Additional Reading: Health Overview

Understanding the Health Effects of Wollastonite

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Introduction

Wollastonite is a fibrous monocalcium silicate ($CaSiO_3$) which is used increasingly throughout the world as a filler in plastics and paints, ceramics, rubber and construction materials. It is also being used as a partial asbestos substitute in several products. Wollastonite occurs naturally in few locations, and deposits suitable for commercial exploitation are presently located in upstate New York, India, Mexico and Finland.

As wollastonite is a fibrous, bladed, acicular or shard-like mineral, some concern has been expressed relative to its health effects. This has become particularly evident since asbestos became a serious environmental concern during the past two decades. Until recently there was little information regarding the health effects of wollastonite following its inhalation and there was a paucity of data regarding the mechanisms by which wollastonite could cause lung disease, if in fact it did cause any long term detrimental health problems. Numerous studies have now been completed, which show that wollastonite is a safe, non-toxic mineral, which has no long-term detrimental health effects if inhaled into the lung.

This paper summarizes the results of the medical and scientific studies carried out during the past several years to determine if wollastonite has any long-term harmful health effects. Studies to date show that wollastonite is a nondurable mineral that does not have any detrimental health effect to occupationally and non-occupational exposed individuals.

Physical Properties Related to the Biological and Pathological Effects of Wollastonite

The fate and eventual health consequences of inhaling a mineral like wollastonite is partly due to its diameter, length and durability or biopersistence. Fibers must be of the appropriate size (respirable) to be inhaled into the respiratory region of the lung. Large fibers are trapped by the body's natural defense mechanisms and rarely reach this region. Animal studies have indicated that those fibers that fall within the respirable range are the long thin fibers, which cause diseases like cancer. However, this has not been proven in humans. Human and animal studies do suggest that fibers less than 5 microns long are less carcinogenic than long respirable fibers. It is believed that the short fibers are more easily cleared from the lung by the body's defense mechanism and have little opportunity to interact with cells and tissue that are responsible for causing injury.

Equally, if not more important that fiber dimensions, is the durability or biopersistence of fibers in tissue. It is now accepted by the medical/scientific community that durability of fibers and minerals in human respiratory tissue is a key aspect in determining the toxicity and pathogenicity of these agents. Generally, inhaled durable minerals remain in the lung for long periods of time (months to years) thus allowing them time to adversely affect surrounding tissue. Conversely, nondurable minerals reside in the lung for only short time periods (days to weeks) and therefore have only a limited chance of causing tissue damage.

Scientific Data Relevant to the Evaluation of Wollastonite Health Risk to Humans

In order to determine if inhalation of wollastonite presents any health risk, three different but complementary studies have been performed. These are: 1) in vitro (in the petri dish) tests using cells, tissues or organs from animals or humans to evaluate the biological and potential pathological (harmful) activity; 2) in vivo (animal) studies used to examine the biological response of the lung to inhaled particles and mechanisms of tissue injury, and 3) epidemiological (human) investigations which are primarily concerned with studying the distribution of disease and its determinants in specific populations. Each study produces its own relevant information that will often interrelate to the other studies.

In Vitro Studies

In vitro tests assess the biological and potential pathological activity of a material by examining the toxic effect of the material towards cells tissues or organs outside the body. The purpose of this type of test is to provide quick, easy and relatively inexpensive reliable methods of studying and comparing large numbers of potentially harmful material in order to select those which are in fact harmful, and those that are not. If in vitro test results suggest that a given material is not harmful, this could be supported by negative animal and epidemiological studies. It becomes apparent that by using a combination of various investigative techniques, it is possible to determine with reasonable scientific certainty whether or not a material such as wollastonite represents a health hazard.

A detailed in vitro cytotoxicity study of two commercial grades of wollastonite possessing high and low aspect ratios was completed in 1987. Wollastonite at various concentrations was incubated with a cell type commonly found in the human respiratory system. Chrysotile asbestos was used as a positive fibrous control and silicon dioxide (alpha-quartz) was used as a nonfibrous positive control. It is well established that both chrysotile asbestos and alpha-quartz are highly toxic to cells and induce biological and pathological changes when inhaled. The results of this study showed that chrysotile asbestos and alpha-quartz was toxic to cells at all concentrations, with cell death being the end result. Wollastonite was not toxic in any of the concentrations studied.

During the past decade several in vitro investigations have been performed using various other cell types. Although these studies indicate that wollastonite imparts limited biological activity, it is less than that observed with known minerals such as asbestos and quartz.

In Vivo Studies

It is well established that a variety of minerals are capable of causing pathologic damage in animals, which may lead to fibrosis (scarring) or cancer. Therefore, carefully designed in vivo investigations are a part of the studies used to determine the potential hazard of the mineral.

Four important animal models have been used to examine the potential clinicopathologic effect of wollastonite. In one study, rats were intraperitoneally injected with wollastonite, and tumor development was followed for up to 130 weeks after treatment. In addition, several groups of animals were injected with known and unknown fibrous and nonfibrous carcinogens including

asbestos, glass fibers, polypropylene, ferric oxide, KEVLAR® fibers, ceramic wool and wood dust. As expected, all types of asbestos induced tumors after injection of extremely low doses (0.01 - 1.0 mg). Wood dust and wollastonite did not induce tumors, while the other materials produced tumors. However, in several instances, the number of tumors in a particular group was low and could be attributed to spontaneous development.

A detailed inhalation study was undertaken in 1982 by Northrop Services, Inc., under a National Institute of Environmental Health Sciences (NIEHS) contract to examine the potential consequences of wollastonite inhalation. Chrysotile asbestos was included as a positive control. Animals were exposed for up to two years and were given complete autopsies including collagen hydroxyproline determinations. The results of this study showed that asbestos caused both pulmonary fibrosis and tumors. Animals exposed to wollastonite did not develop fibrosis or tumors of the respiratory system or any other organ examined.

In 1992, Bellman and Associates completed a study which examined the durability of inhaled wollastonite in rat lungs. The result of this study showed that wollastonite was rapidly eliminated from the lungs because of its nondurability in the tissue. The wollastonite-exposed animals were compared to animals exposed to asbestos, a durable mineral that remains in the lung for years.

Epidemiological Studies

In 1976 the National Institute of Occupational Safety and Health (NIOSH) conducted a health hazard evaluation of wollastonite workers at the NYCO Minerals, Inc. wollastonite mill and mine in Willsboro, New York. The study found no increase in the prevalence of respiratory disease among wollastonite workers.

In 1982 NIOSH conducted a follow-up evaluation of current and former workers from the same facility. No wollastonite worker was found in the study as suffering from any disabling respiratory disease. This evaluation did, however, express concern that long term exposure to wollastonite might cause changes in the large conducting airways among exposed workers. However, this concern of increased prevalence of chronic bronchitis could be attributed to the smoking habits of the individuals studied or their second occupation, which is farming. There were no controls included for either of these factors.

This NIOSH report suggests that smokers exposed to wollastonite may have a higher risk of respiratory impairment than non-smokers. However, both smoking and advancing age may themselves have an adverse effect on lung capacity. It is, therefore, difficult to know what effect these aspects of some worker’s history may have had in the test results from survey answers relied upon in these evaluations.

In 1990, a review of a detailed health survey of the NYCO workers detected no worker with severe respiratory impairment, which could be attributed to wollastonite exposure. Any effect on the lung appeared to be primarily attributable to tobacco smoking rather than wollastonite exposure.

Conclusion

The conclusion which may be drawn from the above surveys of wollastonite workers, in addition to other epidemiologic information collected from surveys at other work sites throughout the world, suggests that wollastonite exposure may cause a mild industrial bronchitis. This effect may occur only in smokers. Epidemiological surveys on wollastonite workers, to date, do not detect any substantial impairment of respiratory health related to wollastonite exposure.

In summary, in reviewing the available in vitro, in vivo and epidemiological studies on wollastonite, there is no evidence to suggest that wollastonite presents a health hazard. The long-term health effects due to inhalation of wollastonite appear to be negligible. In support of this conclusion is the decision by the MAK Commission of Germany to remove wollastonite from their list of hazardous toxic materials. The MAK is similar to the U.S. Environmental Protection Agency.

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