NIOSH Skin Notation Profiles

Ethylene Glycol Dinitrate (EGDN)

SK

- ID^{SK}
- [~~SK~~]
- SYS
- SYS (FATAL
- DIR
- DIR (IRR)
- DIR (COR)
- SEN

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Skin Notation (SK) Profile

Ethylene Glycol Dinitrate (EGDN)
[CAS No. 628–96–6]

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Foreword

As the largest organ of the body, the skin performs multiple critical functions, such as serving as the primary barrier to the external environment. For this reason, the skin is often exposed to potentially hazardous agents, including chemicals, which may contribute to the onset of a spectrum of adverse health effects ranging from localized damage (e.g., irritant contact dermatitis and corrosion) to induction of immune-mediated responses (e.g., allergic contact dermatitis and pulmonary responses), or systemic toxicity (e.g., neurotoxicity and hepatoxicity). Understanding the hazards related to skin contact with chemicals is a critical component of modern occupational safety and health programs.

In 2009, the National Institute for Occupational Safety and Health (NIOSH) published *Current Intelligence Bulletin (CIB) 61: A Strategy for Assigning New NIOSH Skin Notation*s [NIOSH 2009–147]. This document provides the scientific rationale and framework for the assignment of multiple hazard-specific skin notations (SK) that clearly distinguish between the systemic effects, direct (localized) effects, and immune-mediated responses caused by skin contact with chemicals. The key step within assignment of the hazard-specific SK is the determination of a substance's hazard potential, or its potential for causing adverse health effects as a result of skin exposure. This determination entails a health hazard identification process that involves use of the following:

- Scientific data on the physicochemical properties of a chemical
- Data on human exposures and health effects
- Empirical data from in vivo and in vitro laboratory testing
- Computational techniques, including predictive algorithms and mathematical models that describe a selected process (e.g., skin permeation) by means of analytical or numerical methods.

This Skin Notation Profile provides the SK assignment and supportive data for ethylene glycol dinitrate (EGDN; CAS No. 628–96–6). In particular, this document evaluates and summarizes the literature describing the substance's hazard potential and its assessment according to the scientific rationale and framework outlined in CIB 61. In meeting this objective, this Skin Notation Profile intends to inform the audience—mostly occupational health practitioners, researchers, policy- and decision-makers, employers, and workers in potentially hazardous workplaces—so that improved risk-management practices may be developed to better protect workers from the risks of skin contact with the chemical of interest.

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Contents

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
CIB	Current Intelligence Bulletin
cm^2	square centimeter(s)
cm/hr	centimeter(s) per hour
DEREK™	Deductive Estimation of Risk from Existing Knowledge
DIR	skin notation indicating the potential for direct effects to the skin following contact with a chemical
EC	European Commission
EGDN	ethylene glycol dinitrate
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
IARC	International Agency for Research on Cancer
K_{aq}	coefficient in the watery epidermal layer
K_p	skin permeation coefficient
K_{pol}	coefficient in the protein fraction of the stratum corneum
K_{psc}	permeation coefficient in the lipid fraction of the stratum corneum
LD_{50}	dose resulting in 50% mortality in the exposed population
LD_{Lo}	dermal lethal dose
log K_{OW}	base-10 logarithm of a substance's octanol–water partition
m^3	cubic meter(s)
mg	milligram(s)
mg/cm^2	milligram(s) per square centimeter
$mg/cm^2/hr$	milligram(s) per square centimeter per hour
mg/m^3	milligram(s) per cubic meter
mL	milliliter(s)
MW	molecular weight
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OEL	occupational exposure limit
OSHA	Occupational Safety and Health Administration
REL	recommended exposure limit
RF	retention factor
SEN	skin notation indicating the potential for immune-mediated reactions following exposure of the skin
SI ratio	ratio of skin dose to inhalation dose
SK	skin notation
S_W	solubility

SYS	skin notation indicating the potential for systemic toxicity following exposure of the skin
USEPA	United States Environmental Protection Agency

Glossary

Absorption—The transport of a chemical from the outer surface of the skin into both the skin and systemic circulation (including penetration, permeation, and resorption).

Acute exposure—Contact with a chemical that occurs once or for only a short period of time.

Cancer—Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Contaminant—A chemical that is (1) unintentionally present within a neat substance or mixture at a concentration less than 1.0% or (2) recognized as a potential carcinogen and present within a neat substance or mixture at a concentration less than 0.1%.

Cutaneous (or percutaneous)—Referring to the skin (or through the skin).

Dermal—Referring to the skin.

Dermal contact—Contact with (touching) the skin.

Direct effects—Localized, non-immune-mediated adverse health effects on the skin, including corrosion, primary irritation, changes in skin pigmentation, and reduction/disruption of the skin barrier integrity, occurring at or near the point of contact with chemicals.

Immune-mediated responses—Responses mediated by the immune system, including allergic responses.

Sensitization—A specific immune-mediated response that develops following exposure to a chemical, which, upon re-exposure, can lead to allergic contact dermatitis (ACD) or other immune-mediated diseases such as asthma, depending on the site and route of re-exposure.

Substance—A chemical.

Systemic effects—Systemic toxicity associated with skin absorption of chemicals after exposure of the skin.

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1 Introduction

1.1 General Substance Information

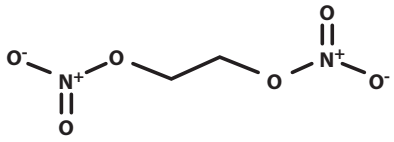
Chemical: Ethylene Glycol Dinitrate (EGDN)

CAS No: 628–96–6

Molecular weight (*MW*): 152.06

Molecular formula: $C_2H_4N_2O_6$

Structural formula:



Synonyms:

EGDN; 1,2-Ethanediol dinitrate; Ethylene dinitrate; Ethylene nitrate; Glycol dinitrate; Nitroglycol; EGN

Uses:

Ethylene glycol dinitrate (EGDN) is used primarily in the production of explosives [NIOSH 1978].

1.2 Purpose

This S*kin Notation Profile* presents (1) a brief summary of technical data associated with skin contact with ethylene glycol dinitrate (EGDN) and (2) the rationale behind the hazard-specific skin notation (SK) assignment for EGDN. The SK assignment is based on the scientific rationale and logic outlined in the *Current Intelligence Bulletin (CIB) 61: A Strategy for Assigning New NIOSH Skin Notations* [NIOSH 2009]. The summarized information and health hazard assessment are limited to an evaluation of the potential health effects of dermal exposure to EGDN. A literature search was conducted through July 2010 to identify information on EGDN, including but not limited to data relating to its toxicokinetics, acute toxicity, repeated-dose systemic toxicity, carcinogenicity, biological system/function–specific effects (including reproductive and developmental effects and immunotoxicity), irritation, and sensitization. Information was considered from studies of humans, animals, or appropriate modeling systems that are relevant to assessing the effects of dermal exposure to EGDN.

1.3 Overview of SK Assignment for EGDN

EGDN is potentially capable of causing systemic toxic effects following skin contact. A critical review of available data has resulted in the following SK assignment for EGDN: **SK: SYS**. Table 1 provides an overview of the critical effects and data used to develop the SK assignment for EGDN.

Table 1. Summary of the SK assignments for EGDN

Skin notation	Critical effect	Available data
SK: SYS	Cardiovascular (Vasodilation; Fluctuations within blood pressure)	Limited human and animal data

2 Systemic Toxicity from Skin Exposure (SK: SYS)

Toxicokinetic studies following dermal exposure to EGDN were identified. In vivo skin absorption studies indicated that approximately 3 milligrams (mg) of the substance (13.7%) of the dose applied under occlusive conditions to 1 square centimeter (cm^2) of the forearms was absorbed through the human skin during the 7-hour test period [Gross et al. 1960]. Hogstedt and Stahl [1980] reported that skin absorption was a major route of entry of the substance into the body when the hands of human volunteers were exposed to dynamite vapors, or to the combination of vapors and the solid phase, with and without gloves. These investigators stated that a substantial part of 20 mg of EGDN was absorbed through the hands after 2 hours. Other studies provided evidence for dermal absorption of EGDN in humans. For example, the substance was reported to cause headache in humans when applied to the skin of the forearms of human volunteers [Crandall et al. 1931]. Fukuchi [1981] reported that workers with undetectable EGDN in blood and urine samples prior to explosive production work had high levels of the substance in the blood and urine after engaging in explosive production. Other in vivo studies in humans also indicated that EGDN penetrated the skin and into the body system through nylon and rubber gloves [Einert et al. 1963; Yoshikawa 1964]. Williams and Murray [1966] conducted an in vitro kinetic analysis of blood EGDN concentration and reported that EGDN is rapidly absorbed into human skin. Gross et al. [1960] also investigated the rate of dermal absorption of EGDN in rats under occlusive conditions, by applying 100 to 600 milligrams per square centimeter (mg/cm^2) of the substance in a gelatinous mixture (containing 93% of the substance and 7% nitrocellulose) or 200 to 800 mg of the substance in an "explosive soft paste" (containing 22% of the substance, 6.0% of dinitrotoluene, 5.0% trinitrotoluene, 0.9% nitrocellulose, 1.0% sawdust, 64.9% sodium chloride, and 0.2% iron oxide). These investigators reported that half of the 100 mg of the gel containing 93% of the substance was absorbed after 1 day, and all of it was absorbed after 8 days. The initial rate of absorption was reported as approximately 10 milligrams per square centimeter per hour (mg/cm^2/hour). However, the substance from the soft paste containing 22% EGDN was absorbed more slowly, with an initial absorption rate of approximately 6.5 mg/cm^2/hour. These rates (i.e., 6.5–10 mg/cm^2/hour) were 3- to 4-fold higher than in volunteers [Gross et al. 1960]. On the basis of available data from toxicokinetic studies in humans and animals, it appears that EGDN is absorbed through the skin following dermal exposure.

The potential of EGDN to pose a skin absorption hazard was also evaluated with use of a predictive algorithm for estimating and

evaluating the health hazards of dermal exposure to chemical substances [NIOSH 2009]. The evaluation method compares an estimated chemical dose accumulated in the body from skin absorption and an estimated dose from respiratory absorption associated with a reference occupational exposure limit. On the basis of this algorithm, a ratio of the skin dose to the inhalation dose (SI ratio) of 39.45 was calculated for EGDN. An SI ratio of ≥0.1 indicates that a chemical is capable of producing systemic toxicity from skin exposure [NIOSH 2009]. Additional information on the SI ratio and the variables used in its calculation are included in the appendix.

No dermal lethal dose (LD_{Lo}) for humans or dermal LD_{50} value (the dose resulting in 50% mortality in the exposed population) has been identified for EGDN. Lack of adequate information on the acute dermal toxicity of EGDN precludes any conclusion regarding the potential of the substance to be toxic following acute dermal exposure.

Studies investigating the health effects of EGDN in humans were identified [Crandall et al. 1931; Einert et al. 1963; Hogstedt and Axelson 1977]. Crandall et al. [1931] studied the development of tolerance to the vasodilating effects of EGDN and the duration of time required to develop tolerance in human volunteers. Response to EGDN was determined based on the "headache dose" or the dose that caused a moderate headache within a subject. Doses ranging from 1.8 to 3.5 milliliter (mL) of a 1% solution of EGDN in alcohol were applied to the skin of the forearm. The authors reported that tolerance to EGDN occurred at 160 mg. The time required to develop tolerance to EGDN following application of one "headache dose" ranged between 24 to 36 hours with an average duration of 32 hours. The results of this study provide evidence of dermal uptake of EGDN and its ability to cause vasodilatation exhibited as within humans. Available epidemiological studies evaluated circulatory system effects of EGDN in exposed workers who handled explosives containing EGDN for 1 to more than 20 years and developed chest pains or died suddenly after a brief period of withdrawal from exposure (e.g., a weekend) [Einert et al. 1963; Hogstedt and Axelson 1977]. The workers investigated in both studies were likely exposed repeatedly through both inhalation and dermal contact. Einert et al. [1963] evaluated 38 workers exposed to EGDN and nitroglycerin during the manufacturing of dynamite. Air and dermal samples were collected and coordinated with medical findings of evaluated workers. Although the effects of inhaling EGDN could not be excluded, the authors reported that dermal uptake of EGDN contributed greatly to the onset of the observed cardiovascular effects including fluctuations with in pulse rate and decreases in blood pressure. Hogstedt and Axelson [1977] conducted a case-control study to investigate the mortality rates within workers exposed to dynamite containing EGDN. A significant increase in ischemic heart disease was reported. The authors stated that the results of this study indicate excessive mortality caused by ischemic heart disease among workers with long-term exposures to dynamite containing EGDN and nitroglycerin. It appears from the studies of humans that repeated and prolonged dermal exposure to EGDN may cause systemic effects that focus on the cardiovascular system, although the contribution of inhalation exposure or exposure to other materials is uncertain.

Table 2. Summary of the carcinogenic designations* for EGDN by numerous governmental and nongovernmental organizations

Organization	Carcinogenic designation
NIOSH [2005]	None
NTP [2009]	None
USEPA [2010]	None
IARC [2010]	None
EC [2010]	None
ACGIH [2001]	None

Abbreviations: ACGIH = American Conference of Governmental Industrial Hygienists; EC = European Commission, Joint Research, Institute for Health and Consumer Protection; IARC = International Agency for Research on Cancer; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; USEPA = United States Environmental Protection Agency.

*Note: The listed cancer designations were based on data from nondermal (such as oral or inhalation) exposure rather than dermal exposure.

NIOSH [1978] reviewed the hazards of occupational exposure to EGDN and nitroglycerin. The results of the evaluation revealed that EGDN was capable of causing several adverse health effects including decreases in systolic, diastolic, and pulse pressures during initial exposure are suggestive of vasodilation, and increases in diastolic pressure from the levels during initial exposure are indicative of compensatory vasoconstriction. Symptoms of exposure include headaches, dizziness, nausea, chest pains, and palpitations. NIOSH [1978] concluded that these effects can be readily produced by dermal exposures to EGDN should be minimized due to the ability of the substance to be absorbed via the skin and contribute to systemic toxicity.

No repeat-dose studies in animals following dermal exposure to EGDN were identified. No standard toxicity or specialty studies evaluating biological system/function–specific effects (including reproductive and developmental effects and immunotoxicity) following dermal exposure to EGDN were identified.

No epidemiological studies that evaluated the potential of EGDN to cause cancer in workers exposed to it or that evaluated the carcinogenicity potential of EGDN in animals following dermal exposure were identified. Table 2 provides a summary of carcinogenic designations for EGDN from multiple governmental and nongovernmental organizations.

Taken together, data from the toxicokinetic studies in humans and animals **[Gross et al. 1960; Fukuchi 1981*]**, data from human studies **[Crandall et al. 1931; Einert et al. 1963; Hogstedt and Axelson 1977]**, supported by a mathematical model, demonstrate that EGDN is absorbed through the skin and can cause systemic toxicity such as circulatory system effects. NIOSH [1978] stated that EGDN was capable of causing decreased blood pressure, vasodilation, headaches, dizziness, nausea, chest pains, and palpitations following dermal exposures. Therefore, on the basis of the

*References in **bold** text indicate studies that served as the basis of the SK assignment.

data for this assessment, EGDN is assigned the SK: SYS notation.

3 Direct Effects on Skin (SK: DIR)

No data on corrosivity of EGDN or from in vitro tests for corrosivity in human or animal skin models or integrity of cadaver skin were identified. No information from occupational exposure experience is available to suggest that EGDN is a skin irritant. A skin irritation test conducted by Kanerva et al. [1991] on 20 persons indicated concentrations of 0.1% to 0.5% EGDN did not cause a skin irritation for any of the test subjects. No data from animal studies was found to suggest that the substance is a skin irritant. The structure-activity relationship model, Deductive Estimation of Risk from Existing Knowledge (DEREK™) for Windows, predicted EGDN to be negative for skin irritation. Tests conducted on humans and animals provided no evidence that EGDN is a skin irritant. Therefore, on the basis of the data for this assessment, EGDN is not assigned the SK: DIR notation.

4 Immune-mediated Responses (SK: SEN)

There is limited information available for determining whether EGDN is a skin sensitizer. Kanerva et al. [1991] has provided an occupational case report of allergic skin reactions. According to this case report, four workers who handled explosives and developed allergic contact dermatitis were patch-tested with a series of dilutions of the chemicals in the explosives. One of two subjects patch-tested with 0.1 to 2% EGDN in aqueous solution had positive allergic reactions to the substance at the dilutions tested, whereas the other was negative at all the dilutions. No standard studies of the skin sensitization potential of EGDN in humans or animals were identified. *DEREK* predicted EGDN to be negative for skin sensitization. Because insufficient data are available for this assessment, EGDN is not assigned the SK: SEN notation.

5 Summary

Data from the toxicokinetic studies in humans and animals **[Gross et al. 1960; Fukuchi 1981]** demonstrate that EGDN is absorbed through the skin following dermal exposure. Although no acute, repeat-dose, subchronic, or chronic dermal toxicity studies in animals were identified, human studies **[Crandall et al. 1931; Einert et al. 1963; Hogstedt and Axelson 1977]** showed systemic toxicity such as cardiovascular system effects. However, those reports provide limited data that preclude a confident estimate of the toxicity from dermal exposure. NIOSH [1978] stated that EGDN was capable of causing decreased blood pressure, vasodilation, headaches, dizziness, nausea, chest pains, and palpitations following dermal exposures. Limited data were noted that showed the substance is not a skin irritant in humans. The data were judged insufficient for assigning a skin sensitization notation for the substance because only one nonstandard study indicated that EGDN is a skin sensitizer. Therefore, on the basis of these assessments, EGDN is assigned a composite skin notation of **SK: SYS**.

Table 3 summarizes the skin hazard designations for EGDN previously issued by NIOSH and other organizations. The equivalent dermal designation for EGDN, according to the Globally Harmonized System (GHS) of Classification and Labeling

Table 3. Summary of the previously issued skin hazard designations for EGDN

Organization	Skin hazard designation
NIOSH [2005]	[skin]: Potential for dermal absorption
OSHA [2009]	[skin]: Based on potential contribution to the overall exposure by the cutaneous route, including the mucous membranes and the eyes, either by airborne particles or, more particularly, by direct contact with the substance
ACGIH [2001]	[skin]: Based on the available data, demonstrating systemic toxicity following absorption through intact skin with considerable ease
EC [2010]	R27: Very toxic in contact with skin

Abbreviations: ACGIH = American Conference of Governmental Industrial Hygienists; EC = European Commission, Joint Research, Institute for Health and Consumer Protection; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration.

of Chemicals, is Acute Toxicity Category 1 (Hazard statement: Fatal in contact with the skin) [European Parliament 2008].

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Note: Asterisks (*) denote sources cited in text; daggers (†) denote additional resources.

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Appendix: Calculation of the SI Ratio for EGDN

This appendix presents an overview of the SI ratio and a summary of the calculation of the SI ratio for EGDN. Although the SI ratio is considered in the determination of a substance's hazard potential following skin contact, it is intended only to serve as supportive data during the assignment of the NIOSH SK. An in-depth discussion on the rationale and calculation of the SI ratio can be found in Appendix B of the *Current Intelligence Bulletin (CIB) 61: A Strategy for Assigning New NIOSH Skin Notations* [NIOSH 2009].

Overview

The SI ratio is a predictive algorithm for estimating and evaluating the health hazards of skin exposure to substances. The algorithm is designed to evaluate the potential for a substance to penetrate the skin and induce systemic toxicity [NIOSH 2009]. The goals for incorporating this algorithm into the proposed strategy for assigning the SYS notation are as follows:

(1) Provide an alternative method to evaluate substances for which no clinical reports or animal toxicity studies exist or for which empirical data are insufficient to determine systemic effects.

(2) Use the algorithm evaluation results to determine whether a substance poses a skin absorption hazard and should be labeled with the SYS notation.

The algorithm evaluation includes three steps: (1) determining a skin permeation coefficient (K_p) for the substance of interest, (2) estimating substance uptake by the skin and respiratory absorption routes, and (3) evaluating whether the substance poses a skin exposure hazard.

The algorithm is flexible in the data requirement and can operate entirely on the basis of the physicochemical properties of a substance and the relevant exposure parameters. Thus, the algorithm is independent of the need for biologic data. Alternatively, it can function with both the physicochemical properties and the experimentally determined permeation coefficient when such data are available and appropriate for use.

The first step in the evaluation is to determine the K_p for the substance to describe the transdermal penetration rate of the substance [NIOSH 2009]. The K_p, which represents the overall diffusion of the substance through the stratum corneum and into the blood capillaries of the dermis, is estimated from the compound's molecular weight (MW) and base-10 logarithm of its octanol–water partition coefficient (log K_{OW}). In this example, K_p is determined for a substance with use of Equation 1. A self-consistent set of units must be used, such as centimeters per hour (cm/hr), outlined in Table A1. Other model-based estimates of Kp may also be used [NIOSH 2009].

Equation 1: Calculation of Skin Permeation Coefficient (K_p)

$$K_p + \frac{1}{\frac{1}{K_{psc} + K_{pol}} + \frac{1}{K_{aq}}}$$

where K_{psc} is the permeation coefficient in the lipid fraction of the stratum corneum, kpol is the coefficient in the protein fraction of the stratum corneum, and K_{aq} is the coefficient in the watery epidermal layer. These components are individually estimated by

$$\log K_{psc} = -1.326 + 0.6097 \times \log K_{OW} - 0.1786 \times MW0.5$$

$$K_{pol} = 0.0001519 \times MW-0.5$$

$$K_{aq} = 2.5 \times MW-0.5$$

The second step is to calculate the biologic mass uptake of the substance from skin absorption (skin dose) and inhalation (inhalation dose) during the same period of exposure. The skin dose is calculated as a mathematical product of the K_p, the water solubility (S_w) of the substance, the exposed skin surface area, and the duration of exposure. Its units are milligrams (mg). Assume that the skin exposure continues for 8 hours to unprotected skin on the palms of both hands (a surface area of 360 cm^2).

Equation 2: Determination of Skin Dose

$$\text{Skin dose} = K_p \times Sw \times \text{Exposed skin surface area} \times \text{Exposure time}$$

$$= K_p(cm/hr) \times Sw\ (mg/cm^3) \times 360\ cm^2 \times 8\ hours$$

The inhalation dose (in mg) is derived on the basis of the occupational exposure limit (OEL) of the substance—if the OEL is developed to prevent the occurrence of systemic effects rather than sensory/irritant effects or direct effects on the respiratory tract. Assume a continuous exposure of 8 hours, an inhalation volume of 10 cubic meters (m^3) inhaled air in 8 hours, and a factor of 75% for retention of the airborne substance in the lungs during respiration (retention factor, or RF).

Equation 3: Determination of Inhalation Dose

$$\text{Inhalation dose} = \text{OEL} \times \text{Inhalation volume} \times RF$$

$$= \text{OEL}\ (mg/m^3) \times 10\ m^3 \times 0.75$$

The final step is to compare the calculated skin and inhalation doses and to present the result as a ratio of skin dose to inhalation dose (the SI ratio). This ratio quantitatively indicates (1) the significance of dermal absorption as a route of occupational exposure to the substance and (2) the contribution of dermal uptake to systemic toxicity. If a substance has an SI ratio greater than or equal to 0.1, it is considered a skin absorption hazard.

Calculation

Table A1 summarizes the data applied in the previously described equations to determine the SI ratio for EGDN. The calculated SI ratio was 39.45. On the basis of these results, EGDN is predicted to represent a skin absorption hazard.

Appendix References

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Table A1. Summary of data used to calculate the SI ratio for EGDN

Variables used in calculation	Units	Value
Skin permeation coefficient		
Permeation coefficient of stratum corneum lipid path(K_{psc})	cm/hr	0.00151
Permeation coefficient of the protein fraction of the stratum corneum (K_{pol})	cm/hr	1.23183×10^{-5}
Permeation coefficient of the watery epidermal layer (K_{aq})	cm/hr	0.20274
Molecular weight (MW)*	amu	152
Base-10 logarithm of its octanol–water partition coefficient (Log K_{OW})*	None	1.16
Calculated skin permeation coefficient (K_p)	cm/hr	0.00151
Skin dose		
Water solubility (S_W)*	mg/cm^3	6.8
Calculated skin permeation coefficient (K_p)	cm/hr	0.00151
Estimated skin surface area (palms of hand)	cm^2	360
Exposure time	hr	8
Calculated skin dose	mg	29.58
Inhalation Dose		
Occupational exposure limit (OEL)†	mg/m^3	0.1
Inhalation volume	m^3	10
Retention factor (RF)	None	0.75
Inhalation dose	mg	0.75
Skin dose–to–inhalation dose (SI) ratio	None	39.45

*Variables identified from SRC [2009].
†The OEL used in calculation of the SI ratio was the NIOSH-recommended exposure limit (REL) [NIOSH 2005].

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