradation ventures. In this survey article, we focused on three vital angles, for example, different sorts of biosurfactants, the gathering of microorganisms engaged with the generation of biosurfactants, and utilization of microbial biosurfactants.

Keywords: Biosurfactants; Chemical; Ecological; Biodegradation; Detoxification; Pesticide

Introduction

Biosurfactants are amphiphilic compounds created on microbial cell surfaces, it contains containing unmistakable polar and non-polar moieties which enable them to shape micelles that collect at interface between fluids of various polarities, for example, water and oil they have capacity to diminish surface pressure [1]. It can have one of the accompanying structures: glycolipids, mycolic corrosive, polysaccharide-lipid composite, lipoprotein/lipopptide, phospholipid, or the microbial cell surface itself [2]. Biosurfactants are delivered by various microorganisms, for example, microscopic organisms, growths and yeast. Biosurfactants pick up consideration as hydrocarbon disintegration operators in the 1960s, and their applications have been enormously reached out in the previous five decades as an enhanced other option to compound surfactants particularly in sustenance, pharmaceutical and oil industry. It was evaluated that more than 10 million tons of compound surfactants and microbial biosurfactants were delivered each year. Despite the fact that the sort and amount of the microbial surfactants created depends chiefly on the maker living being, factors like nitrogen and carbon, temperature, air circulation and follow components likewise influence their production by the life form [3]. All the commercials surfactants are obtained from non-sustainable oil based commodities; they are costlier and have potential dangers to the earth because of their unwilling nature. To overcome with this issue microbial surfactants are the best choices in the surfactant creation the one of a kind properties of biosurfactants make them conceivable to supplant or to be added to engineered surfactants. Contrasted and manufactured surfactants, biosurfactant have higher surface action, compound assorted variety, bring down harmfulness, higher biodegradability and better ecological similarity. With their high surface movement and natural similarity, biosurfactants are generally utilized as a part of ecological applications, for example, for upgrade of oil debasement, as cancer prevention agents, as antimicrobials in the beautifying agents industry and as hostile to glues against a few microscopic organisms and yeasts in medicinal applications. Microorganisms creating biosurfactant were normally present in the oil debased soil. Oil tainted condition contain substantial measure of hydrocarbons and these are made out of complex concoction structure

i.e., aliphatic and sweet-smelling hydrocarbons. Microorganisms display emulsifying movement by delivering biosurfactants and use the hydrocarbons as substrate to changing over them into safe items.

Surfactants are broadly utilized for mechanical, farming, nourishment, beauty care products and pharmaceutical application however the vast majority of these mixes are orchestrated artificially and possibly cause ecological and toxicology issue due to the refractory and determined nature of these substances [4]. With current advances in biotechnology, consideration has been paid to the option ecological cordial process for generation of various sorts of biosurfactants from microorganisms [5].

Properties of Biosurfactants

The properties of biosurfactants when compared to their chemically synthesized counterparts and broad substrate availability made them suitable for commercial applications. Microbial surfactants are identified with their surface movement, resilience to pH, temperature and ionic quality, biodegradability, low poisonous quality, emulsifying and demulsifying capacity and antimicrobial action [6]. The major highlights of every property of biosurfactant are talked about underneath.

Surface and interface activity

Surfactant helps in decreasing surface strain and the interfacial pressure. Surfactin produced by *B. subtilis* can lessen the surface tension of water to 25 mN m⁻¹ and interfacial strain water/hexadecane to under 1 mN m⁻¹ [7]. *P. aeruginosa* produces rhamnolips which diminished

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surface tension of water to 26 mN m^{-1} and interfacial strain of water/hexadecane to 1 mN m^{-1} [8]. Biosurfactants are more powerful and effective and their Critical Micelle Concentration is around a few times lower than chemical surfactants, i.e., for maximal decline on surface strain, less surfactant is fundamental [9].

Temperature and pH tolerance

The biosurfactant production from extremophiles has gain up consideration in a decade ago for their commercial application. A large portion of the biosurfactants and their surface action are safe towards natural factors, for example, temperature and pH. McInerney et al. reported that lichenysin from *Bacillus licheniformis* was resistant to temperature up to 50°C , pH in the vicinity of 4.5 and 9.0 and NaCl and Ca concentration up to 50 and 25 g L^{-1} . Another biosurfactant produced by *Arthrobacter protophormiae* was observed to be both thermostable ($30\text{--}100^\circ\text{C}$) and pH (2 to 12) stable. Since, industrial procedures include extremes of temperature, pH and weight, it is important to separate novel microbial items that ready to work under these conditions [10].

Biodegradability

Microbial derived compounds can be easily degraded when compared to synthetic surfactants and appropriate for natural applications such as bioremediation/biosorption [11,12]. The expanding ecological concern compels us to look for elective items, for example, biosurfactants [13]. Synthetic chemical surfactants impose ecological issues and thus, biodegradable biosurfactants from marine microorganisms were concerned for the biosorption of ineffectively solvent polycyclic sweet-smelling hydrocarbon, phenanthrene contaminated in aquatic surfaces [14]. The blossoms of marine algae, Cochlodinium by utilizing the biodegradable biosurfactant sophorolipid with the removal efficiency of 90% of every 30 min treatment [15].

Low toxicity

Although, not very many written works were accessible with respect to the poisonous quality of biosurfactants, they are by and large thought to be low or non-harmful items and are proper for pharmaceutical, corrective and sustenance employments. Poremba et al. showed that the higher toxicity of the chemical-derived surfactant which displayed a LC_{50} against *Photobacterium phosphoreum* and was found to be 10 times lower than of rhamnolipids. The low toxicity profile of biosurfactant, sophorolipids from *Candida bombicola* made them helpful in nourishment ventures [16].

Emulsion framing and emulsion breaking

Biosurfactants act as emulsifiers or de-emulsifiers. An emulsion can be depicted as a heterogeneous framework, comprising of one immiscible fluid scattered in another as beads, whose distance across by and large surpasses 0.1 mm . Emulsions are two types: oil-in-water or water-in-oil emulsions. They have a minimal stability which might be balanced out by added substances, for example, biosurfactants and can be kept up as steady emulsions for a considerable length of time to years [17].

Antiadhesive agents

A biofilm can be depicted as a group of microbes/other organic matter that have aggregated on any surface [18]. The initial step on biofilm foundation is bacterial adherence over the surface was influenced by different components including sort of microorganism, hydrophobicity and electrical charges of surface, ecological conditions and capacity of microorganisms to deliver extracellular polymers that

assistance cells to grapple to surfaces [19]. The biosurfactants can be utilized as a part of changing the hydrophobicity of the surface which thus influences the bond of microorganisms over the surface. A surfactant from *Streptococcus thermophilus* backs off the colonization of other thermophilic strains of *Streptococcus* over the steel which are in charge of fouling. So also, a biosurfactant from *Pseudomonas fluorescens* hindered the connection of *Listeria monocytogenes* onto steel surface [20].

Types of Biosurfactants

Glycolipids

Most of the biosurfactants which are known produces glycolipids. They are comprised of sugars with long-chain of aliphatic acids or hydroxyaliphatic acids. The association is by methods for either ether or ester gathering. The best known glycolipids are rhamnolipids, sophorolipids and trehalolipids.

Rhamnolipids

Rhamnolipids are the glycolipids in which one or two molecules of rhamnose are linked to one or two molecules of hydroxydecanoic acid. It is the widely studied biosurfactant which are the principal glycolipids produced by *P. aeruginosa*.

Sophorolipids

These are glycolipids which are produced by yeasts and consist of a dimeric carbohydrate sophorose linked to a long-chain hydroxyl fatty acid by glycosidic linkage. Sophorolipids, generally a mixture of at least six to nine different hydrophobic sophorolipids and lactone form of the sophorolipid is preferable for many applications.

Trehalolipids

This is another kind of glycolipids. Disaccharide trehalose connected at C-6 and C-6 to mycolic corrosive is connected with most types of *Mycobacterium*, *Corynebacterium* and *Nocardia*. Mycolic acids are the long chain, α -spread and β -hydroxy unsaturated fats. Trehalolipids from assorted living beings shift in the size and structure of mycolic corrosive, the quantity of carbon molecules exhibit and the degree of unsaturation. Trehalose lipids got from *Rhodococcus erythropolis* and *Arthrobacter* sp. decreased the surface pressure and interfacial strain in culture stock.

Surfactin

This is a standout amongst the most potential biosurfactant is incorporated by *Bacillus subtilis*. It is comprised of a seven amino-corrosive ring structure joined to an unsaturated fat chain by methods for lactone linkage. It diminishes the surface strain from 72 to 27.9 mN/m at a fixation as low as 0.005% .

Lipopeptides and lipoproteins

Lipopeptides are surfactin. An extraordinary number of cyclic lipopeptides, including decapeptide anti-toxins (gramicidins) and lipopeptide anti-toxins (polymyxins) are delivered. These contain a lipid connected to a polypeptide chain.

Lichenysin

Several biosurfactants incorporated by *Bacillus licheniformis* go about as synergistically and display extraordinary temperature, salt and pH security. They are likewise comparative in their auxiliary and physio-synthetic properties to surfactin. Surfactants that are delivered

by *B. licheniformis* can diminish the surface strain of water to 27 mN/m and the interfacial pressure amongst water and n-hexadecane to 0.36 mN/m.

Fatty acids, phospholipids and neutral lipids

A few microbes and yeast create huge amounts of unsaturated fats and phospholipid surfactants amid development on n-alkanes. In *Acinetobacter* spp. 1-N, phosphatidyl ethanolamine-rich vesicles are delivered which shape optically clear smaller scale emulsions of alkanes in water. These biosurfactant are basic for therapeutic applications. Gautam and Tyagi detailed that the lack phospholipid protein complex is observed to be the real reason for the breath disappointment in the rashly conceived kids. They have additionally proposed that the detachment and cloning of the qualities in charge of such surfactant can be utilized in their fermentative creation.

Polymeric biosurfactants

Alasan, liposan, lipomanan emulsan and some other polysaccharide-protein buildings are the best-contemplated polymeric biosurfactants are. *Acinetobacter calcoaceticus* RAG-1 integrates an extracellular strong polyanionic amphipathic heteropolysaccharide bioemulsifier. Emulsan is a powerful emulsifying specialist for hydrocarbons in water, even at a fixation as low as 0.001 to 0.01%.

Particulate biosurfactants

Extracellular film vesicles segment hydrocarbons to form a microemulsion, which assumes an essential part in alkane take-up by microbial cells. Vesicles of *Acinetobacter* sp. having a distance across of 20-50 nm and a light thickness of 1.158 cg/cm³, comprises of protein, phospholipids and lipopolysaccharide (Table 1) [21].

Factors Affecting the Production of Biosurfactants

The production of biosurfactant isn't just relies upon the maker strain yet in addition on the way of life conditions, in this way, the nature of the carbon source, the nitrogen source and also the carbon: nitrogen proportion, nutritious restrictions, concoction and physical parameters, for example, temperature, pH, air circulation, divalent cations and saltiness impact the measure of biosurfactant created as well as the kind of polymer delivered.

Carbon sources for biosurfactant production

Large quantities of carbon sources have been utilized by many investigate for the creation of biosurfactant. Diesel, raw petroleum, glucose, sucrose, glycerol have been accounted for as a decent wellspring of carbon substrate for biosurfactant production. It is clear that the significance of carbon substrate plays a noteworthy part in biosurfactant union, however its significance is life form needy as amid a production with *Pseudomonas* sp., diverse carbon sources in the medium influenced the sythesis of the biosurfactant creation yet substrate with various chain lengths displayed no impact on the chain length of unsaturated fat moieties in glycolipid.

Nitrogen source for biosurfactant production

Nitrogen source is a vital for biosurfactant creation. Medium containing nitrogen gives fundamental part in the microbial development as protein and chemical blends rely upon it. Distinctive nitrogen sources have been utilized for the creation of biosurfactants like yeast separate, ammonium sulfate, ammonium nitrate, sodium nitrate, meat concentrate and malt extricates. Nitrate sources utilized most extreme for surfactant creation in *P. aeruginosa*. Ammonium salts

| Biosurfactant | Microbial source | References |
|--------------------|---------------------------------|------------|
| Rhamnolipids | <i>Pseudomonas aeruginosa</i> | [18] |
| | <i>Pseudomonas chlororaphis</i> | |
| | <i>Serratia rubidea</i> | |
| Sophorolipids | <i>Candida bombicola</i> | [5] |
| | <i>Candida batistae</i> | [20] |
| | <i>Trichosporon ashii</i> | [6] |
| Saphorose Lipid | <i>Torulopsis bombicola</i> | [21] |
| Trehalose lipids | <i>Rhodococcus erythropolis</i> | [22] |
| | <i>Arthrobacter</i> Sp. | |
| | <i>Nocardia erythropolis</i> | |
| | <i>Cornybacterium</i> sp. | |
| Ornithine lipids | <i>Pseudomonas</i> sp | [11] |
| | <i>Thiobacillus thiooxidans</i> | |
| | <i>Agrobacterium</i> sp | |
| Viscosin | <i>Pseudomonas fluorescens</i> | [3] |
| | <i>Leuconostoc mesenteroids</i> | |
| Carbohydrate lipid | <i>Pseudomonas fluorescens</i> | [25] |
| | <i>Debaryomyces polymorphus</i> | |

Table 1: Microbial source and type of biosurfactants.

and urea are favored for *Arthrobacter paraffineus*. In spite of the fact that yeast separate is the most utilized nitrogen hotspot for biosurfactant creation, its use concerning focus is creature and culture medium ward. it was accounted for that the creation of surface-dynamic mixes frequently happens when the nitrogen source is exhausted in the way of life medium, amid the stationary period of cell development.

Natural elements

Environmental elements are critical in the yield of the biosurfactant delivered. To acquire huge amounts of biosurfactants, it is constantly important to upgrade the bioprocess as the item might be influenced by changes in temperature, pH, air circulation or unsettling speed. Most biosurfactant preparations are accounted for to be performed in a temperature scope of 25-300°C, be that as it may, in *A. paraffineus* and *Pseudomonas* sp. strain DSM-2874, this temperature extend caused modification in the organization of biosurfactant created. The impact of pH on biosurfactant delivered was considered by Zinjarde and Pant (2002) who announced that the best creation happened when the pH was 8.0 which is the regular pH of ocean water which is *Y. lipolytica* regular natural surroundings. With *Pseudomonas* sp, rhamnolipids creation was at its most extreme at a pH go from 6 to 6.5 and diminished pointedly above pH 7.

Aeration and agitation

These are imperative factors that impact the production of biosurfactants as both encourage the oxygen exchange from the gas stage to the fluid stage. It might likewise be connected to the physiological capacity of microbial emulsifier, it has been recommended that the creation of bioemulsifiers can improve the solubilisation of water insoluble substrates and subsequently encourage supplement transport to microorganisms. It was accounted for that the best creation

estimation of the surfactant (45.5 g/l) was acquired when the wind current rate was 1vmm and the broken up oxygen focus was kept up at half of immersion [22].

Salinity

Salinity of a specific medium additionally assumes critical part in the biosurfactant production. In any case, opposite perceptions were seen for some biosurfactant items which were not influenced by fixations up to 10% (weight/volume) albeit slight diminishments in the CMC were distinguished [23].

Applications of Biosurfactants

Pharmaceuticals and therapeutics

The biosurfactants could have an extensive variety of utilization in pharmaceutical fields. Antibacterial, antifungal, antiviral operators, safe modulator particles, antibody, quality treatment are appeared by biosurfactant. Several biosurfactants demonstrate antimicrobial action against different microscopic organisms, green growth, parasites, and infections. Antifungal action appeared by a lipopeptide iturin from *B. subtilis* development of destructive sprout green growth quelled by rhamnolipids. The mannosylerythritolcations lipid indicates antimicrobial movement especially against Gram-positive microorganisms. Immunological adjuvants: Bacterial lipopeptides constitute powerful non-harmful, non-pyrogenic immunological adjuvants when blended with ordinary antigens. A change of the humoral others conscious reaction was shown when low sub-atomic mass antigens Iturin AL and herbicolin A.

Antimicrobial action

Because of the differing structures of biosurfactants it applies poisonous quality on the phone layer penetrability. Few biosurfactants have solid antibacterial, antifungal and antiviral action; these surfactants assume the part of against cement specialists to pathogens making them helpful for regarding numerous maladies and additionally its utilization as remedial and probiotic operator. A decent case is the biosurfactant delivered by marine *B. circulans* that had a powerful antimicrobial action against Gram positive and Gram negative pathogens and Semi pathogenic microbial strains including MDR strain [24].

Anticancer activity

Some microbial extracellular glycolipids instigate cell separation rather than cell expansion in the human promyelocytic leukemia cell line, likewise, presentation of PC 12 cells to MEL improved the movement of acetylcholine esterase and intruded on the cell cycle at the G1 stage with coming about abundance of neurites and incomplete cell separation, this propose MEL incites neuronal separation in PC 12 cells and gives the basis to the utilization of microbial extracellular glycolipid as novel reagents for the treatment of disease cells.

Antiviral activity

C. bombicola orchestrates a sophorolipid, its basic analogs have been considered for their spermicidal, hostile to HIV and cytotoxic exercises. The sophorolipid diacetate ethyl ester subsidiary is the strongest spermicidal and virucidal specialist of the arrangement of sophorolipids examined.

Cosmetic industry

Sophorolipids has huge scale application in the beautifying agents industry. They have exceptional attributes that incorporates hostile to

radical properties, incitement of dermal fibroblast meta-bolism, and hygroscopic properties to help sound skin physiology, future prospects of so phorolipid based items incorporate a few sorts of facial makeup, creams, excellence washes and hair items [25].

Oil industry

Biosurfactant and bioemulsifiers are novel gathering of atoms and among the most effective and adaptable result that advanced microbial innovation can offer in fields, for example, bio-consumption and biofouling corruption of hydrocarbons inside oil stores, catalysts and biocatalysts for oil up-reviewing. Besides, biosurfactants assume a noteworthy part in oil extraction, transportation, overhauling and refining and petrochemical producing.

Agriculture

Biosurfactants are additionally utilized as a part of agribusiness they play critical part in help of biocontrol components of microorganisms such as parasitism, antibiosis, rivalry, instigated fundamental protection and hypo harmfulness. One approach to improve the dissolvability of bio-perilous substance mixes, for example, PAH is to apply surfactants as preparing specialists. This expands the clear solvency of Hydrophobic Organic Contaminants (HOC). Additionally surfactants are said to enable organisms to adsorb to soil particles involved by toxins, therefore diminishing the dispersion way length between the site of assimilation and site of biouptake by the microorganisms. Additionally in horticulture, surfactants are utilized for hydrophilization of overwhelming soils to acquire great wettability and to accomplish even appropriation of compost in the dirt. They additionally keep the hardening of certain compost amid capacity and advance spreading and entrance of the toxicants in pesticides. The rhamnolipid biosurfactant, for the most part delivered by the variety *Pseudomonas* is known to have intense antimicrobial action. Further, no unfavorable impacts on people or the conditions are expected from total presentation to rhamnolipid biosurfactants. Fengycins are likewise answered to have antifungal movement and in this way might be utilized in biocontrol of plant ailments.

Commercial laundry detergents

All surfactants, an essential part utilized as a part of current business clothing cleansers, are synthetically integrated and apply danger to new water living beings. Developing open mindfulness about the ecological dangers and dangers related with compound surfactants has invigorated the scan for ecofriendly, characteristic substitutes of concoction surfactants in clothing cleansers. Biosurfactants, for example, Cyclic Lipopeptide (CLP) are steady finished a wide pH extend (7.0-12.0) and warming them at high temperature does not bring about any loss of their surface-dynamic property. They indicated great emulsion development capacity with vegetable oils and showed brilliant similarity and strength with business clothing cleansers supporting their consideration in clothing cleansers plan.

Phytoremediation

Heavy metals are the main problem among the inorganic pollutants. At higher concentration they are toxic as they form free radicals and cause oxidative stress. Additionally they disturbed the ordinary action of some fundamental proteins and shades by supplanting them. In any case, by utilizing both metal safe and biosurfactant creating microscopic organisms, the capacity of the plant can be expanded for phytoremediation. For instance biosurfactant creating *Bacillus* sp. J119 strain can build the effectiveness of the plant development of assault,

sundagrass, tomato and maize and furthermore take-up of cadmium. From this examination clear that the species taken for this reason has the root colonization action. So an organism helping phytoremediation process is produced for the remediation of overwhelming metals [26].

Conclusion

Biosurfactants demonstrate a few properties which could be valuable in many fields of industry. Due to their anti-adhesive properties they gain consideration as another device to hinder and upset the biofilms shaped in contact surfaces. Due to their specific attributes, such as emulsifying, anti-adhesive and antimicrobial activities they are recommended as multipurpose fixings or added substances. Inadequate data in regards to danger, joined with high creation costs is by all accounts the significant reason for the constrained employments of biosurfactants in sustenance zone. Be that as it may, the utilization of agro-industrial squanders can decrease the biosurfactants creation costs and additionally the waste treatment consumes and furthermore renders another option for sustenance and nourishment related ventures for valorizing their losses as well as to getting to be plainly microbial surfactant makers. Biosurfactants got from Generally Regarded As Safe (GRAS) microorganisms like lactobacilli and yeasts are of awesome guarantee for nourishment and solution applications however, significantly more research is now required on this field. The possibility of new sorts of surface-dynamic mixes from microorganisms can contribute for the recognition of various atoms as far as structure and properties however the toxicological parts of new and current biosurfactants ought to be accentuated with a specific end goal to affirm the safe of these mixes for sustenance use. Regardless of numerous lab based achievement in biosurfactants generation and its massive business applications, the creation of biosurfactant at a plant scale remains a testing issue as the arrangement of conclusive item is influenced by the supplement, micronutrient and natural components. Rule and direction ought to be detailed for utilization of biosurfactants in various areas. It is normal that in future, super-dynamic microbial strains will be created utilizing hereditary building for generation of biosurfactants at mechanical level utilizing inexhaustible substrates as crude material.

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