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Occupational Exposure to TALC – A Review

KEYWORDS: Talc, Asbestos, Quartz, Talcosis, Talco-silicosis, Talco-asbestosis, Mesothelioma

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ABSTRACT *Occupational exposure to talc gives a lung disease called talcosis. This aspect does not appear to be open to debate as it has been shown in many studies of respiratory morbidity and mortality. Many times talc is contaminated with crystalline silica (quartz) and/or asbestos fibres. Exposure to talc contaminated with crystalline silica or asbestos may give diseases called talco-silicosis, talco-asbestosis and mesothelioma. Therefore, it is important to know the concentration of airborne talc along with quartz and asbestos fibres in work environment. This will also help in proper application of Threshold Limit Values (for talc, asbestos or silica) and for designing proper control measures. The paper gives a brief account of health hazards due to talc and reviews methods to analyse airborne contaminated talc dust.*

INTRODUCTION

Rocks or mineral composites that contain talc mineral include agalite, potstone, soapstone and talcite. Soapstone is very soft having hardness of 1.0 on Mohs scale. Density of soapstone ranges from 2.58-2.83 gm/cc (IARC). Soapstone generally contains at least 25% of minerals other than talc while talcite is sometimes used to describe rock that contains at least 75% talc (Harben & Kuzvart, 1996). Steatite originally referred to a rock that is relatively pure talc and is used as an electrical insulator. The talc that is used in such applications is known as steatitic talc. French chalk is soft massive talc (Piniazkiewicz *et al*., 1994). Talc has also been referred to as snowgoose, agalite and kerolite. Industrial talc generally refers to products that contain abundant minerals other than talc; cosmetic talc normally contains >98% talc (Zazenski *et al*., 1995) but the content may have been lower in the past (Rohl *et al*., 1976). Pharmaceutical talc contains >99% talc. Talcum powder is cosmetic-grade talc (Zazenski *et al*., 1995). Pyrophyllite is similar to talc in atomic structure but contains aluminium instead of magnesium (Al2Si4O10(OH)2) (Bish & Guthrie, 1993); the two minerals do not occur together in nature, although they have similar industrial applications (IARC).

Talc is used in pesticide formulations, soaps, paints, Pharmaceutical products, rubber industry, paper industry, ceramics, gypsum joint compound, polymers, pesticide formulations, plastics agricultural chemicals, Wastewater treatment, fertilizers and cosmetics (as a talcum powder) (IRSST , 2012).

The uses for talc are: ceramics (31%), paper (21%), paint (19%), roofing (8%), plastics (5%), rubber (4%), cosmetics (2%) and others (10%) (Virta, 2009, IRSST, 2012).

Talc used in industries may contain mixtures of silica, amphibole varieties of asbestos like tremolite,actinolite,crocid olite and anthophyllite (Talc toxicology).e.g. New York talc contains about 30-55% tremolite, 3-10% anthophylite, 1-2 % serpentine and 1-3%quartz. (Harben & Kuzvart, 1996, IARC).

ASSESSMENT OF OCCUPATIONAL EXPOSURE

Measurement of talc not containing asbestos and silica (quartz):

Inhalable (less than 100 microns) and respirable (less than 4 microns) dust in the work environment is measured gravimetrically by personal samplers and compared with ACGIH threshold limit value (TLV) or any other standards. The TLV for soapstone dust is 6 mg/m^3 for inhalable dust and 3 mg/m^3 for respirable dust (OSHA). TLV is valid only for dust that is not contaminated by asbestos fibers and silica (quartz) content is <1% (OSHA).Later on TLV for respirable dust was changed to 2 mg/m^3 (ACGIH, 2008). If dust contains silica or asbestos then respective TLVs for silica and asbestos may be used.TLV for asbestos and quartz is 0.1 fibres /ml and 0.025 mg/m^3 repectively(ACGIH,2008).

Measurement for talc containing crystalline silica (quartz):

If sample contains quartz, the percentage of silica in the dust sample needs to be estimated by techniques like Fourier Transform Infrared spectroscopy (FTIR) or X-ray diffraction (XRD).

Crystalline silica analysis by FTIR

In this method, samples collected on membrane filters (37 mm diameter, 0.8 µm pore size) by personal samplers are placed in porcelain crucibles, and ashed in muffle furnace for 2 hours at 600°C. After ashing, the ash is mixed with 200 mg of potassium bromide (IR grade), dried overnight at 110°C and thoroughly mixed with pestle. The mixture is transferred carefully to a 13-mm evacuable pellet die (NIOSH, 2003, Cares et al. 1973, Bhagia et al, 2009). The mixture is then pressed by standard technique to make pellets. To avoid contamination, in between preparation of samples, the die is cleaned with ethanol.

The standard pellets are prepared with known quantity of Standard Reference Material (SRM) of quartz supplied by National Institute of Standards & Technology (NIST, 1999), USA.The spectra are taken in the range of 1000 cm^{-1} to 600 cm^{-1}.Quartz has characteristic peaks at 800 cm^{-1} and 695 cm^{-1}. Absorbance is measured at 800 cm^{-1} (NIOSH, 2003, Cares et al.1973, Bhagia et al, 2009). Estimated limit of detection (LOD) for quartz by FTIR is 5µg (NIOSH, 2003).

Analysis of crystalline silica (quartz) by X- ray diffraction

NIOSH method (NMAM- 7500) can be used for analysis of quartz by XRD which can also distinguish three polymorphs of silica viz. quartz, crystobalite and tridymite.

Measurement for talc containing asbestos:

Most of the studies describing the health effects related to talc exposure contain very little information on the characterization of the talc involved. Talc particles are normally thin and plate-like. When viewed under the microscope, talc platelets may appear as fibres (Cralley et al., 1968). More rarely, they can take the form of long and thin fibres (fibrous talc), in a bundle that can be easily separated (asbestiform talc). Asbestiform talc must not be confused with talc containing asbestos (ACGIH, 2010).

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Since some talcs can contain amphiboles, namely tremolite, possibly with asbestiform (or fibrous) and non-asbestiform (cleavage fragments) morphology, it is important to know the composition of the talcs so that exposure monitoring strategies can be designed (IRSST, 2012).This will also help in proper application of TLVs (for talc, asbestos or silica) and for designing proper control measures.

Asbestos fibers are measured by using phase contrast optical microscopy (PCOM) as per analytical methods described by international agencies like NIOSH 7400 (1994), OSHA ID-160(1998), WHO (1997), AIA (1988), and ISO 8672 (1993).

In general, samples are collected on membrane filters (0.8 micron pore size, 25 mm) in a cowled cassette and slides are prepared by Acetone-Triacetin method. Fibers are counted on PCOM (x 400) using Walton-Becket graticule[10]. All fibers having length greater than 5 microns, diameters less than 3 microns and having aspect ratio greater than or equal to 3:1 are counted.

As per the guidelines of analytical methods, hundred fields or 100 fibers (whichever is earlier) are counted. The fiber concentration is given by:

$$C\ (\text{fibers/ml}) = \frac{A}{a} \times \frac{N}{n} \times \frac{1}{rt}$$

Where,

C = Concentration (fibers/ml)

A = Effective filter area (mm^2)

a = Graticule area (mm^2)

N = Total number of fibers counted

n = Number of graticule areas counted

r = Flow rate (ml/min)

t = Sample duration (minutes)

The threshold value for asbestos fibers is 0.1fibers/ml (ACGIH, 2008).

PCOM is routinely used for counting of fibers in asbestos based industries but it is not capable of identifying fibers. When there is a known asbestos exposure, e.g. in mining and milling of asbestos fibers, asbestos cement products, brake liners, manufacture of thermal insulating boards, asbestos textiles and rope manufacturing, this method is routinely used because it is known that the fibers are asbestos fibers. This method is inexpensive and convenient. But when we are not sure whether fibers are asbestos, as in the case of talc, PCOM with fiber selection criteria mentioned above may give incorrect results. For example, in bulk samples of talcum products, Cralley *et al.* (1968) reported that particles longer than 5 µm with a 3:1 aspect ratio in 22 talcum products represented 19% of the particles, which were predominantly talc (IARC).

Several studies have been published for the purpose of proposing counting criteria, generally by PCOM, in order to distinguish between asbestiform and non-asbestiform amphiboles (IRSST, 2012).With PCOM, the asbestiform variety is generally recognized by the following characteristics:

Length>5 µm

Width<0.5 µm and

Mean aspect ratios ranging from 20:1 to 100:1 or higher.

Aspect ratios are determined for fibres, not bundles and the fibres are thin, usually less than 0.5 micrometres in width. In the review article on asbestos by Walton (1982), it has been mentioned that Campbell et al (1977) studied aspect ratios of non-asbestiform anthophylyte and tremolite. They reported that 30% of the non-asbestiform particles had aspect ratio of >3:1 and 5% particles had aspect ratio >10:1 whereas 30-40% of asbestiform particles had aspect ratio of >10:1.They further reported that (Campbell et al, 1979) on the average 2.5% of the non-asbestiform particles had aspect ratio>10:1 and virtually no particle had aspect ratio >20:1. It has been reported that for particles greater than 5 µm counted on membrane filters by phase contrast microscopy, use of an aspect ratio >20:1 would include most asbestos fibres. In any event the use of aspect ratio of 3:1 is not justified on mineralogical grounds (Wylie, 1979, Walton W.H., 1982). OSHA (1992) defines cleavage fragments as mineral particles formed during ore milling, characterized by relatively parallel sides and moderate aspect ratios

(< 20:1)(IRSST,2012).

Asbestiform varieties of asbestos are characterized by long and thin fibres, while cleavage fragments of the corresponding non-asbestiform varieties consist of short fibres of larger diameter. A clear distinction between cleavage fragments and asbestos fibres would be that the width of the cleavage fragments is directly proportional to length, while the width of asbestos fibres is relatively constant (Siegrist, 1980, IRSST, 2012)

Chatfield (2008) also formulated rules for identifying an asbestos fibre:

- Fibres > 5 µm and ≤ 10 µm with aspect ratio > 35:1;
- Fibres > 10 µm and ≤ 20 µm with aspect ratio > 30:1;
- Fibres > 20 µm with aspect ratio > 20:1. (IRRST, 2012)

NIOSH method 7400 has been improved by a research group using modified Walton & Beckett graticule which allows the measurement of particles having length > 5 µm having aspect ratio greater than 3:1 and particles longer than 10 µm and of diameter less than or equal to 0.5 µm. It has been suggested that if 50% of the fibres have a length greater or equal to than 10 µm or a diameter equal to or less than 0.5 µm, the fibres are considered as asbestiform. This type of sample must be re-analysed by Electron Microscopy (Bailey *et al.*, 2004, IRSST, 2012).

NIOSH (2011) mentions that it is very important that an analytical method capable of clearly distinguishing between asbestiform and non-asbestiform Elongated Mineral Particles (EMPs) bedeveloped, validated and used (IRSST, 2012).

Rohl (1974) reported that very large number of asbestos fibers may be present in talc end products, yet remain undetected if only PCOM and XRD is used. On the other end, electron microscopy can be very sensitive technique for detecting extremely minute amounts of asbestos. For identification of asbestos fibers, electron microscopy (EM) coupled with Energy Dispersive X-Ray Analysis (EDXA) is used.

For bulk samples, semi-quantitative analysis by polarized light microscopy (PLM) and quantitative analysis using the X-ray diffraction (XRD) technique are widely used (IRSST, 2012).

HEALTH HAZARDS DUE TO TALC EXPOSURE

Talc used in industrial units may contain mixtures of silica and amphiboles. Exposure to low-grade talc may give rise to talco-silicosis or talco-asbestosis, where the disease will exhibit the symptoms similar to silicosis or asbestosis, respectively (Talc toxicology).

Pure Talcosis:

Pure talc is relatively less fibrogenic than the other varieties.

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It is known that exposure to high levels of talc produces talc pneumoconiosis/ talcosis. This aspect does not appear to be open to debate as it has been shown in studies of respiratory morbidity and in mortality studies (Fegin, 1989, Wergeland et al; 1990, Kleinfeld et al; 1967, Rubino et al; 1976). Gysbrechts et al (1998) reported that a 62 year old woman who had worked from the age of 14-18 years ,in a rubber hose factory, where there was severe exposure to talc for 5 years which caused interstitial lung disease even after 40 years. Honda et al. (2002) also reported that exposure to talc contributed to the elevated rate of non-malignant respiratory diseases (NMRD), particularly pulmonary fibrosis. Talcosis can be occupational or non –occupational. Non occupational talcosis may occur by excessive use of talcum powder as well as the accidental aspiration of talc by infants.

Talco-Silicosis:
Talco-silicosis, is caused by talc mined with high-silica-content. Symptoms are similar to those of silicosis. Soapstone powders are generally contaminated by asbestos fibers (<10%) but silica content is less than 1%.But in some cases the silica content may be more than 1%.Symptoms of talco-silicosis are similar to that of silicosis.

Talco-Asbestosis:
Talco-asbestosis is similar to asbestosis and is produced by crystalline talc, which is generally inhaled by workers with asbestos fibers. Talc containing more than 1% asbestos is considered a human carcinogen (talc toxicology). Symptoms of talco-asbestosis are similar to that of asbestosis.

Mesothelioma:
The possibility of mesothelioma related to talc dust exposure remains a controversial subject. Mesotheliomas present diagnostic and causal recognition difficulties. With the current state of knowledge, there is no proof linking mesothelioma and exposure to talc not containing asbestos or asbestiform fibre (IRSST, 2012). However, mesothelioma has been reported in workers working with talc containing asbestos. Hull et.al (2002) reported mesothelioma among workers in asbestiform fiber bearing talc mines in New York State. They concluded that New York Talc miners are exposed to mixture of talc, tremolite and related fibrous minerals resulting in a disease pattern much more complicated than pure talcosis. The asbestiform fibers in New York talc miner's lungs were found to be containing talc, tremolite and related mineral series. Gibbs et al. (1992) also showed that talcosis frequently represents disease associated with variety of minerals and that talc is a common denominator. Roggli et al (2002) concluded that tremolite in lung tissue samples from mesothelioma victims was derived from both talc and chrysotile fibers and that tremolite accounts for a considerable fraction of excess fiber burden in end users of asbestos products.

In India, no studies on exposure to soapstone powder or talc have been reported except Bhagia et al (2008).They studied exposure to soapstone dust and fibers in a facility where pesticide formulations are manufactured using soapstone powder. Dust concentrations (Inhalable and respirable) were found to be much higher than threshold limit values for soapstone dust in feeding and bagging sections except for respirable dust in bagging. Quartz content as analyzed by FTIR spectrophotometery was reported to be less than1%. Fibers were counted by phase contrast microscopy using membrane filter method. Fibers,>5 µm and width <3 µm (Aspect ratio>3:1) were found to be up to 1.0 fiber/ml. X-Ray diffraction analysis of the soapstone powder showed the presence of calcic amphiboles in traces. Asbestos fibers were neither confirmed with aspect ratio of >20:1 nor with other techniques like Electron microscopy with Energy Dispersive X-Ray analysis (EDXA) by them.

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