New York State Integrated Pest Management Program | Cornell Cooperative Extension

Sodium Lauryl Sulfate Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

Brian P. Baker and Jennifer A. Grant
New York State Integrated Pest Management, Cornell University, Geneva NY

Label Display Name: Sodium lauryl sulfate

Active Components: Sodium lauryl sulfate

CAS Registry #: 151-21-3

U.S. EPA PC Code: 079011

CA DPR Chem Code: 907

Other Names: Sulfuric acid -mono-dodecyl ester sodium salt (1:1); sodium dodecyl sulfate; SDS; SLS; Dodecyl alcohol, hydrogen sulfate, sodium salt; Irium; Akyposol SDS; Duponol PC; Stepanol ME; Aquarex methyl; Dodecyl sodium sulfate; Gardinol; Hexamol; Melanol; Lauryl sulfate, sodium salt

Other Codes: BRN: 3599286; Gmelin: 117722; SMILES: [Na+].CCCCCCCCCCCCOS([O-])(=O)=O

Summary: Sodium lauryl sulfate (SLS) is an anionic surfactant commonly used in detergents and cleaning products. While widely used in pesticide formulations as a surfactant and dispersant, SLS is usually an inert ingredient or used in combination with other active ingredients, most of which are ineligible for use in minimum-risk pesticides. SLS has some antimicrobial activity but is more often a synergist used with other antimicrobial active ingredients. When currently required label instructions on products containing SLS are followed, the EPA did not find any unreasonable adverse effects to the U.S. population.

Pesticidal Uses: Commonly used as an adjuvant or synergist with antimicrobials and insecticides, with some activity.

Formulations and Combinations: Commonly used as a surfactant and emulsifier in many formulated products. As of this writing, it is listed as an active ingredient in one registered pesticide product. May be used as a virucide with citric acid and malic acid.

Basic Manufacturers: Alfa Chemical, Akzo Nobel, BASF, Croda, Dow, DuPont, Evonik, Galaxy Surfactants, Godrej, Guangzhou Xingyi Chemical, Huntsman, Kao, Nease, Oxiteno, Rhodia, Spectrum, Southern Chemical and Textiles (SCT); Stepan, Sinolight, Unger Surfactants, Zhejiang Zanyu, and Zibo Jujin; Technology Co., Ltd., Kao Corporation, Godrej Industries Ltd., Trading Co., Ltd. and Oxiteno.

This document profiles an active ingredient currently eligible for exemption from pesticide registration when used in a Minimum Risk Pesticide in accordance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) section 25b. The profile was developed by the New York State Integrated Pest Management Program at Cornell University, for the New York State Department of Environmental Conservation. The authors are solely responsible for its content. The Overview Document contains more information on the scope of the profiles, the purpose of each section, and the methods used to prepare them. Mention of specific uses are for informational purposes only, and are not to be construed as recommendations. Brand name products are referred to for identification purposes only, and are not endorsements.

Safety Overview: In its last registration review, conducted in 2010, EPA did not find any unreasonable adverse effects to the U.S. population in general, and to infants and children in particular, or to non-target organisms, from the use of registered products containing lauryl sulfate salts when currently required label instructions are followed. In that same final decision, the EPA stated that "currently registered uses of lauryl sulfate salts will have 'no effect' on any federally listed, threatened or endangered species nor will such use destroy or adversely modify any designated critical habitat of such species" and that no new risk assessments were needed (Harrigan-Farrelly 2010).

Background

Sodium lauryl sulfate (SLS) is a surfactant and emulsifier that is primarily used as a wetting agent and detergent (Merck 2015). It is an alkyl sulfate salt (EMBL 2015), generally prepared by the sulfation of lauryl alcohol followed by neutralization with sodium carbonate (Merck 2015). SLS is classified as an anionic surfactant alkyl sulfate detergent, and is one of the most studied and widely used surfactants (Tadros 2000). It has two moieties. One is a 12-carbon chain that is non-polar and lipophilic (fat soluble), and structurally similar to lauric acid. The other part of the molecule is a polar and hydrophilic (water soluble) negatively charged sulfate ion. The sodium ion increases the ability to go into aqueous solution over that of lauryl sulfate (Tadros 2000). Even though both have the same solubility at equilibrium, SLS reaches equilibrium more quickly. The combination of water solubility and fat solubility enables SLS to change the surface tension in a water-based liquid and disperse suspended fats and oils (Tadros 2000).

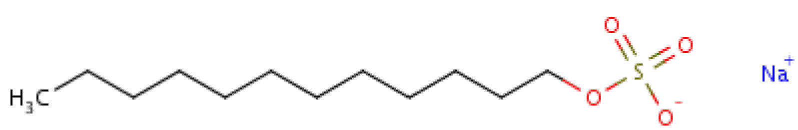
SLS is a surfactant and emulsifier that is primarily used as a wetting agent and detergent (Merck 2015). The textile industry is a heavy user, using SLS to clean and prepare fabric for dying. It is used in separation of proteins and lipids by electrophoresis (ChemNetBase 2015). SLS is a common ingredient in many household and personal care products, such as dishwashing and laundry detergents, toothpastes and shampoos.

Chemical and Physical Properties

The molecular structure of SLS is presented in Figure 1.

Figure 1

Sodium Lauryl Sulfate molecular structure



Source: (EMBL 2015)

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

Table 1

Physical and Chemical Properties of Sodium Lauryl Sulfate

Property	Characteristic/Value	Source
Molecular Formula:	$C_{12}H_{25}NaO_4S$	(Merck 2015)
Molecular Weight:	288.38	(Merck 2015)
Percent Composition:	C: 49.98%; H: 8.74%; Na: 7.97%; O:22.19%; S: 11.12%	(Royal Society of Chemistry 2015)
Physical state at 25°C/1 Atm.	Crystals or flakes	(Merck 2015; ChemNetBase 2015)
Color	White or Cream	(Merck 2015)
Odor	Faint odor of fatty substances	(Merck 2015)
Density/Specific Gravity	0.6 g/cm^3	(Harrigan-Farrelly 2010)
Melting point	204°-207°C	(Merck 2015)
Boiling point	588°C	(EPI 2012)
Solubility	1 g/10 ml water	(Merck 2015)
Vapor pressure	1.1 x 10^{-12} mm Hg at 25°C	(Harrigan-Farrelly 2010)
pH	Neutral to alkali (8.5-11.0 in a 1% aqueous solution)	(Merck 2015; Stepan 2014)
Octonol/Water (K_{ow}) coefficient	1.6	(UNEP 2015)
Viscosity	Not determined but expected to be close to the viscosity of water	(Harrigan-Farrelly 2010)
Miscibility	Not found	
Flammability	Does not contain combustible liquids	(Harrigan-Farrelly 2010)
Storage stability	Stable beyond one year	(Harrigan-Farrelly 2010)
Corrosion characteristics	Not found	
Air half life	0.7 hr	(EPI 2012)
Soil half life	77.5 hrs	(EPI 2012)
Water half life	19.8 hrs	(EPI 2012)
Persistence	595 hrs	(EPI 2012)

SLS lowers the surface tension of water (Merck 2015). When heated to decomposition, it releases toxic sulfur oxides (US NLM 2016). Lauryl sulfate was compared with SLS in carrying out catalytic reactions on complex chemical structures. Both increased the rate of reaction, an effect that was decreased in the presence of various alcohols. SLS consistently had a higher degree of dissociation than lauryl sulfate (Bravo et al. 1992).

Human Health Information

SLS is considered moderately toxic, with a probable oral lethal dose for humans estimated to be 500-5,000 mg/kg, between 1 oz and 1 pint (or 1 lb) for 70 kg (150 lb) person (Gosselin et al. 1976). Human exposure to SLS via dentifrices has been linked to ulceration of oral tissues—recurrent aphthous stomatitis—in some dental patients (Shim et al. 2012).

Contact dermatitis symptoms have been linked to SLS exposure in humans. Out of 330 patients incidentally exposed to SLS, 53 or about 16% reacted adversely. Most could be considered minor irritations, but 6.4%—a little over one in 15—had allergic reactions diagnosed as true erythemato-papular allergic reactions or eruptive rashes (Blondeel et al. 1978). Other reported reactions included hair loss, difficulty in breathing, and rashes.

Acute Toxicity

The acute toxicity of SLS is summarized in Table 2.

Table 2

Acute Toxicity of Sodium Lauryl Sulfate

Study	Results	Source
Acute oral toxicity	Rat LD_{50}: 1,288 mg/kg	(Merck 2015)
Acute dermal toxicity	Rabbit: LD_{50} = 600 mg/kg Guinea pig: LD_{50} > 1,200 mg/kg	(UNEP 2015)
Acute inhalation	Not found	
Acute eye irritation	Rabbit: Moderately irritating	(Griffith et al. 1980)
Acute dermal irritation	Not found	
Skin sensitization	Not found	

The EPA concluded that given the use patterns of SLSs in registered pesticides, dermal and inhalation risks were not expected (Harrigan-Farrelly 2010).

Sub-chronic Toxicity

The sub-chronic toxicity of SLS is summarized in Table 3.

Table 3

Sub-chronic Toxicity of Sodium Lauryl Sulfate

Study	Results	Source
Repeated Dose 28-day Oral Toxicity Study in Rodents	Rat: NOAEL = 100 mg/kg/day LOAEL = 300/600 mg/kg/day	(HSDB 2015)
90 day oral toxicity in rodents	Rat: NOAEL = 100 mg/kg/day LOAEL = 500 mg/kg/day	(HSDB 2015)
90 day oral toxicity in non-rodents	Dog: NOAEL = 400 mg/kg/day LOAEL = 800 mg/kg/day	(HSDB 2015)
90 Day dermal toxicity	Not found	
90 Day inhalation toxicity	Not found	
Reproduction/development toxicity screening test	Mice: NOAEL develop. = 300 mg/kg/day LOAEL develop. = 600 mg /kg/day	(HSDB 2015)
Combined repeated dose toxicity with reproduction/development toxicity screening test	Not found	
Prenatal developmental toxicity study	Mice: NOAEL develop. = 300 mg/kg/day LOAEL develop. = 600 mg /kg/day	(HSDB 2015)
Reproduction and fertility effects	Mice: NOAEL reprod. = 1,000 mg /kg/day LOAEL reprod. = could not be established.	(HSDB 2015)

Chronic Toxicity

The chronic toxicity of SLS is summarized in Table 4.

Table 4

Chronic Toxicity of Sodium Lauryl Sulfate

Study	Results	Source
Chronic toxicity	Negative	(HSDB 2015)
Carcinogenicity	Negative	(HSDB 2015)
Combined chronic toxicity & carcinogenicity	Negative	(HSDB 2015)

Human Health Incidents

Between 1948 and 2010, EPA had one reported human incident directly linked to exposure to SLS as a pesticide active ingredient (Harrigan-Farrelly 2010). Symptoms included blisters on the face and nose that remained for 3.5 weeks after exposure. The National Pesticide Information Center (NPIC) received 11 reported human health incidents involving SLS between April 1, 1996 and March 30, 2016 (NPIC 2016). All incidents involved SLS and additional active ingredients. None were in New York State.

Environmental Effects Information

Effects on Non-target Organisms

The effects of SLS on non-target organisms are summarized in Table 5.

Table 5

Effects of Sodium Lauryl Sulfate on Non-target Organisms

Study	Results	Source
Avian Oral, Tier I	Not found	
Non-target plant studies	Not found	
Non-target insect studies	Not found	
Aquatic vertebrates	Oncorhynchus mykiss (Rainbow Trout) LC_{50} 24 hr = 58,100 µg/l LC_{50} 48 hr = 41,200 µg/l LC_{50} 96 hr = 24,900 µg/l	(HSDB 2015)
Aquatic invertebrates	Daphnia magna: LC_{50} = 1,800 µg/l	(HSDB 2015)

As a surfactant, SLS is highly toxic to aquatic species when released in water (Singer and Tjeerdema 1992; Cserháti et al. 2002). However, SLS was shown to be an effective repellent that discouraged carp (*Cyprinus carpio*)—a desirable fish for human consumption—from exposure to several more toxic and less repellent pesticides (Ishida and Kobayashi 1995). While this did not negate the fact that SLS itself was toxic to carp, and the synergy between the SLS and pesticides was not analyzed, the authors concluded that SLS would protect fish from more toxic pesticides.

Exposure of the model free-living soil nematode *Caenorhabditis elegans* to a 0.01% SLS solution shortened their lifespan to one day, compared with 20 to 28 days for the control group (Kurauchi et al. 2009).

NPIC received 7 reported animal incidents involving SLS between April 1, 1996 and March 30, 2016 (NPIC 2016). All involved active ingredients in addition to SLS. None were in New York State.
Two exempt pet shampoo incidents were reported to the American Society for the Prevention of Cruelty to Animals' Animal Poison Control Center (APCC) between 2006 and 2008. Both incidents involved an exempt-from-registration, plant-derived flea shampoo with 7.5% SLS. The formulation also contained the 25(b)-eligible active ingredients peppermint oil, clove oil, cedarwood oil, cinnamon oil, and rosemary oil. One incident included skin erythema, vomiting, diarrhea, lethargy, edema, ataxia, seizures and renal failure in a 3-year-old dog, and resulted in euthanasia 6 days after appropriate use. The other incident involved a 13-year-old cat that was euthanized 72 hours after appropriate use (Genovese, et al. 2012).

Environmental Fate, Ecological Exposure, and Environmental Expression

Because of releases from everyday household use of detergent and shampoos, and releases from industrial processing such as textile manufacturing, SLS is commonly found in wastewater and effluent. Given that it is the most common surfactant found in sewage treatment systems, SLS's biodegradability and the impact it has on the biodegradation of other substances has been extensively studied (Singer and Tjeerdema 1992; Rebello et al. 2014). A review of the literature shows a consensus that SLS is rapidly biodegradable in the environment (Singer and Tjeerdema 1992) and readily biodegradable under laboratory conditions (Sanchez Leal et al. 1991). However, the conditions under which it would be readily biodegradable in the environment are subject to a number of factors such as temperature, sunlight, pH, aeration, and biological activity (Sanchez Leal et al. 1991; Marchesi et al. 1991; Rebello et al. 2014).

Moreover, SLS and other surfactants can impede the biodegradation of readily biodegradable substances in the environment, particularly starches (Feitkenhauer and Meyer 2002). Because of its widespread use and well-understood degradation properties, it is used as a benchmark for the comparison of the biodegradability of other surfactants (Gathergood et al. 2006).

Environmental Incidents

An extensive review of the environmental impacts of SLS has been published (Singer and Tjeerdema 1992). It covered environmental fate, pharmacological properties, exposure, toxicokinetics and metabolism, cytotoxicity, phytotoxicity, and insect, aquatic, mammalian, and avian toxicities. NPIC received four reports of incidents not classified as human health or animal related between April 1, 1996 and March 30, 2016 (NPIC 2016).

Efficacy

Over a thousand published journal articles were found that examined the efficacy of SLS as a surfactant, dispersant and synergist with other pesticide formulation ingredients. However, there are relatively few that look at SLS's pesticidal properties by itself in isolation from other active ingredients. Most of these studies involve registered insecticides, herbicides and fungicides that are not exempt from the requirement of registration; their primary mode of action is assumed to come not from SLS, but from the other active ingredients in most cases. SLS is exceptional among minimum risk pesticides in this regard, and that is why a different approach was taken with respect to summarizing its efficacy. Studies that involved

EPA registered pesticides with SLS as an inert ingredient or synergist and not the primary active ingredient were not included in the efficacy review.

Insecticidal and Acaricidal Activity

SLS can be used to control immature mosquitos. Mosquito pupae were found to be more susceptible to surfactants—including SLS—than the larvae. The LC_{50} of SLS to *Culex pipiens quinquefasciatus* pupae was 78ppm; the LC_{90} was 96ppm (Piper and Maxwell 1971). The authors concluded that lowering water surface tension surfactants, such as SLS, results in oxygen deprivation and suffocation. SLS was found to increase the efficacy and reduce the effective dose when combined with various essential oils, such as cinnamon oil, citronella oil, cedar oil, clove oil, garlic oil, lemongrass oil, linseed oil, rosemary oil, soybean oil, thyme oil, and peppermint oil. As such, its effect can be considered synergistic.

The time it took an aerosol of corn mint oil to kill German cockroaches (*Blattella germanica*) was reduced from 76 seconds to 39 seconds at a 4% corn mint oil solution when 1% SLS was added. For a 10% solution of SLS, the kill time went from 30 to 21 seconds (Zobitne and Gehret 2003). With American cockroaches (*Blattella americana*), the effect was more dramatic. Corn mint oil was completely ineffective by itself at even a 10% aerosol solution. However, 4% corn mint oil and 1% SLS resulted in a kill time of 45 seconds and 10% corn mint oil and 1% SLS had a kill time of 38 seconds. The patent explicitly mentions that the intent is to formulate a minimum-risk pesticide that EPA exempts from registration.

SLS can also be formulated using its crystalline solid needle form in aqueous solution and applied to building cracks and crevices for the control of crawling insects, particularly cockroaches (Herrera and Barcay 2012). The needle form resulted in over 90% mortality of cockroaches (species not named) with 1% and 6% concentrations sprayed into jars. The mortality rate caused by the needle form of SLS was significantly higher than for the substance's powder or liquid forms.

Two 25(b) minimum-risk products formulated with SLS and essential oils caused over 90% mortality of bed bugs (*Cimex lectularius*) (Singh et al. 2014). One was EcoRaider (Reneotech), a formulation consisting of 2% SLS, 1% geraniol and 1% cedar oil applied at a rate of 4.07 mg/cm^2 (1 gal/1000 $feet^2$). EcoRaider caused mortality that was not significantly different from Temprid SC that contains the active ingredients imidacloprid (21%) and ß-cyfluthrin (10.5%) (Singh et al. 2014). The second was Bed Bug Patrol (Nature's Innovation), consisting of 1.3% SLS, combined with 0.03% clove oil and 1% peppermint oil. It also caused over 90% bed bug mortality.

SLS (0.35%) combined with eugenol (0.52%), peppermint (0.15%) and citronella oil (0.06%) applied at the ready-to-use (RTU) label rate in a 25(b) exempt commercial formulation called Bug Assassin caused 80% mortality of two-spotted spider mite (*Tetranychus urticae*) (Cloyd et al. 2009). However, it was not the most effective product tested. Bug Assassin was not effective against the sweet potato whitefly (*Bemisia tabaci*) (Cloyd et al. 2009).

Antimicrobial Activity

In conducting its reregistration evaluation of SLS—along with the related substances ammonium lauryl sulfate, magnesium lauryl sulfate, and triethanolamine lauryl sulfate—the EPA concluded that these lauryl sulfate salts had 'no independent pesticidal activity' when included in antimicrobial products, and thus are properly classified as inert ingredients in those products (US EPA 1993).

Prior and subsequent to that conclusion, the EPA recognized SLS as effective as a synergist in combination with other active ingredients. A combination of 10% citric acid, 5% malic acid, and 2% SLS impregnated in a facial tissue effectively deactivated human rhinovirus in a contact time of 1 minute (Guse 1983). A subsequent study showed that even with a reduced dose of 3.2% citric acid, with 1.6% malic acid and 0.5%, SLS showed sufficient efficacy to reduce not only rhinovirus, but also parainfluenza and herpes simplex viruses as well (Guse 1986). Tissues impregnated with 7.53% citric acid and 2.02% SLS demonstrated sufficient efficacy to support a claim of controlling Rhinovirus 2 (Whyte 2004). That determination followed a previous review of another formulation that showed efficacy but was insufficient to support a public health claim as an EPA registered pesticide (Mitchell 2002).

In addition to the data submitted to the EPA, there are several studies that explored the antimicrobial activity of SLS. Cantaloupes washed with a commercial detergent that contained 0.2-0.5% SLS and phosphoric acid adjusting the formulation to a pH of 2 had a significantly reduced total endogenous microbial load (Sapers et al. 2001). SLS at concentrations of 0.25% and 0.5% inhibited but did not eliminate *Listeria monocytogenes* (Johnson 2006). When combined with methanobactin against that organism, SLS had a significant synergistic effect in reducing surviving target organisms.

However, the antimicrobial activity of SLS is limited. *Salmonella* spp. and *Shigella* spp. cultured in agar and treated with a 0.1% solution of SLS survived at both 22° and 40°C (Raiden et al. 2003). SLS in a 1% solution was ineffective in inhibiting *Salmonella* and *E. coli* O157:H7 on both lettuce and poultry (Zhao et al. 2009). While SLS can increase efficacy of acidic antimicrobials like citric and phosphoric acids, it can also inhibit efficacy of other antimicrobials. For example, formulated products of SLS combined with acriflavine are ineffective against *Staphylocooccus aureus* (Valko and DuBois 1944).

Herbicidal Activity

SLS is claimed to have a mode of action similar to herbicidal soaps (Vento 2004). However, a search of the literature found no specific information regarding SLS's mode of action (ICF Consulting 2006). No efficacy data specific to SLS acting alone as an herbicide was found in preparing this profile. Formulated 25(b) exempt insecticides that contained SLS and essential oils were noted to be phytotoxic in insecticide trials (Cloyd et al. 2009). One, Sharpshooter, consisted of clove oil and SLS, while the other, Bug Assassin, contained eugenol, peppermint and citronella oil in addition to SLS. Two minimum-risk insecticide formulations exempt from registration and containing SLS have been shown to be phytotoxic (Cloyd et al. 2009). However, each contains other ingredients known to be phytotoxic: clove oil in Sharpshooter and eugenol in Bug Assassin (Tworkoski 2002).

Standards and Regulations

EPA Requirements

SLS is exempt from the requirement of a tolerance as both an inert and an active ingredient in antimicrobial formulations for use on food-contact surface sanitizing solutions. Ready-to-use formulations are limited to an end-use concentration not to exceed 350 ppm [40 CFR 180.940(a)]. The formulation needs to be used in accordance with good manufacturing practices, provided that the substance is applied on a semi-permanent or permanent food-contact surface other than food packaging with adequate draining before contact with food. The same limitation applies to the use of SLS in dairy processing [40 CFR 180.940(b)]. Food processing equipment and utensils may also be cleaned with SLS without any limitation to the concentration [40 CFR 180.940(c)].

FDA Requirements

According to the FDA, SLS may be safely used as a food additive for human consumption [21 CFR 172.822]. However, when SLS is used in food it is subject to specific restrictions. Food grade specifications require SLS to be a mixture of sodium alkyl sulfates consisting chiefly of SLS with a minimum content of 90 percent sodium alkyl sulfates [21 CFR 172.822(a)].

Food uses of SLS considered GRAS by FDA are limited to: as an emulsifier in egg whites at 1,000 ppm for solids and 125 ppm for frozen or liquid [21 CFR 172.822(b)(1)]; as a whipping agent for gelatin in marshmallows up to 0.5% by weight of the gelatin [21 CFR 172.822(b)(2)]; as a surfactant in fumaric acid in beverages and fruit drinks not to exceed 25 ppm in the final product [21 CFR 172.822(b)(3)]; and as a wetting agent in crude vegetable oils and animal fats at a level not to exceed 10 parts per million in the partition of high and low melting fractions followed by alkali neutralization and deodorization [21 CFR 172.822(b)(4)].

Finally, SLS must be properly labeled with adequate use directions to provide a final product that complies with the limitations described above [21 CFR 172.822(c)].

Other Regulatory Requirements

SLS was petitioned for use in organic production in 2004 (Vento 2004). The National Organic Standards Board determined that SLS was synthetic and did not recommend it to the National Organic Program for inclusion on the National List (NOSB 2006). Because it is synthetic and does not appear on the National List of allowed synthetic substances allowed for crop production [7 CFR 205.601] SLS is therefore prohibited for use in organic production [7 CFR 205.105(a)].

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