
Dibismuth tritelluride (undoped and Se-doped)

(CAS No: 1304-82-1)

Health-based Reassessment of Administrative
Occupational Exposure Limits

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

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1 Introduction

The present document contains the assessment of the health hazard of dibismuth tritelluride (undoped and Se-doped), in this document referred to as bismuth telluride, 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 KJ van den Berg, Ph.D. and H Stouten, M.Sc. (TNO Nutrition and Food Research, Zeist, the Netherlands).

The evaluation of the toxicity of bismuth telluride 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, literature was retrieved from the on-line databases Medline, Toxline, and Chemical Abstracts covering the period 1966 to 24 October 1997 (19971024/UP), 1965 to 20 October 1997 (971020/ED), and 1967 to 28 October 1997 (971028/ED; vol. 127, issue 18), respectively, and using the following key words: bismuth sesquitelluride, bismuth (1W) telluride, dibismuth tritelluride, BI2TE3, 1304-82-1, and 37293-14-4. HSDB (no record) and RTECS, databases available from CD-ROM, were consulted as well (NIO97, NLM97). The final literature search was carried out in October 1997.

In February 1999, the President of the Health Council released a draft of the document for public review. The committee received no comments.

An additional literature search in May 2002 did not result in information changing the committee's conclusions.

2 Identity

name	:	dibismuth tritelluride
synonyms	:	bismuth telluride, tellurobismuthite, bismuth tritelluride, bismuth sesquitelluride
molecular formula	:	Bi ₂ Te ₃
CAS number	:	1304-82-1

Data from ACG91, NIO97.

3 Physical and chemical properties

molecular weight	:	800.83
boiling point	:	-
melting point	:	585°C
flash point	:	-
vapour pressure	:	-
solubility	:	decomposed by nitric acid
log P _{octanol/water}	:	-
conversion factors (20°C, 101.3 kPa)	:	-

Data from ACG91, NLM97.

Bismuth telluride is a grey solid in the form of single crystals, hexagonal platelets, or ingots.

4 Uses

Bismuth telluride is used extensively for thermoelectric cooling, and power generation applications (Ric92, ACG91). For use as a semiconductor, bismuth telluride is often 'doped' with Bi₂Se₃ (20 mol%) and small amounts of SnTe (Bel94).

5 Biotransformation and kinetics

In general, insoluble bismuth compounds are poorly absorbed when given orally or applied to the skin (Bel94). Specific information on the absorption, distribution, metabolism, and excretion of bismuth telluride is not available. However, some data on the kinetics and metabolism of other bismuth compounds have been published in an overview, and these data may also be applicable for bismuth tritelluride. In summary, following oral intake of 'insoluble' bismuth compounds such as bismuth subnitrate or bismuth subcitrate, a significant rise in the concentration of bismuth in the blood of human volunteers or patients has been demonstrated. Multiple dosing of patients with bismuth subcitrate produced a steady state plasma concentration after 4 weeks. In one study, the percentage of absorption from the

gastrointestinal tract was estimated 0.2%, but large interindividual variations have been shown. Distribution of bismuth in the organs is largely independent of the compound administered or the route of administration. The concentration of bismuth in the kidney, and its retention time, is higher than in other organs (lung, liver, brain). After repeated exposure, bismuth is bound to a low molecular weight bismuth-metal binding protein in the kidney, the synthesis of which can be induced by the metal itself. Bismuth is eliminated from the body by the urinary and faecal routes, but the exact contribution of both routes is still unknown. Elimination from blood displays multicompartment pharmacokinetics. Following intravenous treatment of human volunteers and patients with the isotope ²⁰⁶Bi, half-lives varied from 3.5 minutes to 3.2 hours. The possibility of a compartment with a much longer half-life (17 to 22 years) has also been reported (Sli89).

6 Effects and mechanism of action

Human data

In industrial experimental work with bismuth telluride under controlled conditions (vacuum hoods), no adverse health effects were encountered other than 'tellurium breath' (ACG91, Bel94).

Exposure to bismuth telluride (Se-doped) in construction work is considered by the Occupational Safety and Health Association (OSHA) as potentially resulting in non-malignant respiratory effects (Sul95).

In 618 patients suffering from bismuth encephalopathy, blood concentrations ranging between 10 and 4600 µg/L have been reported (Sli89).

Animal data

In an unpublished study, not available to the committee, dogs, rabbits, and rats were exposed daily for 1 year by inhalation to doped bismuth telluride at a concentration of 15 mg/m³ and an average particle size of 1.04 µm. In dogs, small granulomatous lesions without fibrosis appeared in the lungs after 6 months. Four months after an exposure of 8 months, the lesions had regressed. The rabbits showed a similar histological picture; however, they had decreased numbers of pulmonary macrophages, no fibrous tissue proliferation, and no cellular or fibrous tissue reactions around the dust deposits in the lymph nodes. The rats showed fewer granulomas, but some areas of epithelialisation of the

alveolar walls. When exposed to pure, undoped bismuth telluride dust at 15 mg/m³ and a particle size of 0.04 µm, for 11 months, no adverse responses of any type were seen, other than the pulmonary responses to the inhalation of an 'inert' dust (ACG91, Bel94).

The way this study was presented raises many questions. The study design was not clear. The number of animals exposed and the presence of control groups were not reported. In case of doped bismuth telluride, animals were stated to be exposed for 1 year, but no results were presented. Apparently, exposure lasted for 8 months and a 4-month recovery period was included. Furthermore, lesions were described occurring after 6 months suggesting an interim section at that time point. The results were very poorly presented. There were no data on the response incidences or statistical evaluations. Lesions were stated to be regressed, but it was not clear whether this recovery was complete or only partial. The response in rabbits was compared to that in dogs. However, the description in rabbits suggests responses in dogs such as fibrous tissue proliferation (however, without clear collagen deposits; 'no fibrosis') and fibrous tissue reactions in the draining lymph nodes, which were not mentioned. Further, it was stated that rabbits had decreased number of macrophages and that rats had fewer granulomas, but the references are not clear (i.e., was comparison made with their own controls or with the other species). With respect to undoped bismuth telluride, the only information presented was that no adverse responses other than pulmonary responses to the inhalation of an 'inert' dust were seen. However, it is not clear whether this includes an epithelial response in rats, persistent macrophage aggregates/dusts deposits in the draining lymph nodes, macrophage aggregates in the exposed animals, or only accumulation of macrophages in the alveoli.

No data on carcinogenicity, mutagenicity, and reproduction toxicity of bismuth telluride have been found.

7 Existing guidelines

The current administrative occupational exposure limits (MAC) for undoped and Se-doped bismuth telluride in the Netherlands are 10 and 5 mg/m³, 8-hour TWA, respectively.

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

8 Assessment of health hazard

Very limited data have been reported on occupational exposure of workers to bismuth telluride. These indicate no adverse health effect other than ‘tellurium breath’.

With respect to animal data, results from only one unpublished study in which rats, rabbits, and dogs were exposed to 15 mg/m³ of doped or undoped bismuth telluride (particle size: 1.04 or 0.4 µm, respectively) for 11-12 months were available to the committee by means of an abstract. Pulmonary responses were observed. However, due to poor and confusing reporting, the committee considered this study to be not appropriate to serve as a basis for setting an occupational exposure limit.

The committee considers the toxicological database on bismuth telluride, doped or undoped, too poor to justify recommendation of a health-based occupational exposure limit.

The committee concludes that the information available from the animal studies indicates that the present MAC value for *doped* bismuth telluride of 5 mg/m³, 8-hour TWA, may be at least one order of magnitude too high, but that there is insufficient information to comment on the level of the present MAC value for *undoped* bismuth telluride.

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Annex

Occupational exposure limits for bismuth telluride 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	-	5 ^c , 10 ^d	8 h	administrative		SZW02
Germany -AGS	-	-				TRG00
-DFG MAK-Kommission	-	-				DFG02
Great-Britain -HSE	-	5 ^c , 10 ^d	8 h	OES		HSE02
	-	10 ^c , 20 ^d	15 min			
Sweden	-	-				Swe00
Denmark	-	-				Arb02
USA -ACGIH	-	5 ^c , 10 ^d	8 h	TLV	A4 ^g	ACG02b
-OSHA	-	5 ^c	8 h	PEL		ACG02a
-NIOSH	-	5 ^c , 5 ^f	10 h	REL		ACG02a
European Union -SCOEL	-	-				EC02

^a S = skin notation; this 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.

^c Se-doped bismuth telluride.

^d Undoped bismuth telluride.

^e For undoped bismuth telluride, as respirable fraction; for total dust: 15 mg/m³ as total particulate; no limit for Se-doped bismuth telluride.

^f For undoped bismuth telluride, as respirable fraction; for total dust: 10 mg/m³.

^g Classified in carcinogenicity category A4, i.e., not classifiable as a human carcinogen: agents which cause concern that they could be carcinogenic to humans but which cannot be assessed conclusively because of lack of data. *In vitro* or animal studies do not provide indications of carcinogenicity which are sufficient to classify the agent into one of the other categories.

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