Potassium hydroxide

(CAS No: 1310-58-3)

Health-based Reassessment of Administrative Occupational Exposure Limits

Committee on Updating of Occupational Exposure Limits,
a committee of the Health Council of the Netherlands

No. 2000/15OSH/110, The Hague, March 30, 2004

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1 Introduction

The present document contains the assessment of the health hazard of potassium hydroxide by the Committee on Updating of Occupational Exposure Limits, a committee of the Health Council of the Netherlands. The first draft of this document was prepared by C de Heer, Ph.D. and H Stouten, M.Sc. (TNO Nutrition and Food Research, Zeist, the Netherlands).

The evaluation of the toxicity of potassium hydroxide has been based on the review by the American Conference of Governmental Industrial Hygienists (ACG91). Where relevant, the original publications were reviewed and evaluated as will be indicated in the text. In addition, in June 1998, literature was searched in the on-line databases Medline, Toxline, and Chemical Abstracts, covering the periods 1966 to 11 June 1998, 1965 to 24 February 1998, and 1967 to 16 June 1998, respectively, and using the following key words: potassium hydroxide, KOH, potash, and 1310-58-3. HSDB and RTECS, databases available from CD-ROM, were consulted as well (NIO98, NLM98).

In March 2000, the President of the Health Council released a draft of the document for public review. The committee received comments by the following individuals and organisations: A Aalto (Ministry of Social Affairs and Health, Tampere, Finland) and L Whitford (Health and Safety Executive, London, England). These comments were taken into account when deciding on the final version of the document.

An additional search in Toxline and Medline in August 2003 did not result in information changing the committee's conclusions.

2 Identity

name	:	potassium hydroxide
synonym	:	caustic potash, potassium hydrate, potassa
molecular formula	:	KOH
structural formula	:	-
CAS number	:	1310-58-3

3 Physical and chemical properties

molecular weight	:	56.10
boiling point	:	1320-1324ºC
melting point	:	360ºC
flash point	:	not available
vapour pressure	:	not available
solubility in water	:	very soluble (at 20ºC: 112 g/100 mL)
log $P_{octanol/water}$	:	-3.88 (estimated)
conversion factors	:	not applicable

Data from ACG91, Pie93, Ric94, http://esc.syrres.com.

Potassium hydroxide is a white deliquescent solid that may be formed into white or slightly yellow lumps, rods, or pellets. It rapidly absorbs moisture and carbon dioxide from the air, and deliquesces. Potassium bicarbonate and carbonate may be formed. A 0.1 M aqueous solution has a pH of 13.5. (ACG91, Pie93, Ric94).

4 Uses

Potassium hydroxide is used in the manufacture of soft and liquid soaps, as a mordant for wood, in paint and varnish removers, in electroplating, photoengraving, and lithography, in drain cleaners, and for the production of other potassium compounds such as high-purity potassium carbonate (K_2CO_3) for use in the manufacture of glass (ACG91, Pie93). It is also used in veterinary medicine, and in processing of black olives and cocoa (Ric94).

Potassium hydroxide is also used in preference to the relatively inexpensive sodium hydroxide as a strong alkali when the generally greater solubility of potassium compounds, in comparison to those of sodium, is important, e.g., as an absorbent for carbon dioxide (ACG91).

5 Biotransformation and kinetics

The committee did not find data on the metabolism and kinetics of potassium hydroxide per se.

Since potassium hydroxide is fully ionised, data on the toxicokinetics of potassium are applicable (Tra74).

6 Effects and mechanism of action

Human data

Contact with eyes or other tissues can cause serious injury (Kuc93, Ric94).

There are many accounts of (fatal) accidental and suicidal ingestion of potassium hydroxide (ACG91). Following ingestion of (a solution of) potassium hydroxide, rapid corrosion and perforation of the oesophagus and stomach, stricture of the oesophagus, violent pain in throat and epigastrium, haematemesis, and collapse may occur (ACG91, ECB95*, Ric94).

When inhaled in any form, potassium hydroxide is strongly irritating to the upper respiratory tract. Acute exposures may cause symptoms in the respiratory tract including severe coughing and pain. Additionally, lesions may develop along with burning of the mucous membranes. Severe injury is usually avoided by the self-limiting sneezing, coughing, and discomfort. Inhalation may be fatal as a result of spasm, inflammation, and oedema of the larynx and bronchi, chemical pneumonitis, and pulmonary oedema (which can develop with a latency period of 5-72 hours). Chronic exposures may cause inflammatory and ulcerative changes in the mouth and possibly bronchial and gastrointestinal disorders (ACG91, Pie93, Ric94).

It has been reported that 10% of workers exposed to KOH during the production of ascorbic acid developed allergic dermatitis (Ric94).

At least one case of oesophageal carcinoma at the site of hydroxide-induced strictures has been reported (ACG91).

Animal data

Potassium hydroxide was judged severely irritating and corrosive after (4- and 24-hour) dermal application of aqueous solutions of 2% (corresponding to 10 mg KOH) or more in rabbits (ECB95). Skin irritation and corrosion was assessed following OECD test guideline 404. In this test, application of 0.5 mL of a 5% solution of KOH to rabbit skin for 4 hours resulted in a primary irritation index (PII) of 5.22, and KOH was hence judged to be severely irritating (ECE95). After

* Following 'Council Regulation (EEC) 793/93 on the Evaluation and Control of the Risks of Existing Substances', the European chemical industry by means of a lead company is requested to submit data to the International Uniform Chemical Information Database (IUCLID) to allow risk assessment of these chemicals by the member states of the EC. The database contained a data sheet on potassium hydroxide (last update: October 23, 1995; lead company: Huels AG, Marl, Germany). However, these data were not yet evaluated by a EC member state.

application of a 10% solution (0.5 mL) for 4 hours, a PII could not be calculated because of the severity of the effects (ECE95). In a skin corrosion test in rabbits, a 4-hour application of 0.5 mL of a 2% KOH solution resulted in severe skin injury in at least 2 out of 6 rabbits. Hence, a 2% KOH solution was judged to be corrosive to the skin. A 1% KOH solution was concluded not to be corrosive based on this test protocol (Ver77).

In an *in vitro* skin corrosion test based on the use of reconstructed human skin cultures, a 1% KOH solution (25 µL added to 1 mL culture medium) did not significantly reduce cell viability and was therefore judged non-corrosive, whereas in the same test system, a 10 % solution was considered corrosive (Per96).

Application of a 8% KOH solution for 30 seconds to the longitudinally opened oesophagus of anaesthetised cats produced marked erythematous injury with underlying muscle spasms. Microscopically, complete liquefaction of the mucosa with oedema formation and mild inflammation in the underlying muscularis mucosa and submucosal adventitial layers were observed (Ash74).

A 5.0% solution (0.1 mL instilled into the rabbit eye for 5 minutes was corrosive, a 1.0% solution (5 minutes or 24 hours) was irritating, a 0.5% solution (24 hours) was marginally irritating, and a 0.1% solution was ineffective (ECB95). In another study, 1 mg instilled into the rabbit eye for 24 hours (rinsed) caused moderate irritation (Ric94). As an alternative to *in vivo* ocular irritancy testing, a ^{51}Cr-release assay with cultured corneal endothelial cells was done and the ED_{50} (i.e., 50% maximal effect) for KOH cytotoxicity was determined at $1.3x10^{-2}$ M correlating with severe irritating in the *in vivo* test (ECB95).

No sensitisation was observed in guinea pigs after repeated intracutaneous injections of 0.1 mL of a 0.1% solution of KOH (3 times/week at separate skin sites, 3 weeks) and a challenge with the same dose 2 weeks after the last injection (ECB95).

Oral LD_{50} values in rat ranging from 214 to 1890 mg/kg have been reported (ECB95, Ric94).

Dogs given oral doses (levels not reported) developed haemorrhagic gastritis with pronounced necrosis in the antrum. Oesophageal necrosis has been documented in cats after a 1-second ingestion of 1 ml of a 25% to 36% aqueous hydroxide solution. The most important factor is clearly the concentration, rather than the volume of the ingested or instilled solution (ACG91). Many authors have evaluated the pathogenesis of hydroxide-induced chemical burns of the gastrointestinal tract.

Mutagenicity and genotoxicity

Mutagenic effects were not observed at concentrations up to 0.019% in an *in vitro* genotoxicity test system with *E. coli* (ECB95). An *in vitro* genotoxicity test with Chinese hamster ovary K1 cells, with metabolic activation was positive (Mor89). KOH at 0.0002-0.001 M interferes with the G- and C-banding patterns of human chromosomes *in vitro* (Ber75).

Carcinogenicity

Repeated applications of aqueous solutions (3-6%) of KOH to the skin of mice for 46 weeks resulted in an increased incidence of skin tumours (males 14%, females 15%). Since tumourigenesis was associated with severe skin damage inducing marked epidermal hyperplasia, a non-genotoxic mechanism was assumed (Ing91).

Reproduction toxicity

The committee did not find data on reproduction toxicity studies with potassium hydroxide.

7 Existing guidelines

The current administrative occupational exposure limit (MAC) for potassium hydroxide in the Netherlands is a ceiling limit of 2 mg/m^3.

Existing occupational exposure limits for potassium hydroxide in some European countries and in the USA are summarised in the annex.

8 Assessment of health hazard

There are no human data from which an inhalation exposure concentration-effect relation can be estimated. However, potassium is a normal body electrolyte. The average daily intake was estimated to be 4 grams (Tra74).

Potassium hydroxide is a corrosive compound. Solutions of 0.5-2.0% are irritating to eyes and skin.

Based on oral LD_{50} values of 214-1890 mg/kg in rats, the committee considers KOH to be harmful if swallowed. There are no data from repeated-dose toxicity studies in experimental animals apart from mouse skin painting studies. Although repeated application of potassium hydroxide induced an

increased incidence of skin tumours, the committee is of the opinion that this is not relevant for man, since these skin effects were considered a consequence of marked epidermal hyperplasia following repeated and sustained severe skin damage.

Potassium hydroxide was not mutagenic when tested in *E. coli*; a chromosome aberration test in hamster ovary K1 cells (with metabolic activation) was positive. In an *in vitro* test, KOH interfered with G- and C-banding patterns of human chromosomes. However, the positive responses are more likely due to a high pH in the culture medium than to an intrinsic clastogenic activity of KOH.

The committee considers the toxicological database on potassium hydroxide too poor to justify recommendation of a health-based occupational exposure limit.

The committee concludes that there is insufficient information to comment on the level of the present MAC value.

References

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ACG03b American Conference of Governmental Industrial Hygienists (ACGIH). 2003 TLVs® and BEIs® based on the documentation of the Threshold Limit Values for chemical substances and physical agents & Biological Exposure Indices. Cincinnati OH, USA: ACGIH®, Inc, 2003: 48.

Arb02 Arbejdstilsynet. Grænseværdier for stoffer og materialer. Copenhagen, Denmark: Arbejdstilsynet, 2002: 29 (At-vejledning C.0.1).

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EC03 European Commission: Directorate General of Employment and Social Affairs. Occupational exposure limits (OELs). http://europe.eu.int/comm/employment_social/h&s/areas/oels_en.htm.

ECB95 European Commission (EC): European Chemicals Bureau - Existing Chemicals. Potassium hydroxide. IUCLID Data Sheet. Ispra, Italy: EC - JRC Environment Institute, 1995.

ECE95 European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC). Skin irritation and corrosion: reference chemicals data bank. Brussels, Belgium: ECETOC, 1995; Techn Rep No 66.

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Swe00 Swedish National Board of Occupational Safety and Health. Occupational exposure limit values and measures against air contaminants. Solna, Sweden: National Board of Occupational Safety and Health, 2000; Ordinance AFS 2000:3.

SZW03 Ministerie van Sociale Zaken en Werkgelegenheid (SZW). Nationale MAC-lijst 2003. The Hague, the Netherlands: Sdu, Servicecentrum Uitgevers, 2003: 31.

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Annex

Occupational exposure limits for potassium hydroxide in various countries.

country - organisation	occupational exposure limit		time-weighted average	type of exposure limit	note[a]	reference[b]
	ppm	mg/m^3				
the Netherlands						
- Ministry of Social Affairs and Employment	-	2	ceiling	administrative		SZW03 -
Germany						
- AGS	-	-			-	TRG00
- DFG MAK-Kommission	-	-				DFG03
Great-Britain						
- HSE	-	2	15 min	OES	-	HSE02
Sweden	-	-				Swe00
Denmark	-	2	ceiling			Arb02
USA						
-ACGIH	-	2	ceiling	TLV-ceiling		ACG03b
- OSHA	-	-	-	-		ACG03a
- NIOSH	-	2	10 h	REL		ACG03a
European Union						
- SCOEL	-	-				EC03

[a] S = skin notation; which means that skin absorption may contribute considerably to body burden; sens = substance can cause sensitisation.

[b] Reference to the most recent official publication of occupational exposure limits.