Industrial Toxicology, Second Edition
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of arsine is related to its affinity for the hemoglobin of the red blood corpuscles and the symptoms of acute arsine poisoning result from hemolysis of the red blood cells with resulting anemia and jaundice. It has been suggested that arsine is carried unchanged to the various tissues by loosely combining with the erythrocytes (13). Fatal termination is frequent.

Analysis

The great importance of arsenic from a toxicological point of view and the extreme sensitivity of the various methods has resulted in the accumulation of immense amounts of literature devoted to the analytical detection and estimation of this substance. The conventional Marsh and Gutzeit methods which depend on the formation of arsine and its detection are convenient and satisfactory within certain limits. The gold chloride test paper method of Turfitt (14) is a particularly useful test for arsenic. Of the various colorimetric procedures for the micro-determination of arsenic, that of Sandell is both accurate and sensitive (15). In this method, the material, freed from substances that prevent complete evolution of arsine, is so treated that the arsenic is quantitatively evolved as arsine. This, in turn, is absorbed in an acid solution of mercuric chloride containing permanganate and the arsenic thus oxidized to arsenate can be determined by the addition of an excess of ammonium molybdate-hydrazine sulfate reagent which yields molybdenum blue in proportion to the amount of arsenic present. This method is particularly applicable to amounts of arsenic within the range of 1 to 15 micrograms with an accuracy of 5 per cent. Arsenic may also be detected qualitatively by *n*-ethyl-8-hydroxy-tetrahydroquinoline hydrochloride, which gives a reddish-brown color in spot tests in the presence of ferric chloride (16). The arc spectrum for arsenic is very poor and there are a number of interfering lines. However, the following lines—2860.5, 2780.2, and 2349.8—are useful for spectrographic identification.

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ASBESTOS

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Characteristics

Asbestos, amianthus, earth flax, stone flax, mountain cork, is a characteristically silky, fibrous mineral, the composition of which varies with its source. The form known as chrysotile is derived from serpentine and is a hydrous magnesium silicate containing from 12.5 to 14 per cent water of crystallization.

About 95 per cent of commercial asbestos is chrysotile. Chrysotile has the silkiest and strongest fiber and can be spun. The fibers may be as long as 6 inches in length. Asbestos derived from amphibole occurs as a variety of minerals consisting of iron, calcium, and magnesium with little water of constitution. The latter type of asbestos consists of short fibers and is usually inferior to that derived from serpentine. Amphibole asbestos (anthophyllite) while not so suitable for spinning is more stable chemically than chrysotile and more resistant to acids and heat.

Canada has been an important source for the chrysotile asbestos used largely in the United States. The Canadian asbestos industry is centered in the Thetford Mines area of the Province of Quebec. A new source for chrysotile type asbestos is a large quarry on the eastern shoulder of Belvidere Mountain in Vermont which was opened in the summer of 1944. This deposit is of importance because it represents the only large source of long-fibered chrysotile so far found in the United States. Deposits of amphibole asbestos are mined in Georgia and North Carolina.

Industrial Uses

Asbestos is an important substance in industry and consumption in the United States for 1951 amounted to 796,992 short tons (1). Due to its fibrous nature, flexibility and heat-resistant properties, it is used extensively for valve packings, gaskets, boiler lagging, and pipe covering in industrial plants and as friction material in the automotive industry. A considerable market exists in the building industry for asbestos-cement products, heat insulation, and fireproofing. The utilization of asbestos for fibers for spinning in the manufacture of asbestos clothing for fire fighting is an important use for asbestos. The largest single outlet for asbestos in manufactured products in 1944 was for clutch facings, and next in quantity of output were brake linings. Asbestos roofing consumed the third largest amount of asbestos in that year.

Industrial Injury

The inhalation of asbestos dust produces a condition known as asbestosis. While certain other minerals of minor importance have been shown to produce lung fibrosis, asbestos is the only important silicate apart from talc and mica which does not contain free silica and yet produces pulmonary lung fibrotic changes leading to disability and death. Asbestosis occurs chiefly in industrial plants where asbestos is fabricated. The spinning and weaving of asbestos in combination with other textiles results in exposure of workmen to asbestos dust. The long-continued inhalation of asbestos dust results in a form of pneumoconiosis. The primary effect of inhalation of asbestos dust is an interstitial pulmonary fibrosis. On an X-ray film the shadows cast by this type of fibrosis resemble ground glass in appearance and usually extend over the lower portions of the lung fields, frequently being heavier on the right side (2). Unlike silicosis, nodular fibrosis has not been detected in asbestos workers (3). The fibrogenic action differs from that of silica in that the effects are produced only by long asbestos fibers while the very short asbestos fibers appear to have little or no effect. The long fibers apparently block the finer bronchioles and produce fibrotic changes as a result of irritation. A progressive dyspnea, variable cough, substernal chest pains, decreased chest expansion, weakness, emaciation, clubbed finger tips, and curved fingernails are the chief symptoms of asbestosis, as in silicosis. A characteristic finding in asbestosis is that of asbestos bodies in the lungs and in the sputum (4). The so-called asbestos bodies are apparently formed only in the lungs and may be demonstrated microscopically on sectioning lung tissue or in the sputum. The core of the body is an asbestos fiber which is surrounded by protein deposits. Unstained specimens are golden yellow or golden brown. They are not stained with ordinary histological stains but may be demonstrated by the Prussian blue staining procedure. The reaction to the fibrous needle in the tissue which becomes manifest in exudate cell infiltration is accompanied by numerous giant cells containing foreign particles and an increase of diffuse interstitial connective tissue and fibrosis. While the essential reaction to asbestos particles is considered to be chemical by many investigators others consider the

pathogenesis of the disease to be mechanical (5) in nature. For instance, the investigations of Vorwald and his associates (6) indicate that the mode of action of the long asbestos fiber is mechanical rather than chemical in nature. When the lungs are examined by the naked eye after death, they are large and densely fibrotic. Often the lung is completely adherent to the chest wall and, in advanced cases, to the diaphragm with the formation of a thick and extremely dense layer of fibrous tissue. Four main complications and sequelae of pulmonary asbestosis are purulent bronchitis, bronchial pneumonia, pulmonary tuberculosis, and emphysema (7). Several cases of asbestosis have been reported which progressed to a fatal termination with heart failure and without evidence of infection or other complicating disease (8). Any appreciable decrease in the amount of asbestos dust will cause a decrease in the incidence and severity of asbestosis (9). In a recent study of 40 cases of asbestosis at necropsy, Lynch and Cannon (10) found support for the belief that fibrosis does not progress indefinitely after cessation of exposure. It would appear that if the dust concentration in asbestos factories can be kept below 5 million particles per cubic foot, new cases of asbestosis would not arise (2). Cartier (11) has found cases of asbestosis only in those employed for at least 14 years and exposed to air containing at least 5 million fibrous particles varying in length from 10 to 250 microns per cubic foot of air. Doll (12) has concluded from a study of 105 necropsies of individuals employed at an asbestos works that lung cancer is a specific hazard of asbestos workers.

Analysis

While the analysis of asbestos dust as an aerial contaminant is not of particular importance, its microscopy and above all the evaluation of the number of particles per cubic foot of air is of paramount importance. Air samples may be secured by the impinger method using 25 to 50 per cent alcohol as a collecting medium and dust counts made by the usual method. Microscopic examination of the dust reveals typical asbestos fibrous particles which may be accompanied also by cotton or other textile fibrous materials in samples taken from the air of weaving factories. The index of refraction being only slightly greater than that of Canada balsam, the relief is low. Other forms of asbestos than chrysotile have somewhat higher indices of refraction. Extinction is parallel except in the case of tremolite which has oblique extinction. The birefringence of chrysotile is moderate $n_\gamma - n_\alpha = 0.013$. The maximum interference color is bright yellow of the first order. The air sampling of asbestos dust both by the impinger method and by the electrostatic precipitator method is discussed in detail by Fehnel (13).

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BARIUM

Characteristics

Barium, Ba, atomic weight 137.36, density 3.5, melting point 850° C., and boiling point 1140° C., is a yellowish-white, slightly lustrous, soft metal which is somewhat malle-