Tellurium and tellurium compounds

(excluding TeF_6)

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 tellurium and its compounds, except for tellurium hexafluoride, 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 MA Maclaine Pont, M.Sc. (Wageningen University, Wageningen, the Netherlands).

The evaluation of the toxicity of tellurium and its compounds has been based on the review by the American Conference of Governmental Industrial Hygienists (ACG99). Where relevant, the original publications were reviewed and evaluated as will be indicated in the text. In addition, literature was retrieved from the data bases Toxline, Medline, and Chemical Abstracts, covering the periods of 1981 to April 1999, 1966 to May 1999, and 1937 to April 1999, respectively*. The final literature search was carried out in May 1999.

The literature search focused on those tellurium compounds of which some information could be found in either the Dictionary of chemical names and synonyms (How92) or in the CRC Handbook of chemistry and physics (Lid96); for dimethyltelluride and diethyltelluride a separate search was performed.

In September 2001, the President of the Health Council released a draft of the document for public review. The committee received no comments.

2 Identity

Forty-two isotopes of tellurium are known with atomic masses ranging from 106 to 138; natural Te exists of eight isotopes (mainly ^{130}Te, ^{128}Te, and ^{126}Te). The half-life times of the unstable isotopes range from 0.06 milliseconds to 1.3 x 10^{13} years (Lid96).

* The following key words were used: tellurium, telluride, methyltelluride, tellurobismethane, ethyltelluride, tellurobisethane, hydrogen telluride, and the CAS numbers 593-80-6, 627-54-3, 7446-07-3, 7783-09-7, 7789-54-0, 7790-48-9, 7803-68-1, 10025-71-5, 10026-07-0, 10031-27-3, 10049-23-7, 10102-20-2, 13451-18-8, 13494-80-9, 13845-35-7, 15192-26-4 and 20941-65-5. Health effects from radiation were excluded.

The following data have been found:

name	molecular formula	synonyms	CAS number
ethane, tellurobis-	$Te(C_2H_5)_2$	diethyltelluride; diethyltellurium; ethyltelluride	627-54-3
hydrogen telluride	H_2Te	hydrogen tellurite	7783-09-7
methane, tellurobis-	$Te(CH_3)_2$	dimethyltelluride; dimethyltellurium; methyltelluride	593-80-6
telluric (VI) acid	H_6TeO_6		7803-68-1
telluric acid	H_2TeO_3	tellurous acid	10049-23-7
telluric acid, disodium salt	$H_2O_3Te.2Na$	sodium tellurate; sodium tellurate (IV); sodium tellurite; tellurous acid, disodium salt	10102-20-2
telluric acid, lead (2^+) salt 1:1	$H_2O_4Te.Pb$	lead tellurate; lead tellurite	13845-35-7
tellurium	Te	aurum paradoxum; metallum problematum; telloy	13494-80-9
tellurium dibromide	$TeBr_2$	tellurium bromide	7789-54-0
tellurium dichloride	$TeCl_2$	tellurium chloride	10025-71-5
tellurium dioxide	TeO_2		7446-07-3
tellurium tetrabromide	$TeBr_4$		10031-27-3
tellurium tetrachloride	$TeCl_4$	telluric chloride; tellurium chloride; tellurium chloride (T-4)-; tetrachlorotellurium	10026-07-0
tellurium tetrafluoride	TeF_4		15192-26-4
tellurium tetraiodide	TeI_4		7790-48-9
tellurium trioxide	TeO_3		13451-18-8

3 Physical and chemical properties

Physical and chemical properties of tellurium and some of its compounds.

name	physical form	mol. weight	solubility in water	melting point	boiling point	vapour pressure	odour threshold
$Te(C_2H_5)_2$		185.72					
H_2Te	unstable gas[c]	129.62	soluble	-49°C	-2°C		
$Te(CH_3)_2$	liquid	157.67		-10°C	91-92°C		[a]
H_6TeO_6	white monoclinic crystals	229.64	soluble	136°C	-		
H_2TeO_3	white crystals	177.61	slightly	decomp. 40°C	-		
$H_2O_3Te.2Na$		223.59					[b]
Te	gray-white rhombohedral crystals	127.6	insoluble	449.5°C	988°C	at 520°C: 0.13 kPa	
$TeBr_2$	green-brown hygroscopic crystals	287.41	reacts	210°C	339°C		
$TeCl_2$	black amorphous hygroscopic solid	198.51	reacts	208°C	328°C		
TeO_2	white orthorhombic crystals	159.6	insoluble	733°C	1245°C		0.003 mg/m^3
$TeBr_4$	yellow-orange monoclinic crystals	447.22	reacts	388°C	±420°C, decomposes		
$TeCl_4$	white monoclinic hygroscopic crystals	269.41	reacts	224°C	387°C	at 253°C: 2.66 kPa	
TeF_4	colourless crystals	203.59	reacts	129°C	195°C, decomposes		
TeI_4	black orthorhombic crystals	635.22	reacts	280°C	-		
TeO_3	yellow-orange crystals	175.6	insoluble	430°C	-		

[a] Measured in waste water, after biological treatment: approximately 0.15 mg Te/kg organic sludge (Dij88).
[b] Taste threshold in water: 10 mg/L (Len67).
[c] The lower ignition limit is lower than 10 kPa; it decomposes with the evolution of 23.83 kcal/mol of heat into H_2 and Te (Mik77).

Data from Ano94, Lid96, Yak74.

Conversion factors for dimethyltelluride (20°C, 101.3 kPa) are: 1 ppm = 6.56 mg/m^3; 1 mg/m^3 = 0.15 ppm and for hydrogen telluride (20°C, 101.3 kPa): 1 ppm = 5.40 mg/m^3 ; 1 mg/m^3 = 0.19 ppm. For the other compounds conversion factors are not applicable.

Further, no flash points, explosion limits, and log $P_{octanol/water}$ values were found.

Elemental tellurium will burn slowly in air; a finely divided suspension in air can explode. Reactions with zinc, chlorine, fluorine, and solid sodium are vigorous and have a potential to cause fires (Bel94). Tellurium alkyls are normally inert in air or in contact with water at room temperature. They form tellurium dioxide as the final product of oxidation or combustion. They also undergo slow oxidation in the presence of water or moisture to form alkylhydroxytellurium derivatives, which are not well characterised (Roy93).

4 Uses

Elemental tellurium is used as an additive to copper, iron, and steel, in vulcanising rubber, as a colouring agent in glass and ceramics, and in some other applications (ACG99, Bud96). Certain telluride alloys are employed in the semiconductor industry (ACG99). Tellurium tetrachloride is used as a catalyst in several condensation reactions. Tellurium dioxide is used in acousto-optical filters in astronomy and in lasers, as a catalyst in oxidation reactions, in electroconductivity devices, as an additive in glass, in optical and photoacoustic devices. Tellurium trioxide is used as a catalyst in oxidation reactions (12th Collective Index of Chemical Abstracts: 12CI).

5 Biotransformation and kinetics

Elemental tellurium is only slowly metabolised, and it is eliminated as dimethyltelluride in urine, sweat, and expired air (ACG99). The proof for the formation of dimethyltelluride in man or laboratory animals was not given. In the literature, one study from 1884 was found that deals with this issue (Tay97). However, the formation of dimethyltelluride by bacteria (*P. fluorescens*) and fungi (*A. falciforme* and *P. citrinum)* has been proven after growth in the presence of potassium tellurite (K_2TeO_3) (Cha90). In humans, the formation of dimethyltelluride is probably reduced by the intake of ascorbic acid (DeM47a) and by 2,3-dimercaptopropanol (BAL = British Anti Lewisite) (Amd47). However, others report that BAL is not effective, and that Te induces kidney and liver toxicity (Amd58 in Ein84).

The daily intake for man is estimated to be 0.6 mg, with an oral absorption of 25% and a half-life time of 3 weeks. The body burden is approximately 0.12

ppm (mainly in the bones). The losses for a reference man are: 83% via the urine, 15.6% via the faeces, and 1.6% in exhaled air (Sca92).

In a group of workers who were occupationally exposed to Te and TeO_2 fumes, the urinary concentration was measured: heavy exposure (0.1-0.29 mg Te/m^3): 9/22 samples contained 0.02-0.03 mg Te/L; moderate exposure (0.05-0.09 mg Te/m^3): 18/30 samples contained 0.01-0.02 mg Te/L; light exposure (0.01-0.05 mg Te/m^3): 33/46 samples contained < 0.01 mg Te/L; the control group (n=26) had no Te in the urine (Ste42).

After an oral dose of a Te compound, human volunteers showed an intestinal absorption of 25 ± 10% for soluble tellurium salts. The renal tellurium excretion was faster after administration of hexavalent tellurium than after ingestion of the tetravalent form. The introduction of Te to cress (the water plant *Lepidium sativum* L.) lowered the intestinal absorption to approximately 15%. For metallic Te, the fractional intestinal absorption was found to be about 10% (Kro91b).

Animal data are summarised in Table 1.

The estimated biological half-life times for the major retention sites of tellurium in rats were estimated to be about 9 days in blood, 10 days in liver, 17 days in muscles, 23 days in kidneys, and 600 days in bones (Fis91).

Summarising, the kinetics of tellurium-compounds after intravenous injection and after oral dosing differ. After intravenous injection, a higher percentage of the dose is found in the liver and the kidneys than after oral dosing. A lower percentage can be found in blood, spleen, and brain. Exhalation comprises a small part of the excretion: 0.1-7% of the intravenously injected dose (DeM47b, Kor65, Mos60, Sca92). After oral dosing, tellurium is absorbed from the intestines to a maximum of 25%; it is excreted mainly via the faeces. After intravenous injection in rats, Te excretion is higher via the urine than via the faeces. After intravenous injection, a half-life time for Te clearance from the body of rats is calculated to be 6 days (Kor65).

Table 1 Summary of experimental animal toxicokinetic data.

animal species	Te compound	dosing regimen	results	reference
rat (white)	$^{127}TeCl_4$, 3 µCi	intratracheal; dose(s) not given	88% was removed from the lungs in the first 24 h; 60% was still retained in the body after 7 days.	Dob70
rat	$^{132}TeCl_4$, 3.2 µCi	iv, single; dose(s) not given	6 h after injection: 20% in the liver; 8.2% in the bones; 7.3% in the kidneys; 2.2% in the lungs; 0.7% in the spleen, 0.4% in the brain; $t_{½}$: for Te clearance from the body: 6 days.	Kor65
rat	Te	iv, single; dose(s) not given	distribution in the body: 24.2% in bones; 16.4% in liver, 10% in blood, 10% in muscles, 10% in skin, 7% in lungs, 5.8% in kidneys.	Mos60
rat	Te	oral, single; dose(s) not given	20-25% absorbed via the intestines; 0.55% in kidneys; 0.35% in blood; 0.4% in liver; 6.2 % in spleen; 70-75% of the excreted quantity was via the faeces; within 16 days, 15% of the amount administered was excreted.	Mos60
rat	^{127}Te	iv, single; dose(s) not given	distribution: 18.6% in blood, 11.9% in muscles; 9.7% in liver; 8.6% in skeleton; 2.5% in kidneys.	Mos64
rat	^{127}Te	oral, single; dose(s) not given	10-25% absorbed via the intestines; of that fraction, 1.2% accumulated in muscles, 0.4% in liver, 0.4% in skeleton, 0.2% in kidneys.	Mos64
rat	^{127}Te	oral, single; dose(s) not given	distribution: blood, kidneys>spleen, liver, lungs>heart, adrenal glands>muscles, brain; 79% was excreted via the faeces, 2.7% via the urine	San63
rat	Te, radioactive	iv, single ; dose(s) not given	33% was excreted via the urine in the first week and ca. 14% via the faeces; in the first 24 h, >14% was excreted, in subsequent days 2-3%; the highest concentrations were found in kidneys, liver, bone, and thyroid gland.	Slo70a
rat	$Na_2{}^{127}TeO_3$	oral, single; dose(s) not given	ca. 25% was absorbed via the intestines; in the first week ca. 65% was excreted via the faeces; ca. 9% was excreted via the urine.	Slo70b
rabbit	Na_2TeO_3	iv, single: 0.18 mg Te; oral, single: 2.5 mg Te	fractional intestinal absorption: 40%.	Kro91a

Table 1 Continued.

animal species	Te compound	dosing regimen	results	reference
rabbit, rat, dog	Na_2TeO_3	iv, single: 0.1 - 0.5 mg Te/kg bw	in the first 24 h: <0.1% was exhaled; the largest concentration was found in kidneys; in heart, lungs, and spleen, concentration was from 1/3 to 1/10 of that of kidneys, but 1.5 to 2 times as much as that of liver; in 5-6 days, 20% of the amount injected was excreted	DeM47b
rabbit, rat, dog	Na_2TeO_3	oral, single; dose(s) not given	3.3% excreted within 6 d	DeM47b
piglet	Te, radio-active in ionic or colloidal form	dermal, single; dose(s) not given	within 15 min, ca. 5% of the activity could be detected deeper than 30 µm; there was no difference in penetration among 7 different isotopes used	Nor68
rat, 15-day old	Te	oral, feed, 35 d; dose(s) not given	on the 2nd day: Te in cytoplasm of Schwann cells	Duc79
rat	K_2TeO_3	ip; 112 d 2 mg/kg bw (i.e., ca. 0.95 mg Te/kg bw/d	accumulation of Te in the cerebellum	Wal78
rat, male	$TeCl_4$	oral, drinking water, 35 d; total ingested dose: 1025 ± 115 mmol Te/kg bw (131 mg Te/kg bw)	concentration in blood: 45 nmol/g; liver: 5.7 nmol/g; kidneys: 2.7 nmol/g; brain: 3.1 nmol/g	Val85

6 Effects and mechanism of action

Human data

In a group of 62 men, who were examined after 15 and 22 months of occupational exposure, the order of frequency of occurrence of symptoms were: garlic odour of the breath, dryness of the mouth, metallic taste, somnolence, garlic odour of the sweat. The odour can remain for months. Its intensity was directly related to the exposure concentration. There was no evidence of Te intoxication (Ste42).

The minimum amount of Te in Na_2TeO_3 required to cause garlic breath varied from 1 to 50 µg per person as a single oral dose (DeM47a).

Animal data

Acute toxicity data of tellurium and compounds are summarised in Table 2.

Table 2 Acute toxicity data of tellurium and compounds.

animal species	Te compound	dosing regimen	results	reference
rat	Te	oral	LD_{50}: 83 mg/kg bw	Lew92
mouse	Te	oral	LD_{50}: 20 mg/kg bw	Lew92
rabbit	Te	oral	LD_{50}: 67 mg/kg bw	Lew92
guinea pig	Te	oral	LD_{50}: 45 mg/kg bw	Lew92
rat, female rat, male guinea pig mouse	$Te(C_2H_5)_2$	inhalation (no further details)	LC_{50}: 55 mg/m^3 LC_{50}: 54.1 mg/m^3 LC_{50}: 45.1 mg/m^3 LC_{50}: 154.0 mg/m^3	Koz81
rat	Na_2TeO_3	oral	LD_{75}: 2.25-2.50 mg/kg bw	Fra36
rat	Na_2TeO_4	oral	LD_{75}: 20.0-30.0 mg/kg bw	Fra36
rat	Te or TeO_2	intratracheal, single dose; sufficient to cause observable stress	after 180 days: no progressive fibrosis	Gea78
rabbit	Na_2TeO_3 Te	iv, single; 50 µg Te/kg bw iv, single; 20-30 mg Te/kg bw	garlic breath; administration of ascorbic acid reduces Te in expired air to 20 or 25% of control garlic breath	DeM47a
rabbit	H_6O_6Te	iv, single	LD_{lo}: 5.6 mg/kg bw	Lew92
rat	H_6O_6Te	iv, single	LD_{lo}: 31 mg/kg bw	Lew92
rabbit	H_6O_6Te	oral, single	LD_{lo}: 56 mg/kg bw	Lew92
mouse	Na_2TeO_3	sc, single; 1.28 mg Te/kg bw	decrease in body temp; increase in gastric content	Wat90

The data on toxicity of tellurium and compounds following repeated exposure are summarised in Table 3.

Table 3 Toxicity data of tellurium and compounds following repeated exposure.

animal species	Te compound	dosing regimen	results	reference
rat	Te, TeO_2	inhalation, 2 h/d, 13-15 w; differently dispersible aerosols 10-100 mg/m^3	in both cases: 100 mg/m^3 is approx. LD_{50}; weight loss; irritation of the respiratory tract; loss of fur; haemolysis	San63
rat, guinea pig, mouse	$Te(C_2H_5)_2$	inhalation, chronic (no further data); 1 mg/m^3 (i.e., 0.69 mg Te/m^3)	dermatitis; weight loss; effects on liver enzymes, serum proteins, CNS; haemolytic effects; effects on liver, kidneys, heart, and other organs	Koz81
rat, less than 3-week old	Te	oral, feed, 1-8 d; dose(s) not given	demyelination of sciatic nerves; oedema of nerves; vacuolar degeneration of Schwann cells; recovery occurred despite continued ingestion of Te	Lam70
rat, 3-week old	Te	oral, feed, several days; 10,000 ppm (i.e., ca. 500 mg Te/kg bw/d)	on day 2 and 3: paresis of the hind legs, most severe at day 7, recovery by day 10; demyelination; vacuolar degeneration of Schwann cells	Tak77
rat, 11-week old	Te	idem	no effects	Tak77
rat, 3-4-week old	Te	oral, feed, several days; 12,500 ppm (i.e., ca. 625 mg Te/kg bw/d)	on day 6 and 7: paresis; degeneration of Schwann cells	Ham 86
rat (white)	Te	oral, feed (period unkown); 375, 750, 1500 ppm (i.e., ca. 19, 38 and 75 mg Te/kg bw/d)	at 1500 ppm: some effect on growth; no pathological effects; at all dose levels: garlic-like breath within 24-72 h, disappearing 1-2 days after discontinuation of treatment	DeM46
rat (white)	TeO_2	oral, feed, 26 d; 375, 750,1500 ppm as Te (i.e., ca. 19, 38, 75 mg Te/kg bw/d)	at 1500 ppm: rats died; at other dose levels: no growth; loss of hair; redness and oedema of the digits; temporary paralysis of hind legs; oligouria or anuria; necrosis of liver and kidneys	DeM48
rat, 15-day old	Te	oral, feed, 35 d; dose(s) not given	within 24 h: demyelination of sciatic nerve; on day 3: paralysis of the hind legs lasting 7-10 days; after 7 days or more: decreased motor nerve conduction velocity; recovery of paralysis and demyelination	Duc79
pig, weanling	$TeCl_4$	oral, feed, 10 wk; 500 ppm	necrosis of cardiac and skeletal muscle in 50-65% of the pigs; decrease in blood GSH activity	Vle81

Table 3 Continued.

animal species	Te compound	dosing regimen	results
rat	Te	oral, feed, 5 mo; 3300 ppm (i.e., ca. 165 mg Te/kg bw/d	impaired learning ability even after discontinuation for 3 months
rat, rabbit	Na_2TeO_3	oral, 7 mo; 0.005 mg/kg bw/d (i.e., ca. 0.00285 mg Te/kg bw/d)	reduced catalase activity, sulfhydryl, and ascorbic acid concentrations; altered conditioned reflexes and brain morphology
rat, rabbit	Na_2TeO_3	oral, 6 mo; 0.0005 mg/kg bw/d (i.e., ca. 0.00028 mg Te/kg bw/d)	no effects
rat (n = 50), rabbit (n = 25)	Na_2TeO_3	oral, 7 mo; 0.005, 0.05, 0.5 mg/kg bw/d (i.e., ca. 0.00285-0.28 mg Te/kg bw/d)	necrosis of liver and intestines; effects on CNS; altered brain morphology
rat, rabbit	Na_2TeO_4	oral (period unkown); 1, 10, 25, 50 mg/kg bw/d (i.e., ca. 0.5, 5.4, 13.4, 26.8 mg Te/kg bw/d)	necrosis of liver and intestines
mouse	Te^{6+}	oral, drinking water, lifetime; 3 ppm	no effect on organ content of Cr, Cu, Mg, Zn
rat	K_2TeO_3	ip; 112 d 2 mg/kg bw/d (i.e., ca. 0.95 mg Te/kg bw/d)	impaired growth; increased activity; no effect on learning ability

The results found by Len67 were not confirmed by more recent studies; may be there was a calculation error in the low dose.

Carcinogenicity

Sodium tellurite or potassium tellurate was given in the drinking water to mice during lifetime. The dose of Te was 2 ppm. Groups of 54 males and 54 females received either tellurite or tellurate. The control group for the tellurite-dosed animals consisted of 51 males and 56 females, the control group for the tellurate-dosed animals consisted of 54 males and 48 females. Males fed tellurate had an increased lifespan, females fed tellurite had a decreased lifespan. Te-fed mice were reported to be less active than their controls, to appear unhealthy, and to have poor coats. Since there was no significant difference in tumour incidence between the tellurite-fed and tellurate-fed mice, the data on tumour incidences were pooled for both the exposed animals and the

unexposed controls. Moreover, the tumour data of males and females were also pooled. Of the 216 mice fed tellurite or tellurate, 187 were necropsied and 90 were examined histologically. In the mice subjected to histological examination, there were 7 lymphoma-leukaemias, 5 lung carcinomas, 1 lung adenoma, several fibromas, and 1 (benign) adrenocortical adenoma. In the 119 control animals examined histologically (total number: 209; number necropsied: 180), there were 2 lymphoma-leukaemias, 7 lung carcinomas, 1 carcinoma of unknown origin, and 13 benign tumours of, amongst others, breast and ovary (Sch72). The committee agrees with the authors that the study did not produce evidence of carcinogenic potential of tellurium. The committee notes the considerable difference between the number of animals necropsied and the number of animals examined histologically. Because of this remarkable difference which was not discussed at all by Schroeder and Mitchener, the committee questions the validity of the long-term carcinogenicity study.

Sodium tellurite was given in the drinking water to rats during lifetime. The dose of Te^{4+} was 2 ppm. [The intake was estimated to be 0.150 mg Te/kg bw/d (Sch68).] When the rats were 21 months old, an epidemic of pneumonia caused considerable loss of life in all groups. The group size before and after the epidemic of pneumonia, at the age of 28 months was: 52 and 36 males and 53 and 42 females; the control groups consisted of 52 and 38 males and 44 and 35 females, respectively. Tellurite had no influence on lifespan. The body weight of the exposed males and females at 30 months was larger than the controls; however, treated and control group were losing weight between 24 and 30 months of age. At 36 months, the treated females weighed more than their controls, the treated males weighed as much as their controls. Treatment did not induce a statistically significant increase in the incidence of total or malignant tumours (total: 36.4% vs. 30.8% in controls; malignant: 18.2% vs. 16.9% in controls) (Sch71). The committee notes the difference between the number of animals necropsied and the number of those examined histologically (controls: 75 and 65, respectively; tellurite treated: 67 vs. 44, respectively), probably due to severe post-mortem changes, and questions the validity of this study.

Mutagenicity and genotoxicity

TeO_2 was positive in a DNA repair test in *E. coli* strains WP2*,* WP2*uvrA,* CM571, and WP100 (Yag77).

$TeCl_4$, $Na_2H_4TeO_6$, and Na_2TeO_3 were positive in a DNA repair test (rec-assay) in *B. subtilis* strains H17 and M45 (Kan80).

Na_2TeO_3 induced mutations in a spot test with *S. typhimurium* strain TA98 (Kan80).

$Na_2H_4TeO_6$ induced mutations in a spot test with *S. typhimurium* strains TA1535 and TA100 (Kan80).

$(NH_4)_6TeO_6$ induced chromatid breaks in human leukocytes *in vitro* (Pat72).

$Na_2H_4TeO_6$ gave equivocal results in a spot test with *S. typhimurium* TA98 (Kan80).

Na_2TeO_3 did not induce mutations in a spot test with *E. coli* strains B/r WP2, WP2, and with *S. typhimurium* strains TA100, TA1535, TA1537 and TA1538 (Kan80).

Na_2TeO_3 did not induce chromatid breaks in human leukocytes *in vitro* (Pat72).

$Na_2H_4TeO_6$ did not induce mutations in a spot test with *E. coli* strains B/r WP2, WP2, and with *S. typhimurium* strains TA1537 and TA1538 (Kan80).

The committee is of the opinion that the positive outcome in several studies indicates the effect of redox cycling; this is a high-dose phenomenon and does not support a carcinogenic mechanism.

Reproduction toxicity

The data on reproduction toxicity are presented in Table 4.

7 Existing guidelines

The current administrative occupational exposure limit (MAC) for tellurium and tellurium compounds in the Netherlands is 0.1 mg/m^3, 8-hour TWA (measured as Te).

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

8 Assessment of health hazard

Human data

In humans, occupational exposure to tellurium and its compounds leads to symptoms such as garlic odour of the breath, dryness of the mouth, metallic taste, somnolence, garlic odour of the sweat. The odour can remain for months

Table 4 Reprodcution toxicity data on tellurium and compounds.

animal species	Te compound	dosing regimen	results	reference
rat, female	Te	oral, feed; during pregnancy; 3000 ppm (i.e., ca. 14 mg/animal/d)	no data on maternal toxicity; all pups of 50% of the litters had hydrocephalus; no brain anomalies.	Duc70
rat, female (Wistar; n=5 per dose); one control group pair-fed, one control group fed *ad lib*	TeO_2	subcutaneous; GD 15-19; 500 µmol Te/kg bw (i.e., ca. 64 mg Te/kg bw/d)	dams: reduced food consumption and weight gain; centrilobular fatty changes in the liver; no histological changes in any organ. Fetuses: 100% hydrocephalus, exophthalmia, oedema; 39-47% ocular haemorrhage; reduced fetal weight and length. No effect was attributable to low food intake.	Per88a
rat, female (Wistar; n=10 per dose)	TeO_2	subcutaneous; GD 15-19; 0, 10, 100, 500, 1000 µmol Te/kg bw/d (i.e., ca. 0, 1.3, 12.8, 64, 128 mg Te/kg bw)	dams: reduced weight gain at the two higest dose levels; in the highest dose group, 4 dams died. Fetuses: at the two highest dose levels: 11 and 81% mortality, resp; dose-related decrease in fetal weight, increase in undescended testes, hydrocephalus and oedema all over the body, exophthalmia, ocular haemorrhage, umbilical hernia. At 12.8 mg/kg: fetal toxicity in the absence of maternal toxicity (100% hydrocephalus and oedema). At 1.3 mg/kg: no effects.	Per88b
rat, female	Te	intramuscular; GD 9 and 10; 13 mg/kg bw	no data on maternal toxicity; hydrocephalus in the offspring, visible only 5-6 days after birth.	Agn72
rat, female (Sprague Dawley; n=22 per dose)	Te	oral, feed; GD 6-15; 0, 30, 300, 3000, 15,000 ppm (i.e., ca. 0, 2.2, 19.6, 166 and 633 mg/kg bw/d on GD 6-10; and 0, 1.9, 18, 173 and 579 mg/kg bw/d on GD 11-15; calculated by the authors)	maternal toxicity at 300 ppm; no effect on pregnancy rate, litter size, dead or resorbed implantations, fetal sex ratio. In 2 highest dose groups: skeletal and soft tissue malformations (primarily hydrocephalus).	Joh88
rabbit, female (New Zealand; n=17 per dose)	Te	oral, feed; GD 6-18; 0, 17.5, 175, 1750, 5250 ppm (i.e., ca. 0, 0.74, 7.6, 53, 101 mg/kg bw/d; based on food intake and maternal body weight given by the authors)	maternal toxicity at 1750 ppm; no effect on pregnancy rate, litter size, dead or resorbed implantations, fetal sex ratio. Highest dose group: slightly elevated evidence of delayed skeletal development and non-specific abnormalities.	Joh88

(Ste42). The most important indication of exposure to tellurium is the garlic-like odour of the breath. Probably, dimethyltelluride is formed in the body and exhaled. However, its formation in humans and laboratory animals was not proven. Only in bacteria and fungi, the formation of dimethyltelluride from potassium tellurite was established (Cha90).

Animal data

Tellurium element

Inhalation of tellurium aerosols by rats resulted in weight loss, irritation of the respiratory tract, loss of fur, and haemolysis. It is not clear what the threshold concentration for these effects is. The range used in the experiment was 10-100 mg/m^3 (San63). This Russian study was only available in abstract form, despite considerable effort to obtain the full paper.

Tellurium induced neurotoxicity in rats after feeding high doses (from 500 mg/kg), in the form of degeneration of Schwann cells and demyelination. The rat was the only species studied in this respect (Duc79, Ham86, Lam70, Tak77).

At maternally toxic doses, administered during organogenesis, tellurium induced skeletal malformation and hydrocephalus in the offspring of rats (at doses of 18-20 mg/kg bw and higher), and delayed skeletal development and non-specific abnormalities in offspring of rabbits (at doses of 53 mg/kg bw and higher) (Joh88).

Due to lack of data, the committee cannot indicate a critical effect or a target organ for toxicity after inhalation exposure to tellurium.

Tellurium compounds

The tellurium compounds will be evaluated groupwise, according to their water solubility. Only one compound was found to be soluble (H_6TeO_6), 2 are insoluble (TeO_2, TeO_3), 6 were reactive ($TeBr_2$, $TeCl_2$, TeI_4, $TeBr_4$, $TeCl_4$, TeF_4), one was an unstable gas (H_2Te), and of the remaining compounds, the water solubility could not be found. Apparently, the valence state of tellurium was not decisive for the water solubility of the compound.

H_6TeO_6 (water soluble)

Of this compound only acute toxicity data from animals are available without reporting the signs of toxicity before death (Lew92).

TeO_2, TeO_3 (water insoluble)

No animal data have been found on the toxicity of TeO_3.

The investigators who studied the inhalation exposure to tellurium aerosol in rats, also studied inhalation exposure to TeO_2 in rats. At the same concentration range, 10-100 mg/m^3, the effects were the same as those after exposure to tellurium (San63). Due to lack of data, the committee cannot indicate a threshold for these effects.

Feeding of doses of TeO_2 of 19 mg/kg bw and higher (expressed as Te) to rats for 26 days induced symptoms similar to those after inhalation exposure: no growth, loss of hair, oedema of digits and temporary paralysis of the hind legs, and necrosis of liver and kidneys. In this study, haemolytic effects were not mentioned (DeM48). Subcutaneous injection during organogenesis of 12.8 mg/kg bw (expressed as Te) induced hydrocephalus and oedema in 100% of the offspring of rats, without maternal toxicity. A tenfold lower dose did not induce any reproductive effects (Per88b).

Due to lack of data, the committee cannot indicate a critical effect or a target organ for toxicity for the tellurium oxides.

$TeBr_2$, $TeCl_2$, TeI_4, $TeBr_4$, $TeCl_4$, TeF_4 (reactive)

Only one study is available, in which $TeCl_4$ is fed to weanling pigs at a concentration of 500 mg/kg feed (expressed as Te). No control group was included. Muscle necrosis and a decrease in blood GSH activity was found (Vle81). Since only one dose was used, the committee cannot indicate a threshold dose for these effects.

Due to lack of data, the committee cannot indicate a critical effect or a target organ for toxicity of reactive tellurium compounds.

H_2Te (unstable)

No data are available.

Te compounds with unknown water solubility

The acute toxicity of diethyltelluride was rather high after inhalation exposure. LC_{50} values were 54-55 mg/m^3 and 154 mg/m^3 for rats and mice, respectively (Koz81). Inhalation of 1 mg/m^3 for an unknown period of time induced a variety of effects like dermatitis, weight loss, haemolysis, and effects on internal organs (Koz81). Due to lack of data, the committee cannot indicate a threshold dose for these effects.

Although the committee questions the validity of the studies, no evidence for a carcinogenic activity of tellurium was found in long-term studies in which rats and mice were given tellurite or tellurate in the drinking water at low levels (2 ppm). Due to lack of data, the committee cannot indicate a critical effect or a target organ for toxicity of Te compounds with unknown water solubility.

Overall conclusion

Since occupational exposure concerns the inhalation route and the kinetics of tellurium compounds differ after intravenous injection from that after oral dosing, a study using the inhalation route should be taken as a starting point in the risk assessment. The longest exposure study is that by Sandratskaya (San63). The author studied the effects of inhalation exposure of Te or TeO_2 aerosol in rats during 13-15 weeks. However, the paper lacks details in study design and data presentation.

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

The committee concludes that there is insufficient information to comment on the present MAC level. The committee expects differences in valence state of the various tellurium compounds to play an important role in the toxic effects.

Tellurium can penetrate the skin (Nor68). However, since there are no quantitative data, the committee is unable to pronounce upon the assignment of a skin notation.

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Annex

Occupational exposure limits for tellurium and tellurium compounds in various countries.

country -organisation	occupational exposure limit[a]		time-weighted average	type of exposure limit	note[b]	reference[c]
	ppm	mg/m^3				
the Netherlands						
- Ministry of Social Affairs and Employment	-	0.1	8 h	administrative		SZW02
Germany						
- AGS	-	0.1[d]	8 h			TRG00
	-	0.4[d]	15 min			
- DFG MAK-Kommission	-	0.1[d]	8 h			DFG02
		0.2[d]	15 min[e]			
Great Britain						
- HSE	-	0.1[f]	8 h	OES		HSE02
Sweden	-	0.1[g]	8 h			Arb00b
Denmark	-	0.1	8 h			Arb00a
USA						
- ACGIH	-	0.1[f]	8 h	TLV		ACG02b
- OSHA	-	0.1	8 h	PEL		ACG02a
- NIOSH	-	0.1	10 h	REL		ACG02a
European Union						
- SCOEL	-	-				CEC00

[a] As tellurium.
[b] S = skin notation; which means that skin absorption may contribute considerably to the body burden; sens = substance can cause sensitisation.
[c] Reference to the most recent official publication of occupational exposure limits.
[d] Measured as the inhalable fraction of the aerosol.
[e] Maximum number per shift: 4, with a minimum interval between peaks of 1 hour.
[f] Except hydrogen telluride.
[g] Total dust.