



## Aluminum

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Aluminum is an abundant metal, comprising about 85% of the earth's crust. Aluminum is a nonessential element in humans. Pure aluminum is a light, ductile metal and is a good conductor of both heat and electricity. When aluminum is exposed to air, a thin film of oxide forms on the surface, creating a protective coating resistant to corrosion. Aluminum occurs in nature as inorganic compounds. Aluminum oxide ( $Al_2O_3$ ) is the raw material used in industrial production of the metal. Aluminum is produced from bauxite, a mineral containing aluminum oxide, ferrous oxide, and silica. By a chemical process, bauxite is refined to aluminum oxide. Pure aluminum is then produced by using an electro-thermal process [1]. The two main methods used for aluminum production are Söderberg and prebake.

Aluminum production and use generally depend on three main steps:

- refining of bauxite to yield alumina;
- electrolytic reduction of alumina to yield aluminum;
- aluminum casting into ingots for subsequent manufacturing uses.

## Usage and exposure

### Aluminum metal

The light weight and ease of processing of aluminum have led to widespread applications in auto bodies, aircraft, tanks, military equipment. It is also used for

cans, containers, pots and pans, wrapping. Powdered aluminum metal is often used in explosives and fireworks. Aluminum siding is used in construction.

### **Aluminum compounds**

Aluminum compounds are used in many diverse and important industrial applications such as alums (aluminum sulfate) in water- treatment and alumina in abrasives and furnace linings. Aluminum oxide is used as a filler in ceramic materials. Aluminum compounds are used in pigments, paints, catalysts. Aluminum hydroxide is used as an antacid and aluminum chloride in antiperspirants [2].

Exposure to aluminum occurs during welding of aluminum metal .In the aluminum reduction industry, workers may be exposed to aluminum fumes Aluminum-containing welding fumes consist of particles smaller than 1 micron [3, Zenz].

**Routes of exposure:** inhalation, ingestion

**Target organs:** lungs

### **Metabolism**

Inhaled aluminum is absorbed, but the degree of absorption is not known.

Absorption via the gastrointestinal tract is minimal and is influenced by several factors. Dietary citrate enhances the absorption.

The total body burden of aluminum has been estimated to be around 30 mg in subjects without excessive exposure to aluminum and with a normal renal function. The concentration of aluminum in the lungs increases with age in non-occupationally exposed subjects. The urine is the major excretion route, but the metal is also excreted via the bile. The biological half-life is variable (days to months) and is dependent on the source and duration of exposure.

## Health hazards

There is little or no evidence to suggest that aluminum exposure by any route (inhalation, dermal, or gastrointestinal) is associated with significant acute toxicity.

Aluminum oxide and aluminum dusts can cause drying and irritation of the eyes, nose and throat. Nosebleeds may occur if exposures are excessive [LaDou]. Exposure to aluminum can cause metal fume fever [ATSDR].

Aluminum can cause irritation of skin.

The risk from chronic aluminum exposure is the development of aluminosis, a progressive pneumoconiosis characterized by upper lung predominance, peripheral emphysema, and frequent pneumothoraces. The intensity of fibrosis is correlated to duration of exposure and pulmonary levels of aluminum [4]. The largest number of reported cases of diffuse interstitial lung disease is attributed to aluminum powder exposure, although similar cases also have been reported in the aluminum production industry.

Asthma, chronic pulmonary disease and skin lesions occur in pot-room workers. Fluorosis has occurred in workers in the aluminum production industry.

Pot-room asthma is characterized by both immediate and late asthmatic response associated with work in aluminum production. The specific causal agent remains unidentified. The pathogenesis is considered to be bronchial hyper-reactivity induced probably by strong respiratory irritants in the pot-room environment [5].

Respiratory disease such as pot-room asthma, have been the main focus of over 50 epidemiological studies since the 1960s. The mechanism is not clear, but may involve a mix of irritancy and sensitization and asthma can continue after a worker is removed from exposure. It has also been reported that workers in aluminum pot-rooms are at increased risk of mortality from chronic obstructive lung disease [6].

A study of pot-room asthma was conducted in Norway. Pot-room workers are exposed to a complex mixture of particulates and gases. The respirable particles of the pot fume emissions are mainly composed of aluminum oxide, carbon dust, and cryolit (a fluorinated compound of sodium and aluminum), to which gases such as hydrogen fluoride and sulphur dioxide are absorbed. As the concentrations of several pollutants are correlated to each other, it has been difficult to identify the causal agent of pot-room asthma, although a number of authors have suggested fluoride compounds to be the major candidate. This study reveals the presence of airway inflammation in subjects with pot-room asthma, shown by significantly increased density of lamina propria CD4 leucocytes and eosinophils, significantly increased numbers of intraepithelial mast cells, thickening of RBM (reticular basement membrane), and increased exhaled NO in asthmatic non-smokers. In addition, a subclinical inflammation, shown by significantly increased lamina propria eosinophils and RBM thickening, was observed in healthy pot-room workers when compared to non-exposed controls [7].

Increased respiratory symptoms, airway obstruction, and asthma may also occur in more heavily exposed workers and welders.

An overview of cases of occupational asthma in Norway presented that the highest incidence of notifications of occupational asthma was found in the primary aluminum industry and in bakers, car painters, and welders [8].

Riihimäki et al. studied relationship between elevated internal aluminum loads and central nervous system function. It was found that both objective neurophysiological and neuropsychological measures and subjective symptomatology indicated mild but unequivocal findings dose-dependently associated with increased aluminum body burden. The study indicates that the

body burden threshold for adverse effect approximates a urine-Al value of 4-6 mmol/l and a serum-Al value of 0.25-0.35 mmol/l among aluminum welders [Riihimäki].

The association between aluminum accumulation in the brain and the development of Alzheimer's disease and other neurological disorders remains controversial. While dose-dependent neurotoxicity has been demonstrated after oral intake of aluminum hydroxide, the relationships are less clear in occupational and environmental exposure settings [LaDou].

### **Carcinogenicity**

In three studies in the aluminum-producing area, an increased risk of bladder cancer was associated with work in aluminum production in plants where primarily the Söderberg process was used.

An excess of lymphosarcoma/reticulosarcoma was noted in two cohort studies which covered partially the same population. Statistically significant excess risks of pancreatic cancer and leukaemia were noted as isolated findings in two studies. The available epidemiological studies provide *limited evidence* that certain exposures in the aluminum production industry are carcinogenic to humans, giving rise to cancer of the lung and bladder.

A possible causative agent is pitch fume. There is *inadequate evidence* that occupational exposures in the aluminum production industry result in haematolymphopoietic and pancreatic cancer.

The available evidence indicates that certain exposures in the aluminum production industry are probably carcinogenic to humans [9].

The cancer hazards associated with exposures in aluminum production were evaluated in IARC Monograph volume 100F. The cohort studies strongly support an association between work in aluminum smelters and bladder-cancer risk. There

is an increased risk for cancer of the bladder from occupational exposure in aluminum smelters.

An excess of lung cancer in aluminum–production workers has been reported also the data were less consistent than for bladder cancer.

Based on both experimental and human studies there is weak-to-moderate evidence for a genotoxic mechanism underlying the effects of occupational exposures during aluminum production.

Occupational exposures during aluminum production are carcinogenic to humans (Group1) [10].

## References

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