WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 13, Issue 5, 429-438. Review Article ISSN 2277–7105

A REVIEW ON TOXICITY OF SODIUM LAURYL SULPHATE AND THEIR GOOD SUBSTITUENTS

Sunayana Vikhe* and Kawade Madhuri

Pravara Rural College of Pharmacy Loni, (Department of Pharmacognosy).

Article Received on
07 January 2024,

Revised on 27 Jan. 2024,
Accepted on 17 Feb. 2024

DOI: 10.20959/wjpr20245-31484

***Corresponding Author**
Sunayana Vikhe
Pravara Rural College of Pharmacy Loni, (Department of Pharmacognosy).

ABSTRACT

Sodium Lauryl Sulfate is a surfactant well known for its cleansing action and are widely used in many industries or for household purpose but its toxicity is the major concern to use. SLS leads to good cleansing action but it has various toxic effects on the environment therefore they are known as emerging contaminants. There is several natural substituents available which have less toxicity as compared to SLS such as ammonium laureth sulphate, lauryl glucoside, sodium cocoyl glycinate, sodium lauryl sulfoacetate, cocyl wheat isethionate, Sodium cocyl isethionate. These substituents are considered milder because they will not strip the moisture from the skin and don't cause toxic results. The use of substituents is demonstrated in the article and risk is reduced to some extent.

KEYWORDS: surfactant, SLS claims, product toxicity, safety review, Alternative used.

INTRODUCTION

A surfactant is a chemical compound that reduces the surface tension between two liquids. They contain both hydrophobic and hydrophilic groups, therefore they are amphiphilic. Surfactants are organic compounds commonly used in detergents, emulsifiers, wetting agents, foaming agents, and dispersants. They are used as wetting agents to lower the surface tension of a liquid and allow for increased spread ability.

There are different types of surfactants such as Anionic surfactants, Non-ionic surfactants, Cationic surfactants, and amphoteric surfactants. That Sodium Lauryl sulphate is an anionic Surfactant that is synthetic that can be dissolved in water and oil.[1] and whose global demand

is about 46% of surfactant consumption. Due to their amphoteric nature, they are used in many industries and therefore they are known as emerging contaminants. It created thicker foam, produced stronger degreasers, and prevented soap scum thus it is commonly used as a cleaning agent in households, slopes, shampoos, toothpaste, and other cosmetics. Their concentration in cosmetics is about 0.01% and 1% in detergents, more than this leads to various adverse effects.[2]

This chemical is synthesized by reacting lauryl alcohol from a petroleum or plant source with sulfur trioxide to produce hydrogen lauryl sulfate, which is then neutralized with sodium carbonate to produce SLS. It is also known as sodium dodecyl sulfate, lauryl sodium sulphate, lauryl sulphate sodium salt, and sodium n-dodecyl sulphate in some products.[3] SLS is a toxic material that can be extracted from petroleum, coconut oil, or palm oil, which leads to acute or chronic toxicity including carcinogenicity irritation to the skin, eyes, mucous membranes, upper respiratory tract, and stomach.[4] It also leads to carcinogenicity too. SLS attracts oil, it can strip off the skin's natural oils leaving behind dry and damaged skin and hair. Some people, though, have different reactions to the compound. Their hair and skin become oilier.

Due to several negative claims against SLS, some alternative surfactants can be used such as ammonium laureth sulphate, lauryl glucoside, sodium cocoyl glycinate, sodium lauryl sulfoacetate, cocyl wheat isethionate, Sodium cocyl isethionate, etc. These compounds are considered milder because they will not strip the moisture from the skin and don't cause toxic results.

SLS profile - sodium lauryl sulphate (SLS) is a synthetic product that is broadly utilized in a wide variety of dosage forms, for example as a wetting agent in oral liquids and toothpaste and as an emulsifying agent in topical dosage forms such as creams, ointments, medicated shampoos, toothpaste, and other cosmetics. SLS is what's known as a "surfactant." This means it lowers the surface tension between ingredients, which is why it's used as a good cleansing and foaming agent because it can be found in beauty and self-care products as well as in household cleaners. SLS containing all of these products are topical or applied directly to the skin or body. SLS is also used as a food additive, usually as an emulsifier or a thickener. It can be found in dried egg products, some marshmallow products, and certain dry beverage bases.

Chemical and Physical Properties

The molecular structure of Sodium Lauryl Sulfate in Figure 1.

Figure 1,

Sodium Lauryl Sulphate molecular structure

Source: (EMBL 2015)

These compound has amphiphilic properties, which means the sulphate group is water soluble having hydrophilic and the 12-C side chain is water insoluble having a hydrophobic nature therefore they show surfactant action. Surfactants are wetting agents that act by lowering the surface tension and interfacial tension between two liquids and air-water interphase, allowing easy droplet spreading and leading to a good cleansing action. It is good to remove dirt, oil stains, product build-up, plaques, debris, etc.

The cleaning action is performed due to the formation of micelle in water, above the critical concentration at which micelle starts to form in a spherical shape is CMC critical micelle concentration. In polar micelles, the heads are hydrophilic while the tails are hydrophobic. The micelles have good detergency properties.[5]

The physical and chemical properties of SLS are presented in Table 1.

Table 1

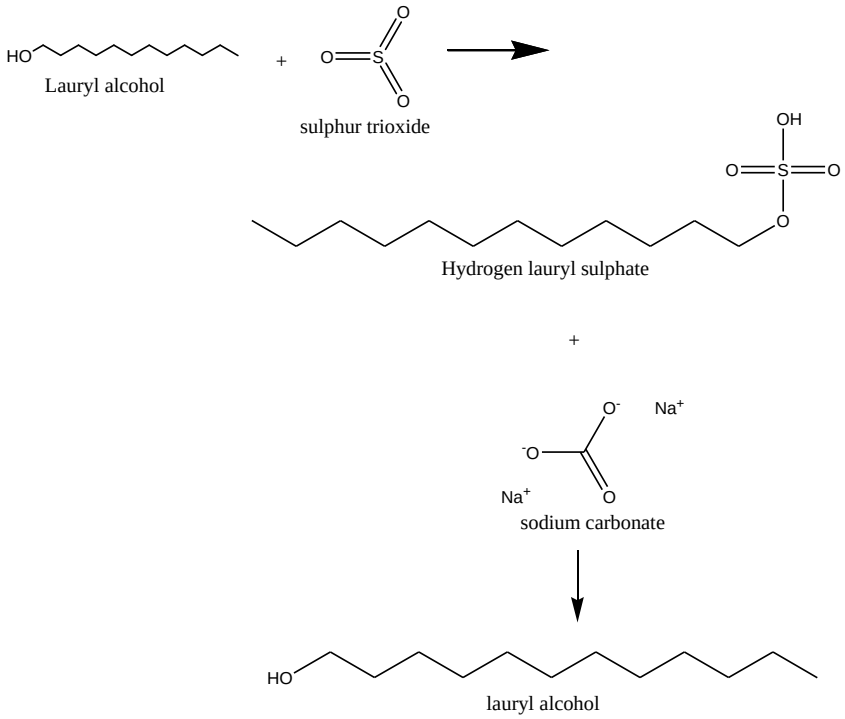
Physical and Chemical Properties of Sodium Lauryl Sulphate,

Property	**Characteristic**
Molecular Formula	C12H25NaO4S
Molecular Weight	288.38
Color	White or Cream
Odor	Characteristics
Density/Specific Gravity	0.6 g/cm3
PH	8.5 – 11
Solubility	1 g/10 ml water
Melting point	204°-207°C
Boiling point	588°C

Sodium lauryl sulfate (SLS) is produced from petroleum by a process called sulfation. In this process, a hydrocarbon chain is reacted with sulfur trioxide to form an intermediate product called a sulfonate. The sulfonate is then neutralized with sodium hydroxide to form SLS.

Production of Sodium Lauryl Sulfate

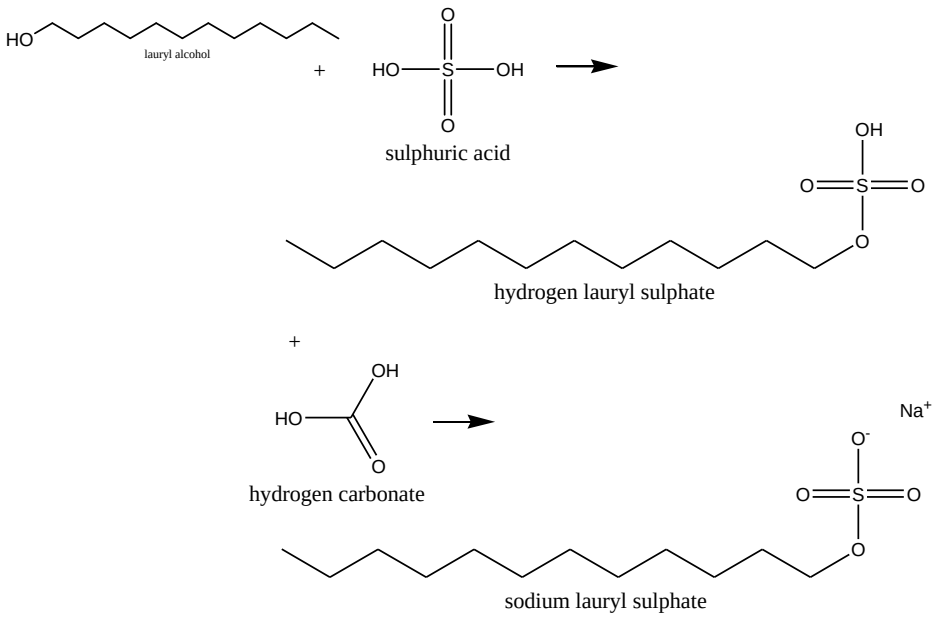
It is derived from palm kernel oil, petroleum, or coconut oil by ethylation reaction of dodecyl alcohol. This compound is synthesized by the reaction of lauryl alcohol from petroleum or plant sources with sulphur trioxide to form hydrogen lauryl sulfate. The Product of this reaction is then neutralized with sodium carbonate or aquase sodium hydroxide. Due to hydrogenation coconut oil or palm kernel oil liberates fatty acid and releases lauryl alcohol. This is the synthetic method of production of sodium lauryl sulphate.



Reaction steps -

1) Lauryl alcohol + sulfuric acid ------> hydrogen lauryl sulfate

2) hydrogen lauryl sulfate + Sodium carbonate ------> Sodium lauryl sulphate.



Due to no common ion effect, the SLS is effective over a wide range of PH in acidic or alkaline solutions or in a hard water. it is more widely used in personal care products like soaps, shampoos, medicated bars, and toothpaste.

Environmental Toxicity Profile

SLS is the main ingredient in household preparation so it is easily traced in wastewater streams therefore environmental toxicity is an important consideration to evaluate the risk to the environment.

Acute toxicity

Acute toxicity is the adverse effects of a compound that result either from a single exposure or from multiple exposures in a short duration of time. To be described as *acute* toxicity, the adverse effects will be occur within 15 days upon ingestion of the compound. The SLS is irritant at concentrations of 2 percent or more and recommends that cosmetic products should not contain concentrations more than <0.1% (w/w). According to the National Institute for Occupational Safety and Health, upon injection, SLS leads to skin and eye irritation, nausea, vomiting as well as diarrhea. 1,4 dioxane a byproduct of the manufacturing process of SLS and SLES, is "*possibly carcinogenic to humans*" and causes negative effects on the body organs such as liver, kidney, and central nervous system. According to the compulsory labeling requirements of the CPSC, manufacturers added warnings and first aid information on the label. According to the U.S. Consumer Product Safety Commission (CPSC;16 C.F.R. §1500) it is mandatory for consumer product

manufacturers to test finished products to characterize the ocular toxicity of the product to test ocular irritation of product. cause SLS may lead to severe eye damage and blindness. The occurrence of physical or chemical damage to the eye, and corneal exposure to a high concentration of SLS can result in a slowed healing process. Upon direct skin contact SLS causes corrosion and leads to irreversible damage to the skin.[7]

Some Precautionary statements are mentioned on the label of SLS-containing products such as H302 Harmful if swallowed, H315 Causes skin irritation, H318 Causes serious eye damage H412 is Harmful to aquatic life with long-lasting effects.

Prevention

P264 Wash … thoroughly after handling.

P270 Do not eat, drink, or smoke when using this product.

P280 Wear protective gloves/protective clothing/eye protection/face protection.

P273 Avoid release to the environment.

Response

P301+P312 IF SWALLOWED: Call a POISON CENTER/doctor/\u2026if you feel unwell.

P330 Rinse mouth.

P302+P352 IF ON SKIN: Wash with plenty of water/...

P321 Specific treatment (see ... on this label).

P332+P313 If skin irritation occurs: Get medical advice/attention.

P362+P364 Take off contaminated clothing and wash it before reuse.

P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes.

Remove contact lenses, if present, and easy to do. Continue rinsing.

P310 Immediately call a POISON CENTER/doctor/\u2026

According to the Globally Harmonized System of Classification and Labelling of Chemicals HS) - Sixth revised edition.

Some of the warnings as mentioned above are stated.

SLS is linked to cataract formation.[8] The eye lens is immersed in a concentrated solution of SLS because it acts as an irritant in an experiment to check ocular irritation of the SLS-containing household products, mainly to check the toxicity of 20% SLS-containing products toxicity. The laboratory animals are exposed to 0.5 ml of shampoo solution for 14 continuous

days, these types of studies do not give exact results of toxicity of household cleaning products but they may help to some extent.[9]

Oral toxicity

Oral toxicity gives immediate results of toxicity upon administration, it is measured in terms of the (lethal dose) LD50 value. The half quantity of drug required to kill the animals receiving that dose. If the LD50 value is ≥5,000 mg/kg then it is non-toxic or a value more than this is considered a toxic dose for laboratory animals. The toxicity of formulation is dicided by its whole content not by any individual content, so depending on the amount of SLS used in many formulations the toxicity may vary, it may be toxic, less toxic, or nontoxic. US FDA allows some concentration of SLS to be added to food products.[10]

The SLS causes baldness, reduction of hair density, or hair loss.[11] The experimental results upon exposure of SLS solution on rat skin are the detergent deposits in hair follicles and denaturation of hair takes place. Hair loss or damage arises upon such deposition. Additional studies are required to check the true effect of their deposition. Dermal formulations do not contain concentrations of SLS >1% because of their potential to deposit on hair follicles.[12]

Another claim of SLS is that it causes dermal Sensitization. Sensitization is a process by which the immune system produces defensive protein as an antigen in response to any allergic substance such as food, pollen grains, mold, or medication and produces allergic symptoms due to the triggering of the immune system.[13] but due to lack of evidence SLS is not directly included in the list of Sensitizing agents.

SUBSTITUENTS FOR SLS

sodium coco sulfate

Sodium Coco-Sulfate (SCS) is the sodium salt of the sulfate ester of coconut alcohol. It is a surfactant which means that it makes foam and cleanses the skin and hair. A fine noodle form of this anionic surfactant is the most common form. Its primary purpose is to serve as the foamer in topical personal cleansing products. It is a salt of fatty alcohols bound to a sulfate group and belongs to the family of compounds called alkyl sulfate. Coconut oil is the source of fatty alcohols for those ingredients with Coco in the name. Sodium Coco-Sulfate is an anionic surfactant and is used to remove oily stains and residues. It is used at concentrations of 0.3% to 29.0%. When used to clean hair and skin, sodium coco sulfate makes a gentle foam that effectively dissolves grease and dirt. It is a good sodium lauryl sulphate substitute

that doesn't use palm oil because it's made from the fatty acids in coconut oil. It is used as a cleansing, emulsifying, and surfactant action. The safety of alkyl sulphates including Sodium Coco-Sulfate has been assessed by the Cosmetic Ingredient Review (CIR) Expert Panel. The CIR Expert Panel evaluated the scientific data and concluded that these compounds were safe for use as a cosmetic ingredient. Formulations with SODIUM COCO-SULFATE are Toiletries: Handmade-Style Shampoo Bar, Charcoal Cleansing Bar, Himalayan Body Bar by Colonial Chemical and Coffee Body Scrub by Lubrizol, etc.

Sodium cocoyl glycinate

Sodium Cocoyl Glycinate is a surfactant that reduces the surface tension of the formulation and is responsible for softening the skin, and also sometimes hair. As an ingredient, it can come in a solid/powder form, and can also be in the form of a colourless to pale yellow liquid. Sodium Cocoyl Glycinate works to leave the skin and scalp clean and healthy. The most important point in that it is non-irritating and creates a rich creamy lather upon application. The formula of Sodium Cocoyl Glycinate is $C_{14}H_{26}NNaO_3$. Its shelf life is about 24 months, Keep stored in cool, dry conditions in well-sealed containers. It is widely used in oral cleansing, daily facial cleansing, personal bath products, and Baby products. In addition to family life washing, it is used in industrial and agricultural production as a wetting agent, emulsifier, dispersant, penetration agent, foaming agent and fungicide, etc. In terms of environmental protection, it can be used for seawater oil pollution treatment, wastewater treatment, flotation separation, dust prevention, Fire fighting, etc. Sodium Cocoyl Glycinate is good for skin and hair. It has been approved for use and is safe as it does not have any major side effects. It may sometimes cause slight irritation on highly sensitive skin. Therefore, a patch test is recommended before full application. Additionally, Sodium Cocoyl Glycinate is non-comedogenic and does not cause acne or breakouts.

Some of their marketed formulations are

Exfoliating Powder Face Cleanser by HDS-Chemie (STOCKMEIER Group)

Skin Care: Zemea® Perilla & Matcha Green Tea Facial Scrub by DuPont Tate and Lyle.

Toiletries: Mysterious Powder-to-Foam by Lucas Meyer Cosmetics.

Toiletries: Sulphate-Free Body Milk Wash.

Cosmetics Formulation | Supplied by Lubrizol.

CONCLUSION

This literature review was conducted to collect all relatable evidence regarding sodium lauryl sulfate and its impact on environmental safety, its reported toxicity, and the effects of SLS exposure. The amount of legal use of SLS in cosmetics formulations. Many alternatives of SLS are available in the natural form with minimal to no side effects. Which may be used in formulations like cosmetics like skin or haircare like f, cleaning preparations. The use of substituents may reduce toxic impact on environment.

RREFERENCE

1. M. J. Rosen, Surfactants and Interfacial Phenomena, Wiley, New York, NY, 2nd ed., 1989.
2. Final Report on the Safety Assessment of Sodium Lauryl Sulfate and Ammonium Lauryl Sulfate. Journal of the American College of Toxicology, 1983; 2(7): 127-181. doi:10.3109/10915818309142005. *Product Bulletin: Sodium Lauryl Sulfate.* Stephan Company; Northfield, Illinois:
3. GuideChem *Sodium Dodecyl Sulfate (CAS151–21–3) MSDS.* [Accessed August 19, 2015]. Available at: http://www.guidechem.com/msds/151-21-3.html.
4. A. Zdziennicka *et al.* Critical micelle concentration of some surfactants and thermodynamic parameters of their micellization Fluid Phase Equilib, 2012.
5. GuideChem *Sodium Dodecyl Sulfate (CAS151–21–3) MSDS.* [Accessed August 19, 2015]. Available at: http://www.guidechem.com/msds/151-21-3.html.
6. Tekbaş ÖF, Uysal Y, Oğur R, et al. Non-irritant baby shampoos may cause cataract development. *TSK Koruyucu Hekimlik Bülteni,* 2008; 7(1).
7. Cater KC, Harbell JW. Prediction of eye irritation potential of surfactant-based rinse-off personal care formulations by the bovine corneal opacity and permeability (BCOP) assay. *Cutan Ocul Toxicol,* 2006; 25(3): 217–33.
8. Consumer Product Safety Commission (CPSC). Federal Hazardous Substances Act Regulations, 16 C.F.R. §1500; 2015. 13. Healthy Choices. *Sodium Lauryl Sulphate.* Available at: http://www.healthy-choices.co.uk/sls.html. Accessed June 30, 2015.
9. Healthy Choices. *Sodium Lauryl Sulphate.* Available at: http://www.healthy-choices.co.uk/sls.html. Accessed June 30, 2015.
10. U.S. Food and Drug Administration (FDA), 21 C.F.R. §, 2015; 172.822.

11. Cosmetic Ingredient Review (CIR) Final report on the safety assessment of sodium lauryl sulfate and ammonium lauryl sulfate. *Int J Toxicol*, 1983; 2(7): 127–81.
12. Willis CM, Reiche L, Wilkinson JD. Immunocytochemical demonstration of reduced Cu, Zn-superoxide dismutase levels following topical application of dithranol and sodium lauryl sulphate: an indication of the role of oxidative stress in acute irritant contact dermatitis. *Eur J Dermatol*, 1998; 8: 12.
13. Health Report. *Sodium Lauryl Sulphate – Sorting Fact from Fiction.* Available at: http://www.health-report.co.uk/sodium_lauryl_sulphate.html. Accessed July 7, 2015.