The MAK Collection for Occupational Health and Safety

Triethanolamine

MAK Value Documentation, addendum – Translation of the German version from 2016

A. Hartwig[1,*], MAK Commission[2,*]

1 *Chair of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Deutsche Forschungsgemeinschaft, Institute of Applied Biosciences, Department of Food Chemistry and Toxicology, Karlsruhe Institute of Technology (KIT), Adenauerring 20a, Geb. 50.41, 76131 Karlsruhe, Germany*

2 *Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Deutsche Forschungsgemeinschaft, Kennedyallee 40, 53175 Bonn, Germany*

***** *email: A. Hartwig (andrea.hartwig@kit.edu), MAK Commission (arbeitsstoffkommission@dfg.de)*

Keywords: triethanolamine; MAK value; maximum workplace concentration; peak limitation; developmental toxicity; irritation; larynx; skin

Citation Note: Hartwig A, MAK Commission. Triethanolamine. MAK Value Documentation, addendum – Translation of the German version from 2016. MAK Collect Occup Health Saf [Original edition. Weinheim: Wiley-VCH; 2017 Oct;2(4):1610-1615]. Corrected republication without content-related editing. Düsseldorf: German Medical Science; 2026. https://doi.org/10.34865/mb10271kske6017_w

Republished (online): 07 Aug 2026

Originally published by Wiley-VCH Verlag GmbH & Co. KGaA; https://doi.org/10.1002/3527600418.mb10271kske6017

Addendum completed: 25 Feb 2015

Published (online): 27 Oct 2017

The commission established rules and measures to avoid conflicts of interest.

1610

Triethanolamine / 2-[bis(2-hydroxyethyl)amino]ethanol

MAK Value Documentation

A. Hartwig[1, *], MAK Commission[2, *]

DOI: 10.1002/3527600418.mb10271kske6017

Abstract

The German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area has re-evaluated the maximum concentration at the work place (MAK value) of triethanolamine [102-71-6], considering the endpoints respiratory tract irritation and developmental toxicity.

Critical effect of triethanolamine is respiratory tract irritation (focal larynx inflammation). The previous MAK value of 5 mg/m³ is based on 5-day and 28-day aerosol studies in rats with a LOAEC of 20 mg/m³. A benchmark calculation gives a BMDL05 of 14,1 mg/m³. Since 2014, the Commission uses an empirical approach to set MAK values for substances with critical effects on the upper respiratory tract or the eyes. Based on this approach, a concentration of 4,7 mg/m³ for the work place air can be calculated from this BMDL05. Therefore the MAK value of 5 mg/m³ is retained.

As local effects are critical, Peak Limitation Category I is retained. At an excursion factor of 2, the allowable maximum concentration is still below the BMDL05.

NOAEL for fetotoxicity are 300 mg/kg bw and day in rats and 1125 mg/kg body weight and day in mice . Teratogenicity was not tested. Nevertheless, because the calculated margins between NOAEL and MAK value are very high, and alkylamines lack teratogenicity, there is no reason to fear damage to the embryo or foetus when the MAK value is observed. Therefore, triethanolamine is assigned to Pregnancy Risk Group C.

Keywords

triethanolamine; 2,2′,2″-nitrilotriethanol; tris(2-hydroxyethyl)amine; trolamine; (sub)acute toxicity; (sub) chronic toxicity; irritation; allergenic effects; reproductive toxicity; peak limitation; prenatal toxicity; absorption through the skin; sensitization; occupational exposure; maximum workplace concentration; MAK value; toxicity; hazardous substance

Author Information

[1] Chair of the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Deutsche Forschungsgemeinschaft, Department of Food Chemistry and Toxicology, Institute for Applied Biosciences, Karlsruhe Institute of Technology (KIT), Adenauerring 20a, Geb. 50.41, 76131 Karlsruhe, Germany

[2] Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Deutsche Forschungsgemeinschaft, Kennedyallee 40, 53175 Bonn, Germany

[*] Email: A. Hartwig (andrea.hartwig@kit.edu), MAK Commission (arbeitsstoffkommission@dfg.de)

Triethanolamine

[102-71-6]

Supplement 2016

MAK value (2009)	**5 mg/m³ I (inhalable fraction)**
Peak limitation (2015)	**Category I, excursion factor 2**
Absorption through the skin	**–**
Sensitization	**–**
Carcinogenicity	**–**
Prenatal toxicity (2015)	**Pregnancy Risk Group C**
Germ cell mutagenicity	**–**
BAT value	**–**

In 2014, the Commission started applying a physiologically and empirically-based method for deriving MAK values for substances that have an effect on the upper respiratory tract and eyes (Brüning et al. 2014; see Section I of the List of MAK and BAT Values); it also includes criteria for classification as a sensory irritant. The review of the MAK value is based on this approach.

The sensitizing effects of triethanolamine were evaluated in 2006 (documentation "Triethanolamine" 2007); this evaluation was followed by a supplement in 2010 (supplement "Triethanolamine" 2010). In the meantime, further studies of developmental toxicity have been published.

Effects in Humans

Allergenic effects

Although many routes of exposure to the substance are possible, there have only been sporadic reports of positive patch test results with triethanolamine to date. Therefore, the evaluation from 2006 (documentation "Triethanolamine" 2007) does not need to be amended.

There are no new findings available for respiratory tract sensitization.

Animal Experiments and in vitro Studies

Subacute, subchronic and chronic toxicity

Inhalation

No new studies have been made available since the supplement from 2010 (supplement "Triethanolamine" 2010).

Triethanolamine had hardly any systemic effects in 3 inhalation studies in rats or in an inhalation study in mice. The most important effects in all studies were found to be effects on the larynx. The longest inhalation study in rats, which was carried out for 28 days according to OECD Test Guideline 412, revealed focal laryngeal inflammation at the low concentration of 20 mg/m^3 and above, up to and including 100 mg/m^3; the severity was graded 1 and 2 on a scale with a maximum of 5. Grade 3 inflammation was observed at 500 mg/m^3 and above in this study and at 400 mg/m^3 and above in the 5-day range-finding study (BG Chemie 1993). This indicates that the effects on the larynx can be expected to be only slightly dependent on time. An overall evaluation of all animals affected by laryngeal inflammation revealed a concentration–effects relationship, which was manifest as a slight increase in both the severity and the incidence of affected animals. Therefore, the effects at 20 mg/m^3 and above are regarded as adverse, and this is the LOAEC (lowest observed adverse effect concentration) (supplement "Triethanolamine" 2010).

A benchmark calculation published for focal laryngeal inflammation in the 28-day inhalation study yielded a BMDL05 of 14.8 mg/m^3 for male rats and 14.1 mg/m^3 for female rats (Gamer et al. 2008).

Local effects on skin and mucous membranes

Skin

Undiluted triethanolamine induced only slight irritation of the intact skin of rabbits in several studies after a single application of 0.5 to 2 ml for up to 20 hours. In long-term studies, however, triethanolamine induced chronic inflammation and acanthosis, erosion and ulcers at the application site after exposure to 32 mg/kg body weight and day and above in rats and 100 mg/kg body weight and day and above in mice (supplement "Triethanolamine" 2010).

Eyes

Pure triethanolamine caused no or only slight, reversible signs of irritation in the rabbit eye (supplement "Triethanolamine" 2010).

Allergenic effects

There are no new data available.

Reproductive and developmental toxicity

Developmental toxicity

To date, no developmental toxicity studies were carried out in conformity with test guidelines. A 3-phase Chernoff-Kavlock screening assay for possible toxic effects on reproduction or development, in which 50 pregnant CD-1 mice were given triethanolamine doses of 1125 mg/kg body weight and day from days 6 to 15 of gestation, did not affect maternal toxicity or the number of live foetuses, the litter size, the birth weights of the foetuses, the percentage of surviving foetuses or their body weight gains up to postnatal day 3 (NIOSH 1987; Union Carbide Corp 1990). A range-finding study for an oral teratogenicity study in Sprague Dawley rats with triethanolamine solutions in doses of up to 5000 mg/kg body weight and day from days 6 to 15 of gestation revealed only a slight decrease in mean foetal weights in the high dose group that was not statistically significant. There were no other signs of developmental toxicity, whereas the body weight gains of the dams were slightly delayed at 2500 mg/kg body weight and day and above as from day 8 of gestation. Visceral or skeletal examinations were not carried out in either study; therefore, the two studies are of limited validity with regard to the developmental toxicity of triethanolamine (supplement "Triethanolamine" 2010).

In a new screening study carried out according to OECD Test Guideline 421, groups of 10 male and 10 female Wistar rats were given gavage doses of triethanolamine of 0, 100, 300 or 1000 mg/kg body weight and day. The animals were exposed for 2 weeks before mating and 2 weeks during mating, and for up to 1 week after mating in the males and up to week 4 of lactation in the females. There was no maternal toxicity up to the high dose. At 1000 mg/kg body weight and day, the number of implantations was reduced by 20%, the number of offspring was reduced by 33%, and the number of post-implantation losses was increased (19.4% compared with 3.7% in the control group). The screening studies did not include a histopathological examination of the foetuses. In this study, the NOAEL (no observed adverse effect level) for foetotoxicity was 300 mg/kg body weight and day (BASF SE 2010).

The currently available studies did not include histopathological visceral or skeletal examinations.

Manifesto (MAK value/classification)

The critical effect is local irritation of the upper respiratory tract in the region of the larynx (slight inflammation) after inhalation exposure in rats and on the skin (acanthosis, erosion and ulcers) after repeated dermal application in rats and mice.

MAK value. A 28-day inhalation study in rats with aerosol exposure revealed a dose-dependent increase in the incidence of focal laryngeal inflammation in rats at the low concentration of 20 mg/m^3 and above, up to and including 100 mg/m^3; the severity was only of grade 1 and grade 2. Grade 3 inflammation was observed at 400 mg/m^3 and above in the 5-day range-finding study and at 500 mg/m^3 and above

in the 28-day study. This indicates that the effect can be expected to increase only slightly over the course of time, if at all, which means that this does not have to be taken into account in the derivation of the MAK value. A benchmark calculation published for focal laryngeal inflammation yielded a BMDL05 of 14.8 mg/m³ for male rats and 14.1 mg/m³ for female rats (Gamer et al. 2008). According to Brüning et al. (2014), the NOAEC of humans for effects on the upper respiratory tract is 1/3 of the NOAEC from animal studies. This corresponds to 4.7 mg/m³ for triethanolamine, which means that the MAK value of 5 mg/m³ can be retained.

Peak limitation. Triethanolamine is classified in Peak Limitation Category I because the limit value is determined by the inflammatory effects on the larynx (grade 1 to 2) that were detected in animal studies. Triethanolamine caused slight irritation in the rabbit eye. Although only slight laryngeal inflammation was observed in the 28-day study at the low concentration of 20 mg/m³, and a BMDL05 of 14 to 15 mg/m³ was determined for this effect, the previous excursion factor of 4 is regarded as too high and has been amended to an excursion factor of 2. The peak concentration of 10 mg/m³ thus remains below the BMDL05.

Prenatal toxicity. To date, no developmental toxicity studies have been carried out in conformity with test guidelines after inhalation, oral or dermal exposure. In a range-finding study in which rats were given gavage doses from days 6 to 15 of gestation, only the foetal weights were reduced at the highest dose tested of 5000 mg/kg body weight and day, which lies far above the limit dose. The NOAEL for foetotoxicity was 2500 mg/kg body weight and day. In mice, the NOAEL for foetotoxicity after gavage administration was the only dose tested of 1125 mg/kg body weight and day (supplement "Triethanolamine" 2010). In the new screening study with gavage administration carried out in rats according to OECD Test Guideline 421, foetotoxic effects were observed at the highest dose tested of 1000 mg/kg body weight and day. Maternal toxicity was not observed at this dose. The NOAEL for foetotoxicity was 300 mg/kg body weight and day.

The following toxicokinetic data were used to extrapolate the NOAEL of 300 mg/kg body weight and day for rats or 1125 mg/kg body weight and day for mice to a concentration in workplace air: the corresponding species-specific correction values for rats or mice determined on the basis of the toxicokinetic data (1:4; 1:7), the assumed oral absorption (100%), the body weight (70 kg) and the respiratory volume of a person (10 m³), and the assumed 100% absorption by inhalation. This results in respective concentrations of 525 and 1125 mg/m³, which are 105 and 225 times higher than the MAK value of 5 mg/m³. However, the currently available studies did not include visceral or skeletal examinations. A direct comparison between triethanolamine and 2-aminoethanol or diethanolamine, two other representatives of this class of substances, is not appropriate because of qualitative and quantitative differences with regard to the interference of 2-aminoethanol with choline metabolism and the membrane fluidity of diethanolamine; triethanolamine does not have these properties. However, the studies of 2-aminoethanol and diethanolamine found no evidence of teratogenic effects for this class of substances although their toxicity, in

view of markedly lower NOAELs for systemic and developmental toxicity, is more pronounced (see documentation "2-Aminoethanol" 1999, supplement "2-Aminoethanol" 2016, available in German only, supplement "Diethanolamine" 2007).

In view of the high bolus doses of triethanolamine that were used, which in some cases were far higher than the limit dose, and the very large 105-fold and 225-fold differences between the calculated NOAEC for foetotoxicity in rats and mice, respectively, and the MAK value of 5 mg/m^3 and the proven lack of evidence of teratogenicity for this class of substances, triethanolamine is classified in Pregnancy Risk Group C.

Absorption through the skin. Triethanolamine is not designated with an "H" (for substances which can be absorbed through the skin) because no new data have become available for absorption through the skin and the MAK value has been retained.

Sensitization. Since the sensitizing effects of the substance were evaluated in the documentation from 2006 (documentation "Triethanolamine" 2007) and the supplement from 2010 (supplement "Triethanolamine" 2010), no additional data have been published which make it necessary to amend the evaluation. Therefore, triethanolamine is not designated with "Sa" or "Sh" (for substances which cause sensitization of the airways or skin).

References

BASF SE (2010) Triethanolamin rein (Triethanolamine, pure), reproduction/developmental toxicity screening test in Wistar rats, oral administration (gavage), 24th Sept 2010, Project No.: 90R0386/09061, BASF SE, Ludwigshafen, unpublished report

BG Chemie (1993) Study on the inhalation toxicity of triethanolamin as a liquid aerosol in rats including examination of possible neurotoxicity, 28-day test, BASF AG, BASF Project No. 40I0711/89098, BG No. 57, 26th October 1993, BG Chemie, Heidelberg, unpublished report

Brüning T, Bartsch R, Bolt HM, Desel H, Drexler H, Gundert-Remy U, Hartwig A, Jäckh R, Leibold E, Pallapies D, Rettenmeier AW, Schlüter G, Stropp G, Sucker K, Triebig G, Westphal G, van Thriel C (2014) Sensory irritation as a basis for setting occupational exposure limits. Arch Toxicol 88: 1855–1879

Gamer AO, Rossbacher R, Kaufmann W, van Ravenzwaay B (2008) The inhalation toxicity of di- and triethanolamine upon exposure. Food Chem Toxicol 46: 2173–2183

NIOSH (National Institute for Occupational Safety and Health) (1987) Screening of priority chemicals for reproductive hazards. Monoethanolamine (CAS No. 141-43-5), diethanolamine (CAS No. 111-42-2), triethanolamine (CAS No. 102-71-6), Report PB89-139067, 14 April 1987, Environmental Health Research and Testing (EHRT), Inc., Cincinnati, OH, USA

Union Carbide Corp (1990) Screening of priority chemicals for reproductive hazards, Final report: monoethanolamine, diethanolamine, triethanolamine with cover letter, NTIS/OTS 0526003, EPA/OTS Doc. I D 86-900000423, NTIS, Springfield, VA, USA

completed 25.02.2015