Iron oxide

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Iron (Fe) is an abundant metal, constituting about 5% of the earth's crust. Iron is second in abundance amongst the metals and is fourth amongst the elements, surpassed only by oxygen, silicon and aluminum.

The most common iron ores are:

Hematite, or red iron ore - Fe_2O_3, which is 70% iron;

Limonite, or brown iron ore, containing 42% iron - most of limonite is made up of Goethite ($Fe_2O_3.H_2O$);

Magnetite, or magnetic iron_ore Fe_3O_4 which has a high iron_content; Siderite, or spathic iron ore - $FeCO_3$;

Pyrite FeS_2, the most common sulphide mineral;

Pyrrhotite, or magnetic pyrite (FeS).

The most important of the oxides are magnetite, hematite and goethite.

Most ores mined may contain between 10% and 12% free silica [1,2].

Usage and sources of exposure

Dust or fumes of metallic iron and iron oxide may be encountered in the following processes:

- Iron and steel rolling;
- Steel grinding;
- Electric arc and oxyacetylene welding;
- Polishing of silver and steel with iron oxide powder;

- Polishing of glass, stone and cutlery;
- Fettling, chipping and dressing castings in iron foundries;
- Boiler scaling;
- Mining and crushing iron ores;
- Mining, milling and mixing emery and its use as an abrasive;
- Mining, pulverizing and mixing natural mineral pigments;
- Magnetic tape industry.

Some workers exposed to metallic iron dust or iron oxide fumes (such as welders, iron foundry men, boiler scalers and miners and millers of iron ores) may also have had significant exposure to other dusts such as quartz, cristobalite or asbestos [3].

Routes of exposure: inhalation, oral.

Target organs: lungs.

Health effects

Iron is an essential metal and takes part in oxygen transport and utilization. Under normal conditions, about 15% to 55% of iron in food is absorbed. Normally the human body contains about 3 to 5g of iron. Two thirds of the amount is bound to hemoglobin in the blood. About 20% to 30% iron in the body is stored in storage proteins (ferritin and hemosiderin).

Acute effects

The primary acute effect of this exposure is irritation of nose, throat, and lungs.

The exposure to the iron fumes can cause metal fumes fever that is more typical for zinc exposure. The symptoms resemble an attack of influenza [Parkes].

Chronic effects

It is not known to what extent inhaled iron is taken up from the lungs, but it has been shown that iron-containing particles are retained and accumulated in the lungs as a result of long-term inhalation exposure [Zenz].

Inhalation of iron, mainly in the form of iron oxide fumes, can give rise to iron pneumoconiosis. Workers may also have exposure to other dusts (quartz, cristobalite, asbestos), so that siderosis may be complicated by the presence of mixed dust fibrosis. Apart from the production of reddish-colored sputum there are no symptoms or abnormal physical signs caused by siderosis, and if any are present they are due to some other cause. There is no impairment of lung function [Parkes]. Siderosis is caused by the accumulation of iron oxide in macrophages within the lung.

When the iron inhaled is admixed with a substantial quantity of silica, the result is silicosiderosis, which may be associated with pulmonary fibrosis.

Typical radiographic findings include small nodules, which are most prominent in the middle third of the lungs, in perihilar regions. The nodules do not indicate reactive fibrosis but, rather, radiopaque accumulations of iron particles in macrophages aggregated along perivascular and peribronchial lymphatic vessels. The pathologic changes are reversible, and complete resolution is possible after the cessation of exposure.

CT scans showed small ill-defined centrilobular nodules (71% of subjects) with or without fine branching structures indicating the deposition of minute iron oxide particles along perivascular and peribronchial lymphatic vessels; emphysematous changes (33% of subjects) likely related to smoking; and honeycombing resembling that in usual interstitial pneumonia (14%). Other findings included ground-glass opacities, reticulation, pleural irregularity suggestive of exposure to asbestos, and conglomerate masses with areas of high attenuation indicating organizing pneumonia with siderosis [4].

Welder’s siderosis was first described in 1936 and occurs in about 7% of arc welders, the presence of radiological opacities being related to the duration of occupational exposure. The iron overload of occupational siderosis is usually considered to be confined to the lungs. Doherty et al in their study present three cases of welder’s siderosis associated with evidence of increased total systemic iron stores, as evidenced by increased serum ferritin levels. Welder’s siderosis was originally thought not to be associated with respiratory symptoms. The symptoms and lung function deficit found in welder’ siderosis are, however, mainly produced by other constituents of welding fumes, rather than just the iron. These cases suggest the possibility that welder’s siderosis may cause total body iron overload [5].

Carcinogenicity

There is no direct evidence of a link between iron oxide accumulation and the development of lung carcinoma [Chong].

A case-control study of the relationship between the risk of colon cancer in men and exposures to occupational agents showed evidence of increased risks by increasing level of exposures to iron oxides [6].

Mortality studies of hematite miners have shown an increased risk of lung cancer. Epidemiological studies of iron and steel foundry workers have typically noted risks of lung cancer elevated by 1.5- to 2.5-fold. An increased incidence of lung cancer has also been reported, but less significantly, among metal grinders. The conclusions for lung cancer among welders are controversial.

On the basis of epidemiological evidence, exposure to hematite dust may be regarded as increasing the risk of lung cancer development in man. The risk is manifest in underground workers but not surface workers, and it is not known whether the excess risk is due to radioactivity in the air of mines, the inhalation of iron oxide or silica, or to a combination of these or other factors. There is no evidence that iron-ore dust (hematite) or iron oxide influences the incidence of cancers at sites

other than the lungs. The International Agency for Research on Cancer (IARC) classifies iron and steel founding as a carcinogenic process for humans- Group 1: Carcinogenic to humans - Exposure circumstances [7,8].

Haematite mining (underground) with exposure to radon - Group 1: Carcinogenic to humans - Exposure circumstances [IARC, 1987].

At 2012 IARC updated assessments of several chemical agents, complex mixtures, and related occupations that were classified as carcinogens for humans. It was determined that there is sufficient evidence in humans for the carcinogenicity of occupational exposures during iron and steel founding. Occupational exposures during iron and steel founding cause cancer of the lung.

Occupational exposures during iron and steel founding are carcinogenic for humans (Group 1) [9].

References

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