

5 June 1997

Jack:

For your information, here are the bibliographical references for the toxicological data I've sent you:

HARTE, JOHN, et. al. *Toxics A to Z: A Guide to Everyday Pollution Hazards*. Berkely, CA: University of California Press, 1991.

PATNAIK, PRADYOT. *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*. New York: Van Nostrand Reinhold, 1992.

- Steve

Dioxane

Other Names

1,4-Dioxane; *p*-dioxane; *p*-dioxan; di(ethylene oxide); diethylene dioxide; diethylene ether; diethylene oxide

Trade Name

Holcomb's Window Cleaner

Introduction

Dioxane is an important commercial solvent. It is also used as a stabilizer during the manufacture of industrial paints. In some biology laboratories it is used to remove water from tissue samples, which are then studied under the microscope. It should not be confused with the similarly named chemical contaminant dioxin.

Physical and Chemical Properties

Dioxane is a synthetic organic compound with no known natural sources. It has a faint, pleasant, alcohol-like odor that can be recognized at low concentrations, but people tend to get used to the smell. The vapors are not irritating until dangerous concentrations are in the air. Pure dioxane is a colorless, volatile liquid that is heavier than water. The vapors are quite flammable and easily react with other chemicals used in industrial settings. It can be explosive when mixed with air. Dioxane is not easily broken down by microorganisms, although it does degrade upon prolonged exposure to light.

Exposure and Distribution

Production of dioxane in the United States averages a little less than 3000 tons annually. It is manufactured in the eastern and southern regions of the United States and shipped primarily via rail and truck in bottles, cans, and metal drums. Contact with high concentrations of dioxane is most likely at job sites where it is used, although the public may be

exposed to it as a result of accidents or spills during shipping. Some consumer products make use of dioxane, most notably Holcomb's Window Cleaner.

Although dioxane has not been included in federal and state surveys of drinking water, it has been reported to occur in both surface water and groundwater. Distribution and average concentrations of the chemical in water are unknown. No information on its occurrence in food or air appears to be available.

Health Effects

Dioxane is readily absorbed through the skin, lungs, and *gastrointestinal tract*. It is a moderately *acute toxin*, but symptoms of overexposure may be delayed for hours following exposures that had erroneously been considered negligible. It easily penetrates the skin, and large amounts spilled on the skin or clothing can be life threatening. Dioxane spilled on the skin can be irritating. It can also make the skin dry with no other signs of irritation, but if it is allowed to remain on the skin or clothing, smarting and reddening of the skin may result. Some people show an *allergic response* when their skin comes into contact with dioxane.

The vapor can be irritating to the eyes, nose, and throat. Inhaled vapors can cause a slight smarting of the eyes or respiratory system if the chemical is present at high concentrations. Symptoms disappear when exposure to the chemical stops. Overexposure may also cause eye irritation and can permanently injure the cornea. Dioxane can also be inhaled in sufficient amounts to cause *systemic intoxication*, *narcosis*, *pulmonary edema*, and even death. The kidney and liver can be damaged as a result of acute inhalation exposure to dioxane. Dioxane can also cause kidney and liver damage if swallowed.

Chronic exposure to dioxane is also hazardous. Prolonged skin exposure can cause a rash or burn. Repeated exposure to levels that do not cause overt symptoms can lead to slowed central nervous system function and

to liver and may be a tendency. Dioxane has effects in low doses. *Epidemiology* of dioxane is available. The probable cause according to Chapter 3 and many sources.

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to liver and kidney damage. These symptoms may be delayed because the chemical has a tendency to accumulate in body tissue. Dioxane has been shown to cause liver and nasal cancers in laboratory rats and mice when low doses are administered orally over a long time. *Epidemiological* data indicating that dioxane is a human carcinogen are not available. The EPA has classified dioxane as a probable human carcinogen (a B₂ substance according to the classification in Table 5 of Chapter 3). Some evidence suggests that dioxane may suppress immune system function.

When dioxane is present in chlorinated water, a highly toxic compound is formed. One researcher found that chlorination of dioxane increased its toxicity 1000 times. Therefore, never pour unwanted dioxane down the drain.

Protection and Prevention

Dioxane is most likely to be encountered at the workplace. If solvents are used at work, be sure to learn the names of those used. Wear protective clothing when required. Request a *Material Safety Data Sheet (MSDS)* if solvents are part of your workplace environment. Avoid buying window cleaners that contain dioxane. Should you inhale, swallow, have skin contact with, or spill dioxane, get medical attention immediately. Remember that damage due to overexposure may be delayed by several hours.

Environmental Effects

The environmental fate of dioxane can only be estimated on the basis of the chemical's physical properties. Few actual measurements exist. Dioxane can be expected to evaporate from soil and surface water and to move easily through soil. This property, combined with dioxane's slow microbial degradation, implies that spilled dioxane could pose a toxic threat to groundwater supplies if concentrations were high enough.

Regulatory Status

Dioxane is listed as a *hazardous air pollutant* in the 1990 Clean Air Act, requiring the EPA to set emission standards. OSHA has set standards regarding maximum average concentrations found in workplace air. Dioxane is subject to *community right-to-know* reporting.

Technical Information

Chemical formula: C₄H₈O₂

Molecular weight: 88

Lowest reported lethal dose for humans:

(oral): 500 mg/kg

(inhaled for one week): 470 ppm

Further Reading

Agency for Toxic Substances and Disease Registry. 1988. *Toxicological Profile for 1,4-Dioxane*. Washington, D. C.: U.S. Public Health Service. SAX, N. I. 1988. *p-Dioxane. Dangerous Properties of Industrial Materials Report*, January/February. New York: Van Nostrand Reinhold.

Analysis

Formaldehyde can be analyzed by several instrumental techniques, such as GC, colorimetry, polarography, and GC/MS. The GC method involves the passage of air through a solid sorbent tube containing 2-(benzylamino)ethanol on Chromosorb 102 or XAD-2. The derivative, 2-benzylloxazolidine, is desorbed with isooctane and injected into GC equipped with an FID (NIOSH 1984, Method 2502). Carbowax 20M or a fused-silica capillary column is suitable. 2-Benzylloxazolidine peak is sometimes masked under the peaks, due to the derivatizing agent or its decomposition and/or polymeric products. The isooctane solution of 2-benzylloxazolidine can readily be analyzed by GC/MS without any interference using a capillary DB-5 column (Patnaik 1989).

Alternatively, air is passed through 1- μ m PTFE membrane and 1% sodium bisulfite solution. The solution is treated with chromotropic and sulfuric acid mixture. The color development due to formaldehyde is measured by a visible spectrophotometer at 580 nm absorbance (NIOSH 1984, Method 3500). In polarography analysis, a Girard-T reagent is used. Formaldehyde forms a derivative that is analyzed by sampled DC polarography (NIOSH 1984, Method 3501). Auel et al. (1987) reported a similar electrochemical analysis of industrial air using an iridium electrode backed by a gas-permeable fluorocarbon-based membrane.

Igawa et al. (1989) have reported analysis of formaldehyde and other aldehydes in cloud and fogwater samples by HPLC with a postcolumn reaction detector. The aldehydes were separated on a reversed-phase C_{18} column, derivatized with 3-methyl-2-benzothiazolinone hydrazone, and detected at 640 nm.

Fluorescence-based liquid-phase analysis for selective determination of formaldehyde and other gases is reported (Dong and Dasgupta 1987; Dasgupta 1987). In this analytical method fluorescence of 3,5-diacetyl-1,4-dihydrolutidine formed upon reaction

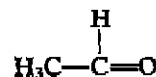
of formaldehyde with ammonium acetate and 2,4-pentanedione is monitored with a filter fluorometer. Draeger tubes used to monitor formaldehyde concentrations in air can give excessively high results (Balmat 1986).

5.3 ACETALDEHYDE

EPA Classified Toxic Waste; RCRA Waste Number U001; DOT Label: Flammable Liquid, UN 1089

Formula CH_3CHO ; MW 44.05; CAS [75-07-0]

Structure and functional group:



contains an aldehyde carbonyl group ($-\text{CHO}$)

Synonyms: ethanal; acetic aldehyde; ethyl aldehyde

Uses and Exposure Risk

Acetaldehyde is used in producing acetic acid, acetic anhydride, cellulose acetate, synthetic pyridine derivatives, pentaerythritol, terephthalic acid, and many other raw materials. Release of acetaldehyde from PET [poly(ethylene terephthalate)] bottles into carbonated mineral waters has been observed (Lorusso et al. 1985); 180 ppm was detected in samples kept for 6 months at 40°C.

Physical Properties

Colorless mobile liquid; pungent odor, fruity smell when diluted; bp 20.8°C; mp -121°C; density 0.7846 at 15°C, vapors heavier than air (vapor density 1.52); soluble in water, alcohol, ether, acetone, and benzene.

Health Hazard

Acetaldehyde is moderately toxic through inhalation and ingestion routes. Ingestion

can result in conjunctivitis, eye system depressant dermatitis. Large cause of its malodorous intoxication compared to those of chronic

Inhalation can irritate eyes, nose, and throat. High concentrations cause sore throat, and irritate muscles. Prolonged blood pressure and white blood cell count (ACGIH 1986).

The functional group $-\text{SH}$ in the molecules are susceptible to Acetaldehyde can irritate protein and hemoglobin. Such covers the biological functions of hemoglobin and enzymes. Rats subjected to acetaldehyde for 21 days such "bound" acetaldehyde in intracellular medium on unexposed rat lungs. Acetaldehyde could probably lead to acetaldehyde generate fermentation of

In a study on the effect of acetaldehyde found to effect in retardation and irritation (Lorusso et al. 1986). The acetaldehyde is both irritant to the nasal mucosa. The toxicity of acetaldehyde in cultured human cells (Graftstrom et al. 1986). Acetaldehyde was found to be more than acrolein an

Exposure Limits

TLV-TWA 180 mg/m³ (200 mg/m³) (150 ppm)

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can result in conjunctivitis, central nervous system depression, eye and skin burns, and dermatitis. Large doses can be fatal. Because of its metabolic link to ethanol, its intoxication consequences are similar to those of chronic ethanol intoxication.

Inhalation can produce irritation of the eyes, nose, and throat, and narcotic effects. High concentrations can cause headache, sore throat, and paralysis of respiratory muscles. Prolonged exposure can raise blood pressure and cause a decrease in red and white blood cells. A 4-hour exposure to 1.6% acetaldehyde in air was lethal to rats (ACGIH 1986).

The functional groups $-\text{NH}_2$, $-\text{OH}$, and $-\text{SH}$ in the three-dimensional protein molecules are susceptible to $-\text{CHO}$ attack. Acetaldehyde can therefore bind to liver protein and hemoglobin to form stable adducts. Such covalent binding probably alters the biological functions of protein and hemoglobin and thus contributes to its toxicity. Rats subjected to inhalation of acetaldehyde for 21 days showed the presence of such "bound" aldehyde adducts in their intracellular medium. A control experiment on unexposed rats, however, showed similar adducts but at a low concentration. This could probably have formed from trace aldehyde generated from intestinal microbial fermentation of alcohols.

In a study on chronic inhalation toxicity of acetaldehyde on rats, the compound was found to effect increased mortality, growth retardation, and nasal tumors (Woutersen et al. 1986). The study indicates that acetaldehyde is both cytotoxic and carcinogenic to the nasal mucosa of rats. Investigating the toxicity of tobacco-related aldehydes in cultured human bronchial epithelial cells, Graftstrom et al. (1985) reported that acetaldehyde was weakly cytotoxic, less so than acrolein and formaldehyde.

Exposure Limits

TLV-TWA 180 mg/m^3 (100 ppm) (ACGIH), 360 mg/m^3 (200 ppm) (NIOSH); STEL 270 mg/m^3 (150 ppm); IDLH 10,000 ppm.

Fire and Explosion Hazard

Acetaldehyde is highly flammable, flash point (closed cup) -38°C (-36°F) (Merck 1989); autoignition temperature 175°C ; vapor pressure 750 torr at 15°C . Its low flash point and autoignition temperature, coupled with high vapor pressure, make it a dangerous fire and explosion hazard. Explosive limits of mixtures with air are 4–60% by volume. Active surfaces may ignite and detonate fuels containing acetaldehyde. It is susceptible to forming peroxide, which can catch fire or explode.

Hazardous Reaction Products

Acetaldehyde polymerizes on treatment with mineral acids such as H_2SO_4 , HCl , and H_3PO_4 to form paraldehyde (toxic—causes respiratory depression and cardiovascular collapse) at ambient temperature, and metaldehyde (toxic to the intestine, kidney, and liver) at low temperature (subambient). It forms ethyl acetate (irritant, narcotic) with aluminum ethoxide catalyst; peracetic acid (explodes at 110°C , corrosive) on oxidation with or without a catalyst (cobalt salt); glyoxal (explodes with air, irritant) on oxidation with HNO_3 or selenious acid; acetaldehyde ammonia (eye and mucous membrane irritant) with NH_3 and H_2 in the presence of Ni at 50°C ; chloroacetaldehyde (highly corrosive and strong irritant) with chlorine at room temperature and with chloral (strong irritant) at $80\text{--}90^\circ\text{C}$; acetyl chloride (highly corrosive, dangerous eye irritant, flammable and explosion hazard) with chlorine in a gas-phase reaction; acetyl bromide (eye irritant, violent reaction with water) on bromination; 1,1-dichloroethane (toxic—irritant) with PCl_5 ; and phosgene (highly toxic, fatal at high concentrations) with CCl_4 in the presence of anhydrous AlCl_3 . It decomposes above 400°C , forming CO and methane.

Disposal/Destruction

Acetaldehyde is burned in a chemical incinerator equipped with an afterburner and scrubber. It may be disposed of in a drain

(not recommended, highly volatile) in small amounts, < 100 g at a time, mixed with 100 volumes of water, as it is biodegradable.

In the laboratory it may be destroyed by KMnO_4 oxidation (National Research Council 1983). To an aqueous solution of 0.1 mol aldehyde, excess KMnO_4 solution is added slowly. The mixture is refluxed until the purple color decolorizes. This is followed by addition of some more KMnO_4 solution and heating. It is cooled and acidified with 6N H_2SO_4 . (Concentrated H_2SO_4 should not be mixed freely with KMnO_4 as it forms Mn_2O_7 —explosion hazard.) Sodium bisulfite is added with stirring to reduce Mn to its divalent state. When the purple color disappears and the solid MnO_2 dissolves, the mixture is washed down the drain with large amounts of water.

Analysis

Acetaldehyde is analyzed by GC or HPLC. The acetaldehyde level in blood and liver can be estimated by forming its derivative with 2,4-dinitrophenylhydrazine and analyzing by HPLC. A GC headspace method using FID is equally suitable. Other analytical methods include colorimetry using thymol blue on silica gel, and derivatizing to 2,4-dinitrophenylhydrazone or semicarbazone followed by polarography or paper chromatography. It can be tested by wet methods such as reduction of Fehling's solution and Tollens' reagent; mercurimetric oxidation; sodium bisulfite/iodometry; and argentometric titration. Its presence in air can be estimated quantitatively by converting it to its derivative, 2,4-dinitrophenylhydrazone, and analyzing by HPLC using a UV detector. Analysis in air by NIOSH (1984) Method 3507 involved bubbling 6–60 L of air through a Girard-T solution at pH 4.5 and measuring the derivative at 245 nm (HPLC/UV detector). The working range is 170–670 mg/m^3 (18–372 ppm).

Jones et al. (1985) estimated the concentration of acetaldehyde in blood from analysis in breath. The method is based on

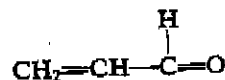
liquid-air partition coefficients of acetaldehyde determined by GC-FID. Jones et al. (1986) reported a GC-headspace method for its analysis in wine. Habboush and co-workers (1988) have reported the analysis of acetaldehyde and other low molecular weight aldehydes in automobile exhaust gases by GC-FID.

5.4 ACROLEIN

EPA priority pollutant; EPA Classified Acute Hazardous Waste, RCRA Waste Number P003; DOT Label: Flammable Liquid and Poison, UN 1092

Formula $\text{C}_2\text{H}_3\text{CHO}$; MW 56.07; CAS [107-02-8]

Structure and functional group:



—CHO (aldehyde carbonyl), simplest member of the class of unsaturated aldehydes

Synonyms: 2-propenal; 2-propen-1-one; allyl aldehyde; acrylaldehyde; acraldehyde; ethylene aldehyde; aqualin; biocide

Uses and Exposure Risk

Acrolein is used as an antimicrobial agent to prevent the growth of microbes against plugging and corrosion, to control the aquatic weed and algae, in slime control in paper manufacturing, as a tissue fixative, and in leather tanning.

Because of its widespread use it occurs in the environment—in air and water. After formaldehyde it is the second most abundant aldehyde, constituting 5% of total aldehydes in air. Acrolein is one of the toxic gases produced in a wood or building fire or when polyethylene or other polymer substances burn (Morikawa 1988; Morikawa and Yanai 1986). Firefighters have a greater risk of exposure to this gas.

Physical Properties
Colorless volatile liquid; boiling point -87°C ; density 0.84; soluble in water, and ether.

Health Hazard

Acrolein is a highly irritating agent that can severely damage the respiratory system and can cause acute pulmonary congestion.

LD₅₀ value, oral

Acrolein is a strong nasal irritant. Direct contact with eyes may result in severe irritation of the cornea. Inhalation of 0.5 ppm causes intolerable eye irritation. Exposure to a concentration of 1 ppm of acrolein in air for 15 minutes causes skin irritation. Acrolein can cause chemical burns to the skin. Chronic respiratory irritation and pulmonary edema may result from administration of a solution of fatty liver extract.

LD₅₀ value, subcutaneous

Based on the acute toxicity of 68 mg/kg to aquatic life in 14 days (U.S. EPA 1985). In freshwater fish, LC₅₀ values as low as 21 ppb have been reported to be more toxic than are p-nitrophenol, aniline, and other aromatic compounds (Harris 1985). In rainbow trout, LC₅₀ values are reported to be as low as 10 ppb. Exposure to an acute concentration of a

Tetrahydrofuran. Solvent containing peroxide can explode when dried with caustic soda or caustic potash, or when evaporated; and may catch fire in contact with aluminum aluminum hydride or other metal hydrides. Violent reactions can occur when combined with strong oxidizers.

Storage and Shipping

It is stored in a cool, dark, and well-ventilated area, separated from heat sources and oxidizing materials. An inhibitor such as butylated hydroxytoluene (~0.025%) is added to inhibit peroxide formation. Discard the unused solvent 2 months after opening the container. It is shipped in cans, drums, and tank cars.

Disposal/Destruction

Tetrahydrofuran waste solvent is burned in a chemical incinerator equipped with an afterburner and scrubber. It may be disposed of in a secure landfill in lab packs.

26.14 1,4-DIOXANE

EPA Designated Toxic Waste. RCRA Waste Number U108; DOT Label: Flammable Liquid, UN 1165
Formula $C_4H_8O_2$; MW 88.12; CAS [123-91-1]

Structure:



Synonyms: diethylene ether; 1,4-diethylene dioxide; 1,4-dioxacyclohexane; glycol ethylene ether; *p*-dioxane

Uses and Exposure Risk

1,4-Dioxane is used as a solvent for cellulose esters, oils, waxes, resins, and numerous organic and inorganic substances. It is also used in coatings and as a stabilizer in chlorinated solvents.

Physical Properties

Colorless liquid with a faint ethereal odor; density 1.033 at 20°C; boils at 101°C; solidifies between 10 and 12°C; miscible with water and most organic solvents.

Health Hazard

The toxicity of 1,4-dioxane is low in test animals by all routes of exposure. However, in humans the toxicity of this compound is severe. The target organs are the liver, kidneys, lungs, skin, and eyes. Exposure to its vapors as well as the absorption through the skin or ingestion can cause poisoning, the symptoms of which include drowsiness, headache, respiratory distress, nausea, and vomiting. It causes depression of central nervous system. There are reports of human deaths from subacute and chronic exposures to dioxane vapors at concentration levels ranging between 500 and 1000 ppm. Serious health hazards may arise from its injurious effects on the liver, kidneys, and brain. Rabbits died of kidney injury resulting from repeated inhalation of 1,4-dioxane vapors for 30 days (Smyth 1956). It is an irritant to the eyes, nose, skin, and lungs. In humans, a 1-minute exposure to 5000-ppm vapors can cause lacrimation.

LC₅₀ value, inhalation (rats): 13,000 ppm/2 hr
LD₅₀ value, oral (mice): 5700 mg/kg

1,4-Dioxane is an animal carcinogen of low potential. Ingestion of high concentrations of this compound at a level of 7000–18,000 ppm in drinking water for 14–23 months caused nasal and liver tumors in rats (ACGIH 1986). Guinea pigs developed lung tumors.

Exposure Limits

TLV-TWA 25 ppm (~90 mg/m³) (ACGIH), 100 ppm (MSHA and OSHA); carcinogenicity: Animal Sufficient Evidence (IARC).

Explosion during distillation, drying, or evaporation.

Vigorous to violent reactions may occur when mixed with strong oxidizers. 1,4-Dioxane forms explosive complexes with perchlorates of many metals, such as silver and mercury. Reaction with hydrogen and nickel above 210°C is explosive (NFPA 1986).

Storage and Shipping

1,4-Dioxane is stored in a flammable-liquids cabinet or storage room isolated from combustible or oxidizing substances and sources of ignition. It is shipped in bottles, cans, and metal drums.

Disposal/Destruction

It is burned in a chemical incinerator equipped with an afterburner and scrubber.

action on the animals' skin. The information on the toxicity of this compound in humans is not known.

The inhalation LC₅₀ value of 4-hour exposure in rats is in the range of 20,000 mg/m³, and the oral LD₅₀ is 3000 mg/kg (NIOSH 1986).

Fire and Explosion Hazard

Highly flammable liquid; flash point (open cup) 2°C (35°F); vapor density 2.55 (air = 1); the vapor is heavier than air and can travel a considerable distance to a source of ignition and flash back; fire-extinguishing agent: dry chemical or CO₂; use water to keep fire-exposed containers cool and to flush and dilute the spills.

1,3-Dioxolane vapors form explosive mixtures with air; the flammability range has not been established. It is capable of

Fire and Explosion Hazard

Flammable liquid; flash point (closed cup) 12°C (54°F), (open cup) 18°C (65°F); vapor pressure 29 torr at 20°C; vapor density 3.0 (air = 1); the vapor is heavier than air and can travel a considerable distance to a source of ignition and flash back; autoignition temperature 180°C (356°F); fire-extinguishing agent: dry chemical, CO₂, or "alcohol" foam; use water to keep fire-exposed containers cool and to flush and dilute spills.

1,4-Dioxane vapors form explosive mixtures with air within a relatively wide range. The LEL and UEL values are 2.0 and 22.0% by volume in air, respectively. Under certain conditions, 1,4-dioxane can form explosive peroxides, which may cause explosion during distillation, drying, or evaporation.

Vigorous to violent reactions may occur when mixed with strong oxidizers. 1,4-Dioxane forms explosive complexes with perchlorates of many metals, such as silver and mercury. Reaction with hydrogen and nickel above 210°C is explosive (NFPA 1986).

Storage and Shipping

1,4-Dioxane is stored in a flammable-liquids cabinet or storage room isolated from combustible or oxidizing substances and sources of ignition. It is shipped in bottles, cans, and metal drums.

Disposal/Destruction

It is burned in a chemical incinerator equipped with an afterburner and scrubber. Waste solvent may be buried in a secure landfill in lab packs.

26.15 1,3-DIOXOLANE

Formula C₃H₆O₂; MW 74.09; CAS [646-05-0]

Structure:



Synonyms: 1,3-dioxacyclopentane; ethylene glycol formal; formal glycol

Uses and Exposure Risk

1,3-Dioxolane is used as an intermediate in organic synthesis.

Physical Properties

Colorless liquid; density 1.061 at 20°C; boils at 74°C; solidifies at -95°C; miscible with water and organic solvents.

Health Hazard

The acute inhalation and oral toxicity of 1,3-dioxolane is low in test animals. The vapor is irritant to eyes and respiratory tract. Application of the liquid produced severe irritation in rabbits' eyes and mild action on the animals' skin. The information on the toxicity of this compound in humans is not known.

The inhalation LC₅₀ value of 4-hour exposure in rats is in the range of 20,000 mg/m³, and the oral LD₅₀ is 3000 mg/kg (NIOSH 1986).

Fire and Explosion Hazard

Highly flammable liquid; flash point (open cup) 2°C (35°F); vapor density 2.55 (air = 1); the vapor is heavier than air and can travel a considerable distance to a source of ignition and flash back; fire-extinguishing agent: dry chemical or CO₂; use water to keep fire-exposed containers cool and to flush and dilute the spills.

1,3-Dioxolane vapors form explosive mixtures with air; the flammability range has not been established. It is capable of forming peroxides on prolonged storage or exposure to air. Such peroxide formation may be inhibited with trace amounts of triethylamine.

References

ACGIH. 1986. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.