IFA
Institut für Arbeitsschutz der
Deutschen Gesetzlichen Unfallversicherung

Aluminium

IDENTIFICATION

Aluminium
E 173

ZVG No:	7130
CAS No:	7429-90-5
EC No:	231-072-3

CHARACTERISATION

SUBSTANCE GROUP CODE

134000 Metals

STATE OF AGGREGATION

The substance is solid.

PROPERTIES

Granules
silver-white

CHEMICAL CHARACTERISATION

Non-combustible substance.
Practically insoluble in water.

Substance information in Wikipedia

DUST EXPLOSIVENESS

No risk of dust explosion.
Quelle: *99999*

FORMULA

Al

Molar mass: 26,98 g/mol

PHYSICAL AND CHEMICAL PROPERTIES

Melting point | Boiling point |
Density

MELTING POINT

Melting point: 660 °C

Reference: 00131

BOILING POINT

Boiling Point: 2372 °C

Reference: 00131

DENSITY

DENSITY

Value: 2,70 g/cm³

Temperature: 20 °C

Reference: 00131

TOXICOLOGY / ECOTOXICOLOGY

ECOTOXICOLOGICAL DATA

LC50 Fish (96 hours)

Minimum:	0,12 mg/l
Maximum:	5,2 mg/l
Median:	1,55 mg/l
Study number:	10

Reference for median:

Li, X., and F. Zhang 1992. Toxic Effects of Low pH and Elevated Al Concentration on Early Life Stages of Several Species of Freshwater Fishes. Acta Sci.Circumstant.(Huanjing KexueXuebao) 12(1):97-104

Reference: 02072

OCCUPATIONAL HEALTH AND FIRST AID

Routes of exposure | Toxic effects |
First Aid

ROUTES OF EXPOSURE

Main routes of exposure

Intake of metallic aluminium (A) in compact form, in particular as block, film or chips, is irrelevant both in the occupational and non-occupational context.
Therefore, the following information specifically pertains to the exposure to dusts, vapours or fumes generated during the extraction, processing and the use of the metal. [99998]
The main route of exposure for metallic A dusts or aerosols/fumes is via the respiratory tract. [7619]
Non-occupational absorption must be considered for metallic A due to its use in cosmetics and as food additive. [10268, 10269]

Respiratory tract

Inhalative exposure to metallic A in the form of dusts or vapours/fumes may occur in the aluminium production and processing as well as during aluminium welding processes. [7639, 7619, 10265]
In air and in aqueous media and in the presence of oxygen metallic A generates a protective oxide layer consisting of aluminium oxide. [7639, 7619]
Depending on workplace hygiene conditions, quantities and particle sizes, inhaled dusts of metallic A or superficially oxidised A particles in fumes are first deposited in the lungs. [7619, 7639, 7620]
It is assumed that very fine particles, which are particularly present in fumes, penetrate the lungs up to the lower lung areas and are preferably absorbed directly into the lungs. [10264, 8093, 610, 630]
Moreover, it must be assumed that particles removed from the respiratory tract via mucociliary clearance mechanisms are transferred to the digestive tract and absorbed to a small extent. (see also “digestive tract”). [10265, 7748, 630] In case of larger particles, the major part is subject to mucociliary lung clearance (confirmed after exposure to aluminium oxide particles). [7619]
In test subjects who had inhaled particles of radioactively labelled aluminium oxide with a mean diameter of 1.2 µm, the 26Al excretion in urine measured over 900 days showed that 1.9% of the dust deposited in the lungs was absorbed. [10202, 7619] The absorbed portion for individuals exposed to the inhalation in the aluminium industry ranged in the same order of magnitude (1.5–2%). [7619, 10264, 7620, 10265, 8093, 630]

Skin

Percutaneous absorption of metallic A in the occupational context is considered hardly significant. [7619]

Gastrointestinal tract

A particles removed from the respiratory tract via mucociliary clearance mechanisms or directly swallowed, are partially dissolved in the acidic environment of the stomach and transformed to the ionised condition. However, the subsequent pH-dependent conversions to partly insoluble compounds in the intestines mean that absorption in the small intestine remains low. [630, 10264, 8093]
In the case of metallic A or poorly soluble aluminium compounds, the absorbed proportion is usually about 0.1–0.3%. [8011, 630, 8093, 10265, 10267] A variety of factors can influence absorption from the digestive tract: amount absorbed, pH value, iron/calcium status, chelating food components (absorption e.g. increased by citrate, decreased by phosphate). [10265, 10267, 10268, 8011, 630]

TOXIC EFFECTS

Main toxic effects

Acute effects:
information on systemic effects in healthy exposed individuals is not available [8057]
Chronic effects:
no risk through compact aluminium [99999]
after exposure to dusts or fumes of the substance: Particle deposition in the lung tissue (aluminosis) after inhalation of very high concentrations [7619, 7639]; impairment of the central nervous system (CNS) [7620]

Acute toxicity

In air, metallic A reacts with oxygen to form an inert, insoluble oxide layer, which usually prevents direct contact of the metal even with biologically reactive structures. [8093, 7619]
The acute potential of the metallic or superficially oxidised A dust is chiefly determined by particle-related effects and less by systemic ones after intake of aluminium ions, which are more relevant for soluble aluminium compounds. Additional exposures to soluble, poorly soluble and insoluble aluminium compounds may occur in some work processes (e.g. welding and processing of metallic A). [10266, 7620]
The local irritant effect of metallic A was not investigated. [99998]
According to experiences gained from the handling of metallic A, e.g. in the form of various articles or materials of daily use, compact metallic A causes no chemically induced eye or skin irritation. However, metal dust must be expected to cause mechanical irritation to the eye. [7619, 99999]
The healing tendency is poor after penetration or injury of the skin by metallic A splinters. [8101]
Studies on the skin-sensitising potential of metallic A are not available. [99998]
Regarding the widespread use and exposure, a contact-sensitising potential of aluminium compounds is reported only in isolated cases, and partly without clinical relevance. [7619]
Apart from accident-related injuries (e.g. explosion of metallic A dusts), there are no indications that single occupational exposure leads to health impairments. Diseases corresponding to metal fume fever were not observed in welders at concentrations of up to 15 mg/m³. [7619, 7639]
In male rats, single 4-hour inhalative exposure to aluminium flake dust concentrations of 10, 50, 100, 200 or 1000 mg/m³ caused first signs of inflammation from 50 mg/m³ (increased number of neutrophils in the bronchoalveolar lavage) and multifocal microgranulomas in the lungs and the hilus lymph nodes from 200 mg/m³, as well as an inflammatory reaction that lasted up to six months. [7748, 7520, 8093]
There are no reports from the general population on acute effects after oral intake of food containing metallic A as a food additive (in decorative coatings of sweets or bakery products). [99999]
Overall, the acute toxicity of metallic A is rated as low. [7639, 10265, 10267]

Chronic toxicity

With regard to repeated exposures of the skin it was reported that frequent contact with wet machine components made of A had led to numbness of the fingertips (acroanaesthesia) of workers at facilities that were involved in the production of cotton. [2110]
Workers complained about allergic lung diseases (including asthmatic complaints, “potroom asthma”, increased bronchial hyperreactivity) after long-term massive inhalative exposure to A or aluminium oxide (details were not provided) in melting plants, foundries or during welding; however, there are no substantiated indications that metallic A produces sensitising effects on the respiratory tract. [7619, 7639, 7620, 7748]
Due to the poor solubility of the particles, repeated inhalative exposure to A metal dust may cause an accumulation in the lungs. As a result, the self-cleaning mechanism of the lungs (clearance) may be impaired, inflammatory reactions may occur and fibrotisation may be triggered. For example, in a metal polisher working with workpieces containing A, high concentrations of A and aluminium oxide (further details were not provided) were detected in bronchioalveolar lavage, lung tissue and lymph nodes and pulmonary fibrosis within five years after the end of exposure. [7619]
Long-term exposure to dust containing A from the aluminium powder production in concentrations above 6 mg/m³ (exposure confirmed by simultaneously increased Al concentration in the urine: › 200 µg/l) can cause lung fibrosis or aluminosis in workers. Aluminosis is characterised by a diffuse interstitial lung fibrosis, which is mostly located in the upper and mid lung fields. The first effects to occur are unspecific symptoms such as dry cough, sputum, stress and resting dyspnoea and also frequent recurrent bronchitis and an increased susceptibility to infections. Subpleural emphysema bubbles and an increased risk of spontaneous lung collapse (pneumothorax) may occur as the disease progresses. The time to onset of first symptoms is subject to strong variations (months to decades). [7619, 7639] The literature provides only insufficient exposure data; a dose-response relationship for the occurrence of aluminosis can thus not be derived. However, some risk factors could be identified (including work on stamping machines with ungreased or lightly greased, stamped A powder, depending on the level of cumulative exposure, the type of exposure and individual factors). [7619]
Other case reports and epidemiological studies report fibrotic lung diseases and obstructive respiratory diseases in workers who had been exposed to grinding dusts or welding fumes containing A, or to fumes and dusts generated during production or processing of aluminium. Due to mixed exposures, e.g. to fluorides, ozone or ultrafine A particles, differentiation between these effects and those induced by A metal dust, and thus a final assessment, is not possible. [7619]
Reliable data on the effects of repeated inhalative exposure particularly to ultrafine metallic A particles as those found during welding or in aluminium plants are not available, as there is often mixed exposure, e.g. to quartz and ozone. [7619, 10264, 99998]
Numerous epidemiological studies on workers from the aluminium (powder) production and on welders processing work pieces from A provide no consistent picture. However, the overall data situation indicates that many years of inhalative exposure to A are accompanied by frequent incidence of neurological changes. [7748] These changes are early signs of potential structural or functional damage to the central nervous system. The onset of such pre-clinical neurotoxic effects has been shown to be the most sensitive endpoint for the toxicological assessment of chronic aluminium exposure at workplaces. [7620]
In these studies, aluminium elimination with the urine was found to be a suitable parameter for internal exposure. For instance, in the majority of the repeatedly conducted neuropsychological tests, welders who had been exposed to A showed worse cognitive performance (including attention, learning and memory) compared to controls at a median A concentration of approx. 100 ? g/g creatinine in the post-shift urine in the 5-year period under consideration. [7620] The analysis of several of these neuropsychological tests yielded an NOAEL of 50 µg Al/g creatinine for cognitive deficits. [7619] A connection between occupational exposure to A and the occurrence of Alzheimer's disease and Alzheimer type dementia or amyotrophic lateral sclerosis could not be definitely proven. [7619, 7620]
Due to the minor absorption, repeated oral intake of metallic A is assumed to involve low toxicity, however, substance-specific data are not available. [99998, 99999]

Reproductive toxicity, mutagenicity, carcinogenicity

For classifying the reproductive toxicity and mutagenic and carcinogenic potential see list in Annex VI of the CLP regulation / TRGS 905 / List of MAK values (see section REGULATIONS).

Reproductive toxicity:
The available information was considered to be insufficient for evaluation and hence for classification.
[7619]
Substance-specific studies with metallic A are not available. [99998]
In developmental toxicity studies performed with poorly soluble aluminium hydroxide on test animals, exposure of pregnant rats and mice entailed no developmental-toxic or maternal-toxic effects up to the highest administered dose (NOAEL, rats: 266 mg Al per kg of body weight per day; mice: 100 mg Al per kg of body weight per day). [7619]
In general, absorbed aluminium can pass the placenta, reach the foetus and enter the breastmilk. However, due to its poor bioavailability, exposure to metallic A provides no relevant contribution in this regard. [610, 10264, 10202]

Mutagenicity:
substance-specific information on metallic A is not available. [99998]
In vitro, the poorly soluble aluminium oxide in the form of nanoparticles caused no mutagenic effects in bacteria. [7520]
The poorly soluble aluminium hydroxide showed no genotoxic potential in an in-vitro gene mutation study with mammalian cells. [7520]
The result of an in-vivo study with aluminium hydroxide on rats (micronucleus test, doses up to 2000 mg per kg of body weight per day) was negative. [7520]
In-vivo studies (micronucleus test, chromosomal aberration test, Comet assay) with A in the form of fine particles (µm range) or of nanoparticles (particle size: 30 nm or 40 nm) showed a positive result in all tests performed with the nanoparticles and a negative result in all tests conducted with fine particles. [7520]
Available data are insufficient and do not permit a final assessment. [99998]

Carcinogenicity:
substance-specific information on metallic A is not available. [99998]
Increased incidences of bladder cancer and, to a smaller extent, also of lung cancer in workers involved in the aluminium production was ascribed to the simultaneous exposure to polycyclic aromatic hydrocarbons (PAK). [7980, 7619]

Biotransformation and excretion

Aluminium ions absorbed after exposure to A are evenly distributed between plasma and cellular blood components. [7619] Non-essential aluminium always occurs in the human body in ionic form (oxidation state +3). [7942, 99999] In plasma, more than 90% of the aluminium is bound to transferrin, a smaller part (about 8%) is bound to citrate, and less than 1% is bound to phosphate in the form of aluminium complexes. [10264, 7619]
The concentration of bound or complexed aluminium ions in the plasma usually ranges between 1 and 3 µg/l, although values may vary widely (95th percentile in serum, plasma or whole blood in the range of 2.4 to 33.3 µg/l). [10268, 7619]
Aluminium is distributed in almost all organs of the human organism and accumulates in the bones, from which it is only slowly eliminated (half-life of several years). The total aluminium content in the organism of healthy individuals is about 30–50 mg per kg of body weight, of which at least half is found in the bones and a quarter in the lungs. [10202, 8093] The aluminium content in the organism increases with advancing age. Aluminium can pass the blood-brain barrier and accumulate in the brain because of the strong protein binding. [7620]
Elimination of absorbed aluminium primarily (› 95%) occurs with the urine via the kidneys, only a small proportion is excreted via the gall bladder. Elimination is retarded in individuals with reduced kidney function. [10268, 10264]
Depending on exposure situation and duration, the biological half-life of renal aluminium elimination after inhalation ranges from a few hours to several weeks and years. In addition to considerable individual differences, aluminium storage in different compartments of the organism with their different elimination behaviour may play a key role. [7619]
The elimination of metallic aluminium with the urine can be used to determine occupational exposure to metallic A and aluminium compounds. The background exposure of individuals who are not exposed to aluminium at their workplaces should also be considered (95th percentile in the range of 7.5 to 21.4 µg/g creatinine for individuals of working age). [7620]

Annotation

This occupational health information was compiled on 30.03.2020.
It will be updated if necssary.
This information was translated from German into English by Übersetzungsbüro Branco.

FIRST AID

Eyes

Rinse the affected eye with widely spread lids for 10 minutes under running water whilst protecting the unimpaired eye.
Arrange medical treatment.
[99999]

Skin

Cleanse the affected skin areas thoroughly with soap under running water.
[99999]

Respiratory tract

Whilst protecting yourself remove the casualty from the hazardous area and take him to the fresh air.
In the case of breathing difficulties have the casualty inhale oxygen.
Arrange medical treatment.
[99999]

Swallowing

Rinse the mouth and spit the fluids out.
If the casualty is conscious have him drink 1 glass of water (ca 200 ml).
Arrange medical treatment.
[99999]

Information for physicians

- Symptoms of acute toxicity:
Eyes: mechanical irritation [99999]
Skin: usually no skin irritation [10366]
Inhalation of dusts: possible effects are mucosal irritation, coughing, dyspnoea [99999]
Ingestion: metallic taste, mucosal irritation cannot be completely ruled out [99999]
Absorption: systemic effects must not be expected [10366, 99999]

- Notes on first aid:
Following eye contact: after completed rinsing of the eyes, the casualty must present to an ophthalmologist [99999]
Following skin contact: medical measures are usually unnecessary after rinsing with soap and water. [99999]
Following inhalation: symptoms require the administration of a short-acting ß-2 sympathomimetic spray and the inhalation of a muscarinic receptor antagonist, such as ipratropium bromide [10014]
Following ingestion: Symptomatic treatment as required [99999]

Recommendations

Provide the physician information about the substance/product and treatment already administered.

Annotation

This first aid information was compiled on 17.01.2021.
It will be updated if necessary.
This information was translated from German into English by Übersetzungsbüro Branco.

SAFE HANDLING

Handling | Storage | Fire and explosion protection | Personal protection | Disposal considerations | Accidental release measures | Fire fighting measures

TECHNICAL MEASURES - HANDLING

Workplace

Select ventilation measures according to the other used substances.
If there is a chance that dusts may be released, then the work room must provide adequate ventilation.
Washing facility at the workplace required.

Equipment

Containers are to be marked clearly.

Advice on safer handling

Do not leave container open.
Sufficient ventilation must be guaranteed for refilling, transfer, or open use.
Fill only into clearly marked containers.
Avoid rising dust.

TECHNICAL MEASURES - STORAGE

Storage

Do not use any food containers - risk of mistake.
Containers have to be marked clearly and permanently.
Keep container tightly closed.

Conditions of collocated storage

Storage class 10 - 13 (Other liquids and solids)
Only substances of the same storage class should be stored together.
Collocated storage with the following substances is prohibited:
- Pharmaceuticals, foods, and animal feeds including additives.
- Infectious, radioactive und explosive substances.
- Strongly oxidizing substances of storage class 5.1A.

Under certain conditions the collocated storage with the following sub-stances is permitted (For more details see TRGS 510):
- Gases.
- Flammable liquids of storage class 3.
- Other explosive substances of storage class 4.1A.
- Pyrophoric substances.
- Substances liberating flammable gases in contact with water.
- Oxidizing substances of storage class 5.1B.
- Ammonium nitrate and preparations containing ammonium nitrate.
- Organic peroxides and self reactive substances.
- Combustible and non combustible acutely toxic substances of stora-ge classes 6.1A and 6.1B.

The substance should not be stored with substances with which hazardous chemical reactions are possible.

TECHNICAL MEASURES - FIRE AND EXPLOSION PROTECTION

Technical, constructive measures

Substance is non-combustible. Select fire and explosion prevention measures according to the other used substances.

PERSONAL PROTECTION

Body protection

Wear an apron or a lab coat.

Respiratory protection

Respiratory protection is not usually required.

Eye protection

Wear glasses with side protection.

Hand protection
Select hand protection according to the other used substances.

Occupational hygiene
Take heed of usual occupational hygiene measures when handling chemical substances, espacially wash the skin with soap and water before breaks and at the end of work and apply fatty skin-care products after washing.

DISPOSAL CONSIDERATIONS

Non-hazardous waste according to Waste Catalogue Ordinance (AVV).
If there is no way of recycling it must be disposed of in compliance with the respective national and local regulations.
Residues should be recycled.
Collect in container for recyclable metal residues. All metals should be collected separately.
Collection vessels must be clearly labelled with a systematic description of their contents. Store the vessels in a well-ventilated location. Entrust them to the appropriate authorities for disposal.

ACCIDENTAL RELEASE MEASURES

Wear a dust mask.
Pick up without creating dust.
Afterwards ventilate area and wash spill site.

Endangerment of watert:
No hazards to sources of water are to be feared if released into water, drainage, sewer, or the ground.

FIRE FIGHTING MEASURES

Instructions
Substance is incombustible. Select fire fighting measures according to the surrounding conditions.

REGULATIONS

GHS Classification/Labelling | Water hazard class | Air quality control | Transport Regulations | MAK recommendations | Biological exposure indeces | Technical rules | Regulations of accident insurers

EUROPEAN GHS CLASSIFICATION AND LABELLING

Not a dangerous substance according to GHS.
Manufacturer's specification by Merck

Reference: 01211
State: 2021
Checked: 2022

GERMAN WATER HAZARD CLASS

Substance No: 1443
non-hazardous to waters

Metals, provided they are solid with a particle size ›= 1mm, that don’t react with water or atmospheric oxygen, unless an hazardous substance legal classification is necessary or a WGK-classification (German water hazard class) was released by the Federal Environment Agency (Umweltbundesamt).
Classification according to the announcement of the list of substances hazardous to water in the Federal Register of 10.08.2017, last update 24.11.2023

TECHNICAL INSTRUCTIONS ON AIR QUALITY CONTROL (TA LUFT)

Chapter 5.2.1 Overall Dust, including fine dust
The emissions of dust in the exhaust gas are not allowed to exceed the following values:

Mass flow: 0,20 kg/hr

or

Mass conc.: 20 mg/m³

The mass per unit volume of 0,15 g/m3 in exhaust gas is not allowed to be exceeded also on observance or lower deviation of a mass flow of 0,20 kg/h.

TRANSPORT REGULATIONS

Not subject to transport regulations.

Reference: 01211

RECOMMENDATIONS OF MAK-COMMISSION

This data is recommended by scientific experience and is not established law.

1,5 mg/m³
with reference to the respirable fraction

4 mg/m³
with reference to the inhalable fraction

Pregnancy: Group D
Either there are no data for an assesment of damage to the embryo or foetus or the currently available data are not sufficient for classification in one of the groups A-C.

GERMAN BIOLOGICAL EXPOSURE INDICES

Parameter:	Aluminium
Value:	50 µg/g
Remark:	creatinine
Assay material:	Urine
Sampling time:	for long-term exposure: at end of shift after several shifts

Reference: 05347

TECHNICAL RULES FOR HAZARDOUS SUBSTANCES

TRGS 500
Schutzmaßnahmen; Ausgabe September 2019

TRGS 509
Lagern von flüssigen und festen Gefahrstoffen in ortsfesten Behältern sowie Füll- und Entleerstellen für ortsbewegliche Behälter; Ausgabe Juni 2022

TRGS 510
Lagerung von Gefahrstoffen in ortsbeweglichen Behältern; Ausgabe Januar Dezember 2020

REGULATIONS OF GERMAN ACCIDENT INSURERS

DGUV Vorschrift 58 (BGV D13): Herstellen und Bearbeiten von Aluminiumpulver

DGUV Vorschrift 59 (BGV D14): Wärmebehandlung von Aluminium oder Aluminiumknetlegierungen in Salpeterbädern

DGUV Regel 109-001 (BGR 109): Schleifen, Bürsten und Polieren von Aluminium

LINKS

International Limit Values
The MAK Collection for Occupational Health and Safety

REFERENCES

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IFA: Erfassungs- und Pflegehandbuch der GESTIS-Stoffdatenbank (nicht öffentlich)
Data acquisition and maintenance manual of the GESTIS substance database (non-public)

Quelle: 00131
The Merck-Index; 14th Edition 2006

Quelle: 00610
Health Council of the Netherlands: Committee on Updating of Occupational Exposure Limits.
Loseblatt-Ausgabe/ Online

Quelle: 00630
US Department of health and human services, Public health services,
Agency for Toxic Substances and Diseases Registry (ATSDR),
Toxicological Profiles
https://www.atsdr.cdc.gov/toxprofiledocs/index.html

Quelle: 01211
GHS-Sicherheitsdatenblatt, Merck
GHS Material Safety Data Sheet, Merck

Quelle: 02072
Ecotoxicological Data, compiled by the US Environmental Protection Agency (EPA), selected and distributed by Technical Database Services (TDS), New York, 2009

Quelle: 02110
National Center for Biotechnology Information:
PubChem
https://pubchem.ncbi.nlm.nih.gov/

Quelle: 05300
TRGS 510 "Lagerung von Gefahrstoffen in ortsbeweglichen Behältern" Ausgabe Dezember 2020

Quelle: 05347
TRGS 903 "Biologische Grenzwerte (BGW)" Ausgabe Februar 2013; zuletzt geändert Juni 2023

Quelle: 07520
Europäische Chemikalienagentur ECHA: Informationen über registrierte Substanzen
European Chemicals Agency ECHA: Information on registered substances

Quelle: 07580
Bekanntmachung der Liste der wassergefährdenden Stoffe im Bundesanzeiger vom 10.08.2017, zuletzt geändert 24.11.2023

Quelle: 07619
DFG Deutsche Forschungsgemeinschaft: The MAK-Collection for Occupational Health and Safety, nach Veröffentlichungsdatum zu finden unter:
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ab 2002 Online: http://onlinelibrary.wiley.com/book/10.1002/3527600418/topics?filter=#
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https://series.publisso.de/en/pgseries/overview/mak/dam/allContents/alphabetical

Quelle: 07620
DFG: Arbeitsmedizinisch-toxikologische Begründungen von BAT-Werten; Verlag Chemie

Quelle: 07639
J. Konietzko, H. Dupuis (Hrsg.) "Handbuch der Arbeitsmedizin, Arbeitsphysiologie, Arbeitspathologie, Prävention" Loseblattausgabe, ecomed-Verlagsgesellschaft mbH, Landsberg ab 1989

Quelle: 07748
American Conference of Governmental Industrial Hygienists "Documentation of the threshold limit values and biological exposure indices Loseblattsammlung mit Ergänzungslieferungen

Quelle: 07942
Holleman A.F., Wiberg E. "Lehrbuch der Anorganischen Chemie" 101. Auflage, Walter de Gruyter & Co., Berlin 1995

Quelle: 07980
IARC - International Agency for research on cancer: Monographs on the evaluation of carcinogenic risks to humans WHO, Lyon; Serie

Quelle: 08011
M.J. Ellenhorn: Ellenhorn's Medical Toxicology, Diagnosis and Treatment of Human Poisoning; Williams & Wilkins, Baltimore Maryland 1997

Quelle: 08057
H. Marquardt, S. Schäfer (Herausgeber) "Lehrbuch der Toxikologie" 2. Auflage, Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart 2004

Quelle: 08093
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Akute Vergiftungen und Arzneimittelüberdosierungen,
11. Auflage,
Wissenschaftliche Verlagsgesellschaft Stuttgart, 2015

Quelle: 08112
DFG Deutsche Forschungsgemeinschaft: MAK- und BAT-Werte-Liste 2023, Senatskommission zur Prüfung gesundheitsschädlicher Arbeitsstoffe, Mitteilung 59; GMS PUBLISSO

Quelle: 10014
Walker et al.
Diagnosis and management of inhalation injury: an updated review.
Critical Care (2015) 19:351

Quelle: 10202
G.F. Nordberg, B.A. Fowler, M. Nordberg: Handbook on the toxicology of metals. 4rd edt. Elsevier, Amsterdam 2015

Quelle: 10264
D. Krewski, R.A. Yokel, E. Nieboer, et al.: Human health risk assessment for aluminium, aluminium oxide, and aluminium hydroxide. J. Toxicol. Environ. Health. B. Crit. Rev., 2007, 10, Suppl. 1, 1-269

Quelle: 10265
Bundesinstitut für Risikobewertung: Reduzierung der Aluminiumaufnahme kann mögliche Gesundheitsrisiken minimieren. Stellungnahme Nr. 045/2019 des BfR vom 18. November 2019. DOI

10.17590/20191115-135258

Quelle: 10266
C.C. Willhite, N.A. Karyakina, R.A. Yokel, et al.: Systematic review of potential health risks posed by pharmaceutical, occupational and consumer exposures to metallic and nanoscale aluminum, aluminum oxides, aluminum hydroxide and its soluble salts. Critical Reviews in Toxicology, 2014, 44, Suppl. 4, 1-80

Quelle: 10267
K. Klotz, W. Weistenhöfer, F. Neff, A. Hartwig, C. van Thriel, H. Drexler: Gesundheitliche Auswirkungen einer Aluminiumexposition. Deutsches Ärzteblatt, 2017, 114(39), 653-659

Quelle: 10268
EFSA, European Food Safety Authority: Safety of aluminium from dietary intake. Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids and Food Contact Materials (AFC). Adopted on 22 May 2008. The EFSA Journal, 2008, 754, 1-34

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EU, European Union: REGULATION (EC) No 1223/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 November 2009 on cosmetic products. Official Journal of the European Union. http://eur-lex.europa.eu, 2009, L 342, 59-209

Quelle: 10366
D. Krewski u.a.: Human health risk assessment for aluminium, aluminium oxide, and aluminium hydroxide. J Toxicol Environ Health B Crit Rev 2007;10 (Suppl 1):1-269.

Quelle: 99998
Liste arbeitsmedizinisch-toxikologischer Standardwerke (3)

Quelle: 99999
Angabe des Bearbeiters
Indication of the editor

Identification | Characterisation | Formula | Physical and chemical properties | Toxicology / Ecotoxikology | Occupational health and first aid | Safe handling | Regulations | Links | Literature register

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