Asbestos: Beyond the Fears

By Fathi Habashi

Asbestos is an industrial mineral of great economic importance that has been studied extensively, both mineralogically and for industrial application. Its extraction from ores has been greatly improved with respect to safety in the work place. In spite of that, there is a decisive effort in many countries to ban its use on the grounds that it is a toxic substance. This action is resulting in a drastic decrease in production and the possibility that the industry will be destroyed. The chelation of asbestos with organic dyes seems to be a promising way to abate its toxicity. Dyeing can be done when the fibers are slurried in water at ambient conditions in the same way as textile fibers.


Asbestos in its raw state.

Asbestos occurs in nature in a variety of forms, but the most important is chrysotile, which represents more than 90% of the asbestos used.

The asbestos fibers that are visible to the naked eye are composed of hundreds of thousands of mono-fibers called fibrils in a close-packed parallel arrangement. The mono-fibers have a tubular shape formed by the rolling up of a sheet composed of hydrated magnesium silicate. This sheet is composed of silica groups in tetrahedral pyramid form linked to each other to form a first layer and conjugated to octahedral groups of hydrated magnesia. The latter groups are bulkier than their conjugate silica groups and the sheet that they form has to curve to accommodate the excess encumberment of the magnesia. Lateral crystal growth of the sheet eventually leads to the formation of a tube. A typical fiber consists of 12 to 20 layers rolled up like a scroll.

The Toxicity Issue

Asbestos is deemed by some to be a workplace problem that can be adequately addressed with current dust control technology and appropriate practices, rather than an environmental issue. Others think that it is a toxic and carcinogenic material that must be banned immediately. It has been demonstrated, for example, that heavy smokers in particular are more susceptible to lung cancer; it seems that any fiber lodging in the lung is, because of its large surface area, capable of adsorbing carcinogenic substances from tobacco smoke. The accumulation of siliceous dust in the lungs may result in a disease called silicosis, and this may be cured by surgery. In case of lung cancer due to asbestos, however, surgery is not effective because the disease spreads rapidly from the lungs to other organs.

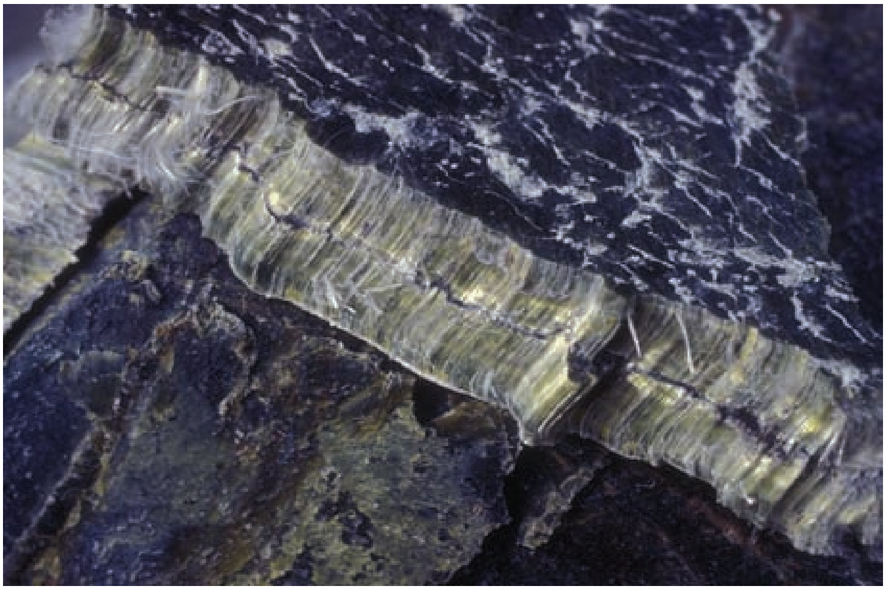
As a result of this controversy, the consumption of asbestos in many countries has been decreasing gradually over the past few years, which has forced production decline and, in some cases, plant shut downs. The industry is looking for substitutes for asbestos, but the long-term environmental effects of other minerals or synthetic substitutes that have been proposed are unknown. There are two widely accepted screening toxicity tests for asbestos: hemolytic and cytotoxicity:

- Hemolytic: In these tests, red blood cells are left in contact with a certain amount of fiber and, after various periods of time, the cells are centrifuged and the hemoglobin content of the supernatant solution is measured using spectrophotometric methods. Usually, 72% of the cells undergo hemolysis when contacted with dry fibers, and 65% when contacted with wet fibers.
- Cytotoxicity: In these tests P 388D1 cells are incubated with a certain amount of fiber for various periods of time. The number of healthy and dead cells is then measured using Trypan Blue dye. Usually, 81% of the cells die when contacted with dry fibers and 50% when contacted with wet fibers.

While hemolysis is a short-term test in which membrane stability is involved, cytotoxicity as outlined above gives a global picture of the toxicity of the fibers. Hence, the two tests do not necessarily correlate together since the factors involved are not the same.

The Chelation of Asbestos

Chrysotile asbestos has the advantage of a large surface area and, unlike activated charcoal, is white in color, so that the action of dyes can be followed easily. When a sample of asbestos fibers is agitated at room temperature with an aqueous solution of an organic dye, the fibers become immediately colored. When the colored fibers are separated by filtration, dried and examined by the scanning electron microscope, they are homogeneous and contain no precipitates. When



Detail of the asbestos fibers into the stone.

boiled with distilled water under a reflux condenser, they do not lose their color, thus indicating that the dye is chemically bound to the fiber. Table 1 gives the color of the dye solution and the color of the asbestos treated by these dyes.

The appearance of new peaks in X-ray diffraction patterns and in infrared spectra, together with the absence of precipitates, supports the view that chelates are formed with asbestos, apparently with its $Mg(OH)_2$ component. This resembles the process of mordant dyeing of textile fibers where $Mg(OH)_2$, $Al(OH)_3$, or $Cr(OH)_3$ are first precipitated on textile fibers then known as “lakes” [13]. Some organic compounds, e.g., bromocresol purple and phenolphthalein, although they are not dyestuffs, color asbestos. They have nearly similar structure and behave nearly the same way towards asbestos. The toxicity of the colored fibers was measured by the tests mentioned earlier and compared with the uncolored sample. It was found that some dyes, e.g., Thiazol Yellow G and Trypan Blue decreased the toxicity of the fibers (Table 2).

Chrysotile asbestos can be colored by a variety of dyes at ambient conditions like textile fibers forming stable magnesium chelates. Certain dyes render it less toxic as measured by the homolytic and cyto toxicity tests. This is a promising area of research that may lead to the preparation of colored asbestos that is nontoxic.

Since the major application of asbestos, about 70%, is in the fabrication of asbestos cement whereby the fibers are slurried in water with Portland cement, the addition of a dye in this step is a simple matter. Colored asbestos is stable with respect to boiling water, which suggests a chemical reaction with magnesium hydroxide in the silicate structure.

Links and References

- Asbestos and Asbestos Health Effects
- Asbestos substitutes
- Agency for Toxic Substances and Disease Registry’s Web site
- Cell toxicity, hemolytic action and clastogenic activity of asbestos and its substitutes
- Comparative studies on the cytotoxicity of amphibole and serpentine asbestos
- EPA Asbestos Bans
- Carter C.F. and Smith A.L., Principles of Microbiology, Mosby, St Louis 1957
- Dodd C.G., in Clays and Clay Technology, Proceedings of the First National Conference, edited by J.A. Pask and M.D. Turner, Department of Natural Resources Bulletin 169, Division of Mines, San Francisco, California, 1955 pp. 105-11
- Somasundaran P. and Nagaraj D.R., in Reagents in the Mineral Industry, edited by M.J. Jones and R. Oblatt, Institution of Mining and Metallurgy, London, 1984, pp. 209-19
- Fu E. and Somasundaran P., Int. J. Min. Processing 18 (1986) 287
- Khare S.K. et al., J. Chem. Tech. & Biotech. 38 (1987) 99
- Makhlouf M.Th. and Khalil Z.H., J. Chem. Tech. & Biotech. 38 (1987) 89
- Giles C.H., Chem. Ind. (London) (1959) 1400
- Habashi F. et al., “Asbestos Fibers Modified with Organic Dyes”, Can. Patent, 1, 220, 492 (1988)
- Habashi F. et al., “Surface Modification of Chrysotile Asbestos with Organic Reagents: A Preliminary in vitro Toxicological Study”, Bull. Can. Inst. Min. & Met. 84 (945), 67-79 (1991)
- Awadalla F.T., Habashi F., “Reaction of Chrystoile Asbestos with Triphenylmethane Dyes”, J. Materials Sci. 25, 87-92 (1990)
- Habashi F., “Dyeing of Asbestos Fibers”, Textile Chemist & Colorist 24 (4), 23-25 (1992)
- Michaels L. and Chissick S.S. (editors), “Asbestos”, vols 1 and 2 (Wiley, New York 1979)
- Trotman S.R. and Trotman E.R., The Bleaching, Dyeing, and Chemical Technology of Textile Fibers, Giffin, London 1948

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