CHROMIUM

Biological monitoring of chromium

Identity

Name (parent)	Chromium trioxide	Chromic (VI) acid
UN number	1463	1755
CAS number	1333-82-0	7738-94-5
Intervention value (AGW in mg/m^3)	no AGW	no AGW
Structure	CrO_3	CrH_2O_4

Occurrence

Chemical state (at 20°C)	Solid (crystals or powder)	Liquid
Physical appearances	Dark red, bi-pyramidal prismatic crystals, flakes or granular powder	Solution of chromium trioxide.
Industrial products	Chrome pigments, chromium plating, copper stripping, welding, corrosion inhibitor	Chromium plating

Physicochemical properties

Molecular weight	100.0	118.01
Vapor pressure (mbar at 20°C)	Negligible	Negligible
Octanol/water partition coefficient (log Po/w)	n/a	n/a
Water solubility (in g/100mL at 25 °C)	62	complete

Toxicokinetics (parent)

Uptake by inhalation	Water soluble Cr(VI) compounds enter the circulation after inhalation. The absorption efficiency depends on water solubility. Cr (VI) is reduced to Cr(III) by epithelium lining fluids [1].
Uptake by skin absorption	Water soluble Cr(VI) compounds are readily absorbed by the intact skin (see above) [2].
Uptake via gastrointestinal tract	Uptake depends on the oxidation state, the water solubility, chemical form and the gastrointestinal transit time. Approximately 10% of inorganic Cr(VI) is absorbed from the gut [1]; Cr(VI) is reduced to Cr(III) in the stomach [3].
Distribution	Cr is distributed throughout the body, mainly in the liver, kidney, spleen and lung tissue; Scarcely water soluble or insoluble Cr compounds have a retention time of months-years; Cr(VI) is contained inside erythrocytes after reduction to Cr (III); (cited by ACGIH [4]).
Metabolism	Reduction of Cr (VI) to Cr(III), by several enzymatic systems (e.g. NADPH-dependent P-450 reductase) and also non-enzymatically by hemoblobin, ascorbic acid, etc.
Excretion via lungs	n/a
Excretion via urine	Predominant excretion route: approximately 60% [1].
Excretion via feces	Bilary excretion: approximately 10% [1].

Toxicodynamics

Mechanisms of toxicity	Cr(VI) is a strong oxidizing agent, exposure can cause corrosion and irritation. Reactive intermediates are formed during the reduction of Cr(VI) to Cr(III) [5].
Classifications for carcinogenicity	Cr(VI): group 1 IARC (confirmed human carcinogen) [6].
Classifications for reprotoxicity	Cr(VI) is able to cross the placental barrier and is teratogenic in animals [1].
Classifications for sensitizing properties	Dermal contact can lead to allergic eczema [7]. Inhalation of chromium can lead to sensitization, inhalation can cause asthma [8].

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Biological monitoring

Biomarkers	**Chromium in urine**	**Chromium in erythrocytes**	**Chromium in plasma**
Molecular weight	52.0	52.0	52.0
Involved enzymatic metabolism	reduction of Cr (VI) to Cr(III)	reduction of Cr(VI) to Cr(III) by ferro-hemoglobin	reduction of Cr (VI) to Cr(III)
Biological material	urine	venous blood sample	venous blood sample
Type of sample	spot urine	venous blood sample	venous blood sample
Sampling strategy	< 48 h	Up to 4 weeks after exposure	< 48 h
Excretion pattern	- Triphasic: 7 h, 15-30 d and 3-5 y (based on studies in welders) [9, 10] - Biphasic: 36 d and 730 d (based on a welder accidentally exposed to welding fumes) [11]	- Linear elimination during lifespan of erythrocytes (120-126 days)	- Triphasic: 7 hours, 15-30 days and 3-5 years (based on studies in welders) [9, 10]
Materials	Acid-washed plastic bottles	Trace metal-free tubes; siliconized needles	Trace metal-free tubes; siliconized needles
Transportation	Within 24 hours at 4°C	Within 24 hours at 4°C	Within 24 hours at 4°C
Storage	24 hours at 4°C in the dark; for > 6 months at -20°C	4°C until fractioning; fractioning into plasma and erythrocytes within 24 hours after collection, after fraction keep at -20°C	4°C until fractioning; fractioning into plasma and erythrocytes within 24 hours after collection, after fraction keep at -20°C
Stability	for > 6 months at -20°C	for > 6 months at -20°C	for > 6 months at -20°C
Measurement principle	- Atomic absorption spectrometry (AAS) with Zeeman background correction [12] - High-resolution – Inductively coupled plasma-quadruple mass spectrometry (HR-ICP-MS) [13]	AAS with Zeeman background correction [12]	AAS with Zeeman background correction [12]
Limit of quantification	0.1 µg/ L (AAS) [12] 15 ng Cr / L urine (detection limit) (ICP-MS) [13]	0.15 µg/ L of plasma [12]	0.06 µg/ L of full blood [12]
Aliquot for 1 analysis	5 mL	5 mL	5 mL
Recommended adjustments	Adjustment for creatinine	Adjusted for hematocrit	Adjusted for hematocrit

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Preferred units for expression of results	µg Cr/ g creatinine		µg/ L		µg/ L
Conversion factor	1 µg/g = 2.18 µmol/mol creatinine		1 µg/L = 19.2 * 10^{-3} µmol/L		1 µg/L = 19.2 * 10^{-3} µmol/L
Biological exposure value US	- End of shift at end of workweek: 25 µg / L [4] - Increase of 10 µg /L during workshift [4]		-		-
Biological exposure value Germany [14]	CrO_3 in air (mg/m^3) 0.03 0.05 0.08 0.10	Chromium (µg/L) (sampling time: end of shift) 12 20 30 40	CrO_3 in air (mg/m^3) 0.03 0.05 0.08 0.10	Chromium (µg/L) (long-term exposure) 9 17 25 35	-
BIOMONECS background in non-smoking m/f adults (based P0.95) [15]	0.42 µg/g creatinine		-		-
Background value	0.2 – 2 µg/L [16]; cited from ACGIH [4]		< 7 µg / L [17]		-
Possible confounders	Occupational exposure (chromium plating, use of chromate-containg primers, metal work in particular stainless steel welding), patients with orthopedic or orthodontistic metal implants/prostheses and active smoking				

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