



— Executive Summary —

A Review of the Toxicology and Epidemiology of Wollastonite

Introduction

This document summarizes information contained in *A Review of the Toxicology and Epidemiology of Wollastonite*, a study by L. D. Maxim¹ and E. E. McConnell published in *Inhalation Toxicology* (Vol. 17, pp. 451-466, 2005). We provide background information on wollastonite properties, production and use, regulatory classification, and occupational exposure limits. We also summarize the results of studies on the toxicology and epidemiology of wollastonite.

Uses and Production

Wollastonite is a naturally occurring calcium silicate (CaSiO_3) that is produced in both powder and fibrous forms. It is a valuable industrial mineral used in plastics, ceramics, metallurgical applications, paint, and friction products. Wollastonite is used in diverse applications—including asbestos replacement.

Natural wollastonite is found in various deposits throughout the world, including the United States (New York and California), Australia, Canada, Chile, China, Finland, India, Mexico, Morocco, Namibia, North Korea, Pakistan, Serbia, South Africa, and Turkey². World production of wollastonite in the year 2000 was approximately 605,000 *metric tons* (MT) of which the US produced approximately 130,000 MT.

Wollastonite deposits may be associated with or contain other minerals that may be toxic, such as asbestiform minerals. NYCO Minerals, Inc. tests all of its mined wollastonite for asbestiform fibers using the transmission electron microscopy technique, and ore released from the mine has been graded as non-detect for asbestiform tremolite.

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² Synthetic wollastonite is also available and has been studied elsewhere. This review summarizes the available information for *natural* wollastonite.

While there are many ways to process wollastonite into fibers, the final product is graded based upon the aspect ratios (the ratio of the fiber length to fiber diameter) of the wollastonite fibers. The low-aspect-ratio *powder* grade has aspect ratios ranging from 3:1 – 5:1. The high-aspect-ratio *acicular* grade has aspect ratios ranging from 10:1 to 20:1. In addition to particle size and aspect ratio, technical specifications for various grades of wollastonite may include types (if any) of surface treatment. Some wollastonite grades contain respirable particles/fibers, some of which have lengths and diameters that might be biologically active if deposited and retained in the lung.

Estimates of Occupational Exposure

Based on the *National Occupational Exposure Survey* (NOES), the number of people estimated to be occupationally exposed to wollastonite in the early 1980's was 70,383. The NOES study is based on *Standard Industrial Classification* (SIC) codes, has not been updated to reflect current data, and is believed to provide a conservative estimate. Based on research the total number of people directly engaged in the mining, beneficiation, and production of wollastonite in the United States is at most 220.

Occupational Exposure Limits

Occupational exposure limits (OELs) have not been established specifically for wollastonite. However, wollastonite is included in the *particulates not otherwise regulated* (PNOR) category with the following published OELs:

- The US Occupational Safety and Health Administration set the Permissible Exposure Limit (as an 8-hour Time Weighted Average) at 15 mg/m³ for total dust and 5 mg/m³ for respirable dust.
- The US National Institute for Occupational Safety and Health Recommended Exposure Limit is 10 mg/m³ for total dust, and 5 mg/m³ for respirable dust.
- The American Conference of Governmental Industrial Hygienists set a Threshold Limit Value of 10 mg/m³ for total dust and 3 mg/m³ for respirable dust.

Toxicology and Epidemiology Studies

Many studies have been done to identify the occupational hazards associated with wollastonite. In general, studies have focused on the effects of wollastonite on the lungs and have been negative for pulmonary fibrosis, lung cancer, or mesothelioma. The studies may be divided into four types: (i) cellular/mechanistic, (ii) biopersistence, (iii) animal (cancer and other), and (iv) human.

(i) Cellular/mechanistic studies

Most of the cellular/mechanistic studies show that wollastonite is capable of producing potentially adverse effects (e.g., cytotoxicity, inflammation, and mesothelial cell proliferation) but also demonstrate that these effects are transient and significantly less toxic than is produced by other types of mineral fibers.

(ii) Biopersistence studies

Biopersistence studies indicate that wollastonite is cleared rapidly from the lung and that the biopersistence of wollastonite is less than those for many other mineral fibers.

Biopersistence is recognized as a major determinant of toxicity and carcinogenicity. The relatively low biopersistence of wollastonite is the major reason why wollastonite is unlikely to be carcinogenic in humans.

(iii) Animal studies

Several studies have been conducted on rats and nearly all of them have been negative in terms of fibrosis and cancer. There are two notable exceptions where the studies produced notable adverse effects, but both of those studies had significant limitations and are of limited evidential value. These two exceptions do not outweigh the large number of long term studies where the results have been negative for cancer.

The animal studies have been evaluated as a group by other agencies. The *International Agency for Research on Cancer* (IARC) classified the evidence of carcinogenicity in experimental animals as *inadequate* in 1997, meaning that the studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect. This classification revised an earlier (1987) decision when IARC classified wollastonite as having *limited evidence* for carcinogenicity in experimental animals.

A more recent review by the Australian *National Occupational Health and Safety Commission* (NOHSC) evaluated the animal data more definitively (including new studies not available to IARC) and concluded that there was *sufficient evidence for the non-toxicity and non-carcinogenicity of wollastonite fibers in experimental animals*.

(iv) Human Studies

There have been several epidemiological studies on wollastonite, including mortality and morbidity studies on occupationally exposed cohorts. Studies show that while cancer is not correlated with occupational exposure to wollastonite, other effects may be associated with unusually high exposure levels. Reviewers of these studies noted, “occupational exposure to wollastonite results in a non-specific increase in bronchitis, reduced lung function, and limited evidence of pneumoconiosis” and, “wollastonite has a low level of toxicity but very well may cause pleural and interstitial changes at exposure levels that are unusually high.”

IARC placed natural wollastonite into Group 3 (*cannot be classified as to its carcinogenicity to humans*) based on the finding that there was inadequate evidence in both humans and animals for the carcinogenicity of wollastonite. The NOHSC study in 2001 concluded that there was inadequate evidence in humans for the carcinogenicity of wollastonite.

Coated Wollastonite

Wollastonite may be treated with various agents (typical concentrations 0.5 – 1%) to improve its properties for certain applications. These surface-treated wollastonites have not been studied extensively. However, one study was done to examine the effects of the coatings on wollastonite biopersistence. The study showed that the coatings did not increase biopersistence and demonstrates that these coatings (at least at the concentrations typically used) would not have an impact on the pathogenicity of wollastonite.

Conclusions

We conclude that there is inadequate evidence for the carcinogenicity of wollastonite in animals and, based on strong evidence that wollastonite is not biopersistent, believe that a well-designed animal inhalation bioassay would have a negative result. The epidemiological evidence for wollastonite is limited, but does not suggest that workers are at significant risk of an increased incidence of pulmonary fibrosis, lung cancer, or mesothelioma. Morbidity studies have demonstrated a non-specific increase in bronchitis and reduced lung function. It is prudent, however, to continue product stewardship efforts by wollastonite producers to control workplace exposures and to monitor scientific developments.