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Review Article

# Biosurfactants in Textiles: Sustainable Future

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## Abstract

Biosurfactants are surface active agents derived from biological systems. These natural chemical ingredients are produced by the microorganisms like bacteria, yeasts, and fungi, which are abundantly present in the environment. However, proper identification of adequate microorganisms and efficient extraction of surfactant moieties play a key role in successfully deriving biosurfactants. They are easily biodegradable and hence provide an ecological and safe alternative to petrochemical-based synthetic surfactants.

**Keywords:** Biosurfactant; biodegradable; biotechnology; green chemistry; sustainability

## Introduction

The World is facing multiple challenges in the implementation and enforcing environmental protection processes and controlling climate change for the next generations. Thus, the need and study of sustainable technologies for environmental remediation are critically important. Thousands of products in our daily usage are prepared from rapidly depleting Petrochemicals. Some examples are plastics, medicines, cosmetics, furniture, appliances, electronics, chemicals, and surfactants. Synthetic surfactants manufactured from petrochemical sources have high levels of toxicity and very little biodegradability. These materials affect marine life and reduce the photochemical energy conversion efficiency of plants. Global usage of surfactants is more than 15 million MT annually, and an estimated 60% of these surfactants end up in the aquatic environment. Synthetic surfactant production is widely seen as unsustainable and contrary to the environment protection goals, and therefore there is an urgent need for developing and utilizing alternatives with lower eco-footprint. One way to achieve sustainability is by replacing synthetic surfactants with Biosurfactants. This would help reduce lifetime CO2 emissions by 8% and avoid an estimated 1.5 million MT of CO2 released into the atmosphere. Biosurfactants are natural products, generated in a sustainable fashion and are environmentally friendly. These compounds are well suited as an alternative molecules to synthetic products due to their high biodegradability, low toxicity, multi-functionality and availability of resources. Biosurfactants perform an efficient and successful application in various industries such as cosmetic, pharmaceutical, food, petroleum, agricultural, textile, and wastewater treatment.

### Need of Biosurfactant

Pretreatment of textiles is an important and complex process for producing high-quality end products. Various natural and synthetic fiber admixtures, natural polymers, sizing agents, and lots of other impurities need to be removed from the fiber surface to prepare textiles for the subsequent production steps. For the removal of such acquired and added oil and soil impurities from the textile material, a strong emulsifying action based surfactant is required, which can not only remove such impurities but also avoid their subsequent redeposition on the fiber surface. Here synthetic surfactants play an important role and are widely used both during industrial textile processing and also during home laundry washing. However, such synthetic surfactants are known to be toxic, slow to biodegrade and contribute to the growing levels of eutrophication in water bodies. For these reasons, new technologies are being explored to facilitate effective and ecologically compatible washing processes within the textile industry. Wetting, penetration, detergency, dispersion, solubilization, emulsification, and softening are the application areas where petrochemical products can be replaced with biosurfactants [1].

## Biosurfactants - Wetting, Emulsification and Detergency

Microbial cultures produce a variety of hydrocarbon substances called biosurfactants during the growth of micro-organisms. Biosurfactants are categorized by their microbial origin, mass molecular weight, or mode of action. The hydrophilic head usually consists of amino acid, peptide, monosaccharide, disaccharide, or polysaccharide, whereas the hydrophobic tail is usually a linear or branched, unsaturated, saturated, or hydroxylated fatty acid. Lower molecular weight biosurfactants are more effective in reducing the surface tension at the air-water interface and the interfacial tension at the oil-water interface. The efficiency of a surfactant is measured by its Critical Micelle Concentration (CMC) (Figure 1). The CMC of most biosurfactant compounds ranges between 1 and 2000 mg/L, which is dependent on its molecular structure. A biosurfactant with optimal surface and interfacial activity can reduce the surface tension of water from 72 to below 35 mN/m and reduce interfacial tension (oil/water) from 40 to 1 mN/m. The higher molecular weight is called bio-emulsifiers, and they are most effectively used in stabilizing oil-in-water emulsions. The ability of biosurfactants to lower surface tension and interfacial tension makes them suitable for various applications in various fields. As compared to synthetic chemical surfactants, biosurfactants are more effective because they decrease the surface tension more efficiently as their critical micelle concentration vaue is several times lower (Figure 2). Additionally, biosurfactants show several desired properties, such as lower foaming tendency, higher emulsification, improved solubility, and detergency which are desired during textile processing [2].

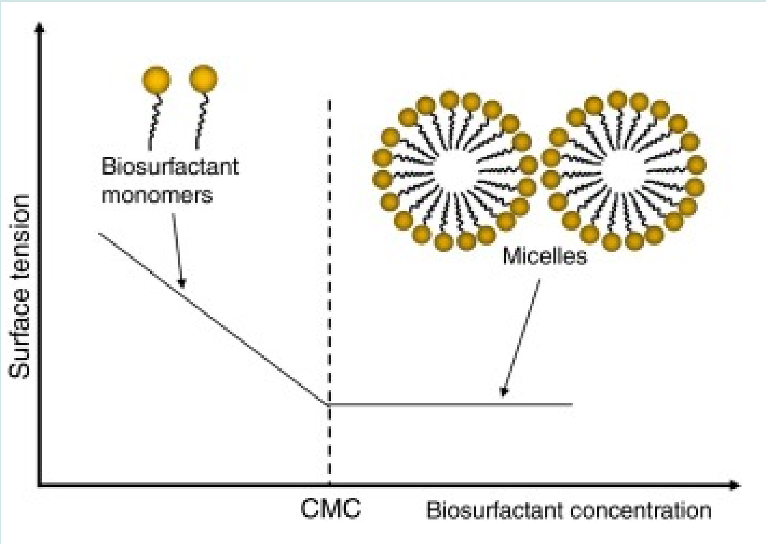


**Figure 1:** CMC and micelle formation of biosurfactant monomer.

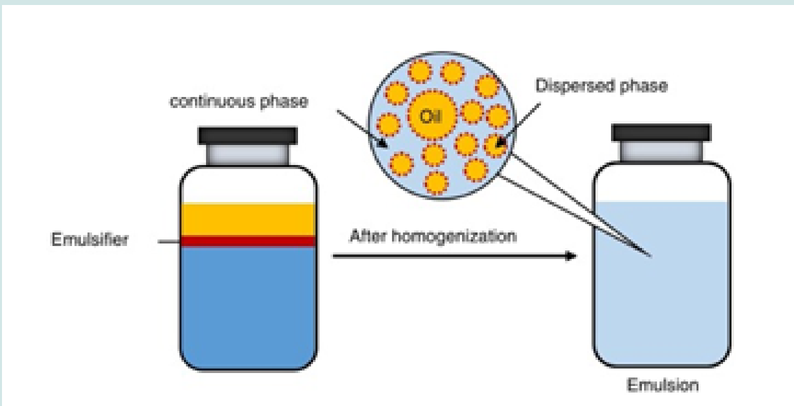


**Figure 2:** Emulsification using biosurfactants.

### Examples of Biosurfactant

a) Glycolipid: These are carbohydrates linked to long-chain aliphatic acids or hydroxy aliphatic acids by an ester group. Such Rhamnolipids are compatible with pectinase enzymes and can be synergistically used during the bio-scouring of cotton.

b) Lipopeptides and lipoproteins: these are Lipids attached to a polypeptide chain. Such lipoprotein from lipase enzyme imparts improved wettability for enhancing dye diffusion and penetration of Acid dyes on wool. This also helps in providing resistance to felting /wool shrinkage without hampering the fabric property.

c) Surfactin: these are formed when an amino-acid ring structure is coupled to a fatty-acid chain via lactone linkage. They are found to reduce the surface tension and interfacial tension of water substantially.

d) Phosphatidylcholine lecithin: these are molecules of phosphoric acid bound to nitrogenous bases and alcohols. It finds use in formulations for providing stable and low-viscosity fabric softening and lubricating compositions.

e) Polymeric biosurfactants: These are polysaccharide-protein complexes, commonly derived from Bacillus mesophilus and provide the best option as a washing-off agent for treating the cellulosic textile material to remove unfixed Reactive dyes.

Thus, there are various sources of biosurfactants with specific properties which can effectively provide a sustainable alternative to synthetic products. Therefore, biosurfactants are considered a molecule of the future because of their numerous advantages over synthetic surfactants [3].

### Benefits of Biosurfactant

a. Biodegradability- easily degraded by microorganisms in water and soil.

b. Nontoxicity- does not harm life forms on the land or in the water.

c. Efficacy– withstands temperature and pH encountered during textile applications.

d. Effectivity - works at small concentrations owing to lower CMC.

e. Multifunctionality – provides a broad spectrum of properties.

f. Waste treatment- acts as food for growing microbes, thus helping reduce waste disposal issues.

### Application in Textile processing

a) Desizing: provides quick wetting and synergistic effect during enzymatic desizing and efficient removal of size ingredients.

b) Bio-scouring: achieves optimum absorbency and soil removal under natural as well as alkaline pH conditions.

c) Dyeing: helps improve dye dissolution/dispersion performance for optimum and uniform dye exhaustion.

d) Washing off: gets rid of hydrolysed unreacted dye from the textile surface and prevents its back-staining tendency.

e) Finishing: enhances the stability of finishing chemical emulsions and avoids the risk of Silicone oil separation.

## Summary

Biosurfactants are considered eco-friendly, multi-functional compounds due to their non-harmful properties as compared to synthetic surfactants. Biosurfactants are rapidly emerging as a sustainable alternative to widely used petroleum-derived products. However, being a comparatively new development, detailed research and thorough analysis are needed to evaluate biosurfactant performance in various textile processes and formulations. Further studies are necessary to understand their potential for human well-being and environmental sustainability before their large-scale and effective use in various applications. It is imperative to make biosurfactant production economically viable and easily available for its widespread utilization.

## References

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