A REVIEW PAPER ON CHRYSOTILE - AN ASBESTOS MATERIAL

By

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1- Introduction

Asbestos is a commercial name given to naturally occurring crystalline fibrous material, which consists of two silicate minerals, Serpentine and Amphiboles having a unique range of physical and chemical properties. Both the minerals develop as cross-fibre seams or veins in the host rocks. The width of the seams determines the fibre length, which is usually in the range of 0.8 to 19 mm. The fibre's exist in extremely tight packed parallel formations. Certain types of asbestos occur in fibrous masses with randomly oriented blocks of fibre's upto 25 mm in length and fibre's upto 100 mm long can be found [1].

Serpentine Minerals contain magnesium ions in trioctahedral single-layer silicate structures. It is composed of unit layers of $Mg_3Si_2O_5(OH)_4$ [2] where as Amphiboles are iron silicate and are highly bio-persistent. The three main groups of Serpentine are;

i) Antigorite

ii) Chrysotile

iii) Lizardite

Antigorite forms lamellar crystals, flattened in appearance and in dark green shades.

Chrysotile or white asbestos is a common constituent of asbestos minerals. It occurs as fibrous crystals in yellowish to off-white or in greenish aggregates. It occurs in veins.

Lizardite occurs as either tiny, little crystal scales or in compacted off-whitish aggregates (various mixed crystal types).

Chrysotile constitutes more than 90 percent of the world asbestos reserves and is used to a large extent in the manufacture of asbestos cement. The fibre is white and silky with a minimum diameter of about 0.01 μ m.

Since 1900, the most important example of fibre cement composite has been asbestos cement. The proportion by weight of asbestos fibre is normally between 9 to 12 percent for flat or corrugated sheets, 11 to 14 percent for pressure pipes and 20 to 30 percent for fire resistant boards and the binder is normally a Portland cement.

2- Compositions

Not only investigations have been carried out for separating short chrysotile fibres from bulk commercial fibres but also attempts have been made to study the possibility of changing chrysotile to nonhazardous mineral which could also be economically viable. Also attempts have been made to synthesize chrysotile using magnesia and silica.

Studies show [3] that antigorite is distinguished by its comparatively low water and high silica contents. Chrysotile is characterized by a relatively high water and magnesia content and by a small ratio of Fe_2O_3 to FeO; while lizardite has high silica and low Fe content. It is also suggested by wet chemical analysis that these minerals have different chemical compositions and can be identified by composition alone as shown in table 1.

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Table 1: Average compositions of serpentine polymorphs [3].

Oxide	**Average Weight Percent**		
	Chrysotile	**Lizardite**	**Antigorite**
SiO_2	41.530	41.024	42.136
Al_2O_3	0.716	1.395	1.639
Fe_2O_3	0.718	4.100	1.165
FeO	0.624	0.419	3.729
MgO	40.928	39.437	38.369
H_2O	13.542	13.286	12.098

Attempts have been made [4] to synthesize chrysotile and investigate reactions between magnesia and silica under hydrothermal and phenmalolytic conditions. Chrysotile and talc were produced, depending on the ratio of the reacting oxides. The chrysotile was submicroscopic and showed to have a fibrous structure under the electron microscope. Chrysotile and talc were prepared from mixtures of magnesium carbonate and silica. The same products were obtained by the action of silica in the vapor phase on solid magnesia. A detailed study was carried out in their work and the effects of temperature, pressure, time, pH, and oxide ratio on the amount of silica transported were determined. The overall rate of transport was found to increase with temperature, pressure and pH. One of the main objects of the work was to prepare chrysotile fibres of larger size, but their attempt proved unsuccessful. However the information obtained appears of sufficient value.

A similar study was carried out, sponsored by the office of Naval Research of America [5]. The purpose was to investigate the manner of formation of certain hydrous siliceous minerals. In this paper, the formation and subsequent crystallization of the initial solid phases in the system Magnesia – Silica – Water was studied. Mixtures of magnesia and silica as silicic acid ranging in composition from 0.5 to 2.0 moles of MgO per mole of SiO_2 were treated hydro thermally at temperatures of 75 ^oC to 350 ^oC for various periods of time. The reaction solids were examined by differential thermal analysis, XRD, electron microscopy and chemical analysis. It was found that the compositions intermediate between 0.75 and 1.5 Magnesia / Silica ratio crystallized as mixtures of talc and Chrysotile like products. The Chrysotile like product appeared as minute needles of submicroscopic in size.

Cheshire [6], in his work concluded that chrysotile can be recycled into an economically valuable and non-hazardous smectite. His work was on chrysotile from Thetford Mines in Quebec, Canada. Chrysotile was treated with mild organic acids at concentrations 0.5 to 2.0 N at 200 ^oC in Teflon lined 12 ml parr bombs. Kerolite seemed to form and was further reacted with 0.2 N NaOH for 48 to 96 hrs at 200 ^oC for the formation of smectite, a non-hazardous mineral.

Shell [7] developed a method for estimating quantitatively the magnetite content, either originally present or as residual in Chrysotile. This method also helps in the beneficiation of chrysotile.

3 – Properties

Huggins and Shell [8] designed and built apparatus for density measurements. Bulk specimens of chrysotile and massive serpentine samples, both by using mercury and by coating the samples with paraffin and immersing in water, were used for density measurements. Samples were obtained from Canada, Africa, Arizona and New York. All the chrysotile samples were nearly free of cracks and admixed mineral impurities, except for 0% to 20% magnetite in the block of Canadian chrysotile. The entire fibre block except one exceeded 3/4 of an inch in cross section and one inch in length. The massive serpentine blocks were from Arizona and were of the highest purity we could obtain.

It was concluded that the density values of bulk chrysotile are in the range 2.2 to 2.4 gm / cc lower than postulated from x-ray diffraction data. The density of both bulk chrysotile and massive serpentine indicates a hollow-tube or partially filled hollow tube structure. X-ray patterns of the matrix were richer and sharper than those of fibre. An outstanding feature of the x-ray data was the ratio of the intensities of the line at 7.3 Å to that at 3.6Å (I 7.3 / I 3.6 ratio), which ranged in value from about 0.8 to 1.4 for the fibre's and 1.3 to 2.4 for the matrix. The specific volumes of the purest fibre's and matrix specimens agreed closely with the values calculated from the published unit cell size. Thermal balance and static loss on heating results indicated that a small amount of the total water is liberated at temperature higher than those required from dehydrating the brucite layer. Electron microscope showed that the matrix specimens contained varying amounts of fibre's apparently ranging in shape from flat laths to complete tubes. Specific volume measurements on three massive samples of chrysotile indicated porosities of 1.0, 8.5 and 12.5 percent.

Kalousek and Mattart [9] studied the chrysotile fibre and the adjoining layer of matrix of several specimens of serpentine and were compared for differences in chemical compositions, x-ray diffraction, specific volume, loss on heating, differential thermal analysis, thermal balance analysis and electron microscopy.

Results of chemical analysis showed that for each serpentine examined, the fibre's contained less Al_2O_3 and generally also less Fe_2O_3 and FeO than did the matrix.

4- Applications

Asbestos is used in wide range of products from household to industrial applications. Some of the products which may contain asbestos are used as construction materials for buildings in the form of corrugated sheets for rooftops and pipes for water supply and sewage. It is also used for thermal and electrical insulation purposes, such as casings for wires, pipes and boilers. It has usage in friction product applications such as clutch facing and brake lining in automobiles.

5- Risk to human health

Harmful health affects, if exposed to asbestos minerals depend on the factors which include ;

1. How much one has breathed in,
2. How long is a duration in which one is exposed to asbestos environment,
3. The route by which one is exposed, i.e., breathing, eating or drinking,
4. Other chemicals to which one is exposed.

Individual Characteristics, such as age, gender, nutritional status, family traits, lifestyle, and ones general state of health also affects the risk of getting disease.

It clearly appears that all the types of asbestos fibre are dangerous if one breathes them. Some people are of the view that some kinds of asbestos fibre are less dangerous however most of the scientists and doctors disagree. Asbestos fibres are measured in units of fibres per cubic centimeter of air (f/cc). The Minnesota department of health has established a clean air level of 0.01 f/cc. Studies show that if breathed, asbestos fibre may increase the risk of asbestosis, lung cancer and mesothelioma which is a cancer of the lining of the chest or abdomen. Asbestos exposure may also increase the risk for cancers of the digestive system including colon cancer.

6- Conclusion

Chrysotile asbestos is legally declared a carcinogenic health hazard in the United States and Canada [6, 10, 11, 12, 13, 14]. Therefore it requires the removal of all forms of asbestos in all public places, which needs chrysotile to be disposed off in the land fills (buried in the soil), hence moving the hazard to a relatively secure place. Further research needs to be done in modifying or altering these hazardous minerals to non hazardous ones by chemical treatment or develop technology for the synthesis of fibre's with minimum respirable level (thicker fibre) and lowest biopersistency.

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