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VOLUME I. SINGLE CHEMICALS

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ABSTRACT: This information profile on*ethyl silicate (78104) is part of a group of 46 such profiles that provide information about chemicals or industrial processes considered to be potential occupational hazards. Each profile contains summary data on known and suspected health effects, the extent of worker exposure and the industrial importance of either a single chemical, class of chemicals, or a particular industrial process. The report was developed for use by occupational safety and health professionals in industry, and labor and other areas, to provide them with a synopsis of information in their workplaces.

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Chemical-properties
Physical-properties
Occupations
Industrial-processes
Work-environment
Safety-research

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INTRODUCTION

An information profile is a working paper used by the National Institute for Occupational Safety and Health (NIOSH) to assist in establishing Institute priorities. It is an initial step in determining the need to develop comprehensive documents or to initiate research. Each profile summarizes data on known and suspected health effects, the extent of worker exposure, physical and chemical properties, and the industrial importance of individual chemicals and classes of chemicals. The profile may also be used by industry, labor, and the occupational health community as a synopsis of information on each subject and to identify possible health hazards associated with their workplaces.

Although detailed literature searches are conducted using computerized and manual searching techniques to identify pertinent and recent information, not all the literature obtained is incorporated in the report due to the summary nature of the profiles. Further, literature published after 1978 may not be included in these profiles because it was generally unavailable at the time the search was completed.

ETHYL SILICATE

SUMMARY

2.5-3.0 million pounds/year of ethyl silicate were produced in the late 1960's. The two major uses of ethyl silicate are as a mold binder for investment casting in the metallurgical industry, and as a binder in corrosion-resistant coatings. Annually, approximately 461,226 workers are exposed to ethyl silicate.

Ethyl silicate is moderately toxic, with concentrations of 500 ppm or more producing kidney, liver, and lung damage, and death in rodents. Humans detect an odor at 85 ppm ethyl silicate, and experience slight eye and nose irritation at 250 ppm. It is recommended that exposures to 700 ppm ethyl silicate or more be limited to a few minutes.

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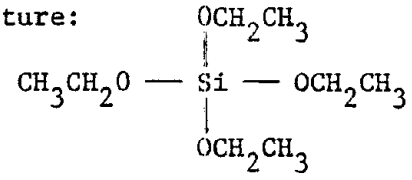
1. Synonyms: Ethyl orthosilicate
Silicic acid, tetraethyl ester
Tetraethoxysilane
Tetraethyl orthosilicate
Tetraethyl silicate

2. Chemical Abstracts Service Number: 78-10-4

3. Registry of Toxic Effects of Chemical Substances Number: VV94500

4. Molecular Formula: $C_8H_{20}O_4Si$

5. Chemical Structure:



6. Physical and Chemical Properties:

Molecular Weight	208.30
Physical State	Liquid
Boiling Point	168.8°C at 760 mm
Melting Point	-82.5°C
Vapor Pressure	1 mm at 20°C
Evaporation Rate	
Solubility	Soluble, decomposes (H_2O)
Specific Gravity	0.9356 (20/20°C)
Stability	

7. Production and User Data

Production and Trends

During the latter 1960's, production and sales of ethyl silicate were on the order of 2.5-3.0 million lbs/yr (Anderson, 1969). More recent production figures are not available.

Growth projections are not available.

Uses

Ethyl silicates have two major applications in commercial industry (Anderson, 1969). They are used extensively in the non-ferrous metallurgical industry as mold binders for investment casting. The next largest application is in corrosion-resistant coatings, primarily as a binder for zinc dust paints. Miscellaneous uses include the protection of white-light bulbs, the preparation of soluble silicas, catalyst preparation and regeneration, and as a cross-linker and intermediate in the production of silicones.

Additives and Impurities

Various grades of ethyl silicate are commercially marketed in the U.S. The pure grade of ethyl silicate is commercially known as tetraethyl orthosilicate.

Condensed ethyl silicate is a light yellow liquid consisting of 85% by weight tetraethyl orthosilicate and 15% polyethoxy siloxanes.

Ethyl silicate "40" is a grade of ethyl silicate containing a 40% silican dioxide equivalent of a polysiloxane.

Producers and Distributors

Ethyl silicate is manufactured and distributed by the following three companies (SRI, 1978):

Anderson Development Co.	Adrian, Mich.
Stauffer	Weston, Mich.
Union Carbide	Institute and S. Charleston, W.Va.

Additional distributors include (Chem. Week, 1978; OPD, 1978):

R. W. Graff & Co.	Kay-Fries Chem.
McKesson Chem.	Petrarch Systems
Ashland Chem.	Schumacher J C Co.

Manufacturing Process

Ethyl silicate is commercially produced by the reaction of ethyl alcohol with silicon tetrachloride as shown below (Anderson, 1969):

$$SiCl_4 + 4C_2H_5OH \longrightarrow (C_2H_5O)_4Si + 4HCL$$

The by-product formation of hydrogen chloride requires specialized removal techniques to minimize the formation of additional by-products. The product ethyl silicate emerges from the reaction chamber to a neutralizer and then goes to purification. Production can be done in either batch or continuous modes, depending upon the volume required (Anderson, 1969).

8. Biological Effects of Exposure

a) Acute Effects

Symptoms resulting from inhalation of ethyl silicate consist of nasal and eye irritation, lacrimation, tremors, respiratory difficulties, and narcosis. Other symptoms which were infrequently exhibited include salivation, skin congestion, low body temperature, paralysis of hind quarters, and uncoordinated movement and scratching (Smyth and Seaton, 1940). Smyth and Seaton (1940) also reported opacity of the cornea at concentrations of 2,500 ppm after 2 hrs of exposure.

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Smyth and Seaton (1940) found that the relative humidity of the inspired air containing ethyl silicate had an effect on the resulting toxicity. It was found that since ethyl silicate undergoes hydrolysis, an increase in humidity would reduce its acute toxicity. It took approximately four-fifths as much time in dry air as it did in air at 70% humidity to produce the same injury.

Exposures to ethyl silicate at concentrations below 100 ppm generally have little or no adverse effects on experimental animals. Above 100 ppm, up to approximately 500 ppm, repeated exposures produce slight to moderate organ damage. Concentrations of 500 ppm and above usually result in severe kidney, liver, and lung damage or death. Concentrations above 2000 ppm produce serious functional disturbances and can be fatal within 30 to 60 minutes in guinea pigs (Smyth and Seaton, 1940). A summary of these data is in Table 1.

Examination of rabbits that died shortly after intravenous administration of 0.023-0.036 ml ethyl silicate/100 g body weight revealed the presence of widely distributed parenchymal hemorrhages in the lungs, usually accompanied by pulmonary edema (Kasper et al., 1937). To a more limited extent, the capillaries of the heart muscle were also damaged. Cerebral capillaries of the deeper portions of the brain contained bubbles or globules interspersed between groups of red blood cells. Kasper et al. (1937) suggest that these bubbles were either air emboli resulting from air being aspirated through the damaged air sacs of the lungs, or that the globules contained ethyl silicate itself. Examination of tissue from rats that died soon after intraperitoneal administration of ethyl silicate developed kidney and liver damage. Kidney damage was reported as pale grayish-brown discoloration and a softening of the entire organ (Kasper et al., 1937). Microscopic examination revealed albuminous degeneration and cloudy swelling of the epithelium of the convoluted tubules. In the same study, the liver was found to have developed fat-like masses on the capsule with yellowish discoloration on the surface of the liver. Microscopic examination revealed necrotic changes in the capsule of the liver and the superficial liver cord cells. Splenic congestion was also reported (Patty, 1949, Vol. II).

b) Subchronic Effects

V.K. Rowe et al. (1948) subjected rats to repeated inhalation exposures at dose levels up to 1000 ppm. They reported that three daily seven-hour exposures to 1000 ppm of ethyl silicate were fatal to six out of ten rats. The remaining four rats died within 24 hours following the third exposure. Kidney damage, an increase in kidney weight, and a loss in body weight were found in all animals. Kidney damage consisted of tubular degeneration, necrosis, extensive cast formation, and complete destruction of the parenchymal tissues. Bloody urine was also observed in the bladders of the animals having severe kidney damage, although the bladders and ureters did not appear to be irritated. At 500 ppm, ten rats received three to five seven-hour exposures over a five day period. These animals lost weight, showed renal changes and slight lung irritation. Those exposed to 250 ppm also lost weight but did not show the severe renal and lung changes that were evident at the higher concentrations.

Table 1. Acute and Subacute Toxicity of Ethyl Silicate[a]

Organism	Dose PPM	Exposure	Effect	Reference
Rodents	440	Repeated	Some died within 30 days	Smyth, 1956
	88	Repeated	None injured	Smyth, 1956
Rats	23, 50, 88	7 hrs/day - 5 days a wk - 90 days	No effect	ACGIH, 1974
	125	5 to 10 exposures	Slight to moderate kidney damage and an increase in kidney weight	ACGIH, 1974
	250	up to 10 7 hr periods	Lost weight and showed lung and kidney changes	ACGIH, 1974
	400	7 hrs/day - 30 days	Mortality/kidney, liver, and lung damage to survivors	ACGIH, 1974
	500	3 to 5 - 7 hr exposures	Died or suffered severe kidney injury	ACGIH, 1974
	1557-2348	4 hrs	Death within 5 days	Patty, 1949, Vol. II
Guinea Pigs	23, 50, 88	7 hrs/day - 5 days/ wk - 90 days	No effect	ACGIH, 1974
	500	Single exposure	Maximum amount for several hrs w/o serious disturbance	Patty, 1949, Vol. II
Man	85	--	Odor detectable	ACGIH, 1974
	250	--	Slight irritation to eyes and nose	ACGIH, 1974
	700	--	Mildly stings eyes and nose	Patty, 1949, Vol. II
	1,200	--	Lacrimatory	ACGIH, 1974
	3,000	--	Extremely irritating to eyes and nose	Patty, 1949, Vol. II

[a]Route of administration for all data was inhalation.

At the 125 ppm concentration, rats received 5, 10, 15, 25 or 30 seven-hour exposures. There was no weight loss observed among these animals, but those receiving 30 exposures showed slight to moderate kidney damage. All rats showed an increase in kidney and liver weight which was proportional to the amount of exposure.

Death usually did not occur during the exposure period except at extremely high concentrations (above 2000 ppm). When serious injury did occur, normal function was usually regained after removal from exposure. With fatal exposures, rats usually died two to three days following exposure. Smyth and Seaton (1940) suggested that because of this delayed fatal action, death is probably due not to ethyl silicate's effect on the central nervous system but rather to pulmonary edema and secondary pneumonia which occur several days after exposure. It was also noted that a few deaths may have been caused by acute nephritis.

c) Chronic effects

i) Carcinogenicity

No data encountered.

ii) Mutagenicity

No data encountered.

iii) Teratogenicity

No data encountered.

d) Human Effects

There have been no industrial intoxications from ethyl silicate reported. Ethyl silicate has a relatively low vapor pressure at room temperature. This results in a relatively low potential for inhalation absorption unless it is being sprayed for some application. It is recommended (Patty, 1949, Vol. II) that irritation of the eyes and nose, which occurs at 700 ppm, should serve as a warning to limit exposure time to a few minutes. This concentration is probably intolerable to man for more than 20 to 30 minutes. This property acts as a safeguard in that concentrations which are reported to be relatively harmless to rodents after four hours exposure have strong irritating effects on humans.

Patty (1949, Vol. II) has suggested a maximum practical working level of 100 ppm. At this concentration, an odor is detectable but it is safely below any irritating effects. It is noted, however, that workers exposed for prolonged periods at this concentration should be periodically examined for signs of lung, kidney, or other injury. Chronic exposure of animals can lead to these injuries and also to liver damage.

Symptoms of exposure in humans consist of irritation of eyes and respiratory passages, fatigue, tremors, and narcosis. If exposure persists, narcosis will eventually lead to death.

9. Threshold Limit Values, OSHA Standards, NIOSH Recommended Standards

Ethyl Silicate	ppm	mg/cu m	Reference
TLV	100	850	ACGIH, 1977
NIOSH	100	850	OSHA, 1976

The recommended Threshold Limit Value (100 ppm) was set sufficiently low to prevent irritation to the eyes and nose (ACGIH, 1974); however, the ACGIH plans to reduce its limit to 85 mg/cu m, one-tenth the present TLV (Wills, 1979).

10. Other Standards

No other standards are available.

11. Occupational Exposures

According to an oral communication from Vera Hudson, Division of Criteria Documentation and Standards Development, NIOSH, approximately 461,226 workers are exposed to ethyl silicate yearly (oral communication, 1978).

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