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PROJECT REPORT

PROPERTIES OF COLLOIDAL CHRYSOTILE ASBESTOS FROM THE COALINGA REGION OF CALIFORNIA

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SUMMARY

The surface and colloidal properties of chrysotile asbestos from the Coalinga deposit in California have been studied during the period 1963 to 1968. Data have been collected and interpreted to develop an understanding about the nature of the chrysotile surface in water. The results of other investigations are quoted extensively to present a more complete description of the asbestos system. The preparation of both chrysotile asbestos and chemically modified asbestos products is described and their utilization in practical systems is discussed.

Flakes of asbestos ore consist of tangled mattes of microscopic fibrils. The ore can be processed readily to yield a much higher proportion of individual fibrils than can the conventional long-fiber asbestos. The fibrils have a diameter of about 260 Å. They are of widely varying lengths but are estimated to average about 5 microns in length.

The composition of the fibrils is: $Mg_6(OH)_8Si_4O_{10}$ with small amounts of aluminum substituting for silicon and some iron substituting for magnesium. The fibril structure is made up of groups of sheets curling around in a helical manner to form hollow tubes. Each sheet consists of a layer of magnesium hydroxide bonded to a layer of silica. The curvature is such that the magnesium hydroxide is always on the outside which gives the fibrils their basic surface properties. The fibrils have a very well developed crystal structure, resulting in mechanical properties high enough to consider them as whiskers.

The magnesium hydroxide surfaces of the fibrils react with water, giving them hydrophilic surface characteristics. A maximum of about 90 micromoles of positively charged sites can be developed per gram of asbestos in water. Some negative sites, up to 20 to 30 micromoles per gram of asbestos, may also be present. The net charge on a fibril surface is zero at pH 10.8 and an increasingly larger positive charge develops as the pH is progressively reduced. An asbestos suspension is normally flocculated, but at a pH value less than 5, the repulsion due to mutual positive charges is large enough to overcome attractive forces between fibrils and a dilute asbestos suspension becomes dispersed. This is observed only if no detrimental anions are present. Acetate, acrylate, and methyl sulfonate anions are not harmful, but such anions as chloride, nitrate, and sulfate, respectively, are increasingly detrimental. They neutralize the surface charge by adsorbing on specific surface sites and prevent dispersion of asbestos suspensions.

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The surface of a fibril can be chemically modified to create silica groups there. A fiber with an adsorbed coating of silica can be further modified with small additions of alumina to give it a permanent negative charge in water. Large amounts of alumina, thoria, titania, or probably any hydroxyl complexes of multivalent cations can be extracted from solution by the silica-treated asbestos surface to make fibers with unique surface properties.

The fibers can be made more hydrophilic than normal by treatment with water-soluble anionic polymers to produce more stable aqueous suspensions. Alternatively, for applications in non-aqueous systems, the asbestos fibers can be made hydrophobic by treatments with various anionic surfactants.

All applications depend basically on three basic properties of the fibrils: their surface properties, their colloidal size and fibrous shape, and their high strength. These naturally lead to applications for making co-flocculated products with other colloids, for thickening of liquids and for reinforcing of plastics. Co-flocculated aggregates are formed when the cationic chrysotile fibrils interact with other anionic colloidal particulates, resulting in commercial products such as Asbestos-T. Thickening of liquids is accomplished at addition levels as low as 1 weight per cent due to the larger number of fibrils, approaching 10^{14} per gram of asbestos, and their elongated shape, which gives them a large "effective" volume for interaction. Composites of asbestos in polystyrene have been prepared in the laboratory which have tensile strengths and tensile moduli that are over three times higher than those of polystyrene.

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INTRODUCTION

An asbestos group was formed under the auspices of the Nuclear Company to exploit colloidal chrysotile asbestos from a huge deposit located in the Coalinga region of California. The ore was in a high-grade, friable, massive deposit found on the surface and could be mined very cheaply. The fiber in the ore was very short, comparable in size to the Grade 7 sold by the traditional asbestos producers. This is the poorest grade and consists of fine rejects from the production of long-fiber grades of asbestos. The Grade 7 product is very impure, containing much rock dust and abrasive particles in addition to the fine asbestos fiber. It was recognized early in the investigation that the Coalinga ore could be processed in an aqueous circuit to make a very pure colloidal fiber product which would be unique in the asbestos industry. A mandate was given to a research and development group to study the properties of this chrysotile and develop new uses for colloidal products made from Coalinga asbestos.

The group was located at the Research Center, Tuxedo Park, New York. F. A. Mumpton and C. S. Thompson established the mineralogy of the deposit. The other research aspects of the project were done by W. H. Dresher and A. W. Naumann. They measured such properties of the asbestos as the dimensions of the fibers and their surface area, textural and thermal characteristics. In addition, they began investigation of the surface and colloidal properties of chrysotile. I joined this group in 1963 and concentrated on further study of the surface chemistry of chrysotile asbestos.

The asbestos group was transferred to the Mining and Metals Division in 1965 and relocated at their facilities in Niagara Falls, New York. At this time the emphasis of the research was changed to finding ways of chemically modifying the surface properties for applications in systems where the intrinsic surface properties of chrysotile were unsuitable. This was considered to be practical since our processing was done in an aqueous circuit. K. Park joined the group in 1966 to study the rheological properties of chrysotile suspensions. The asbestos group formally became part of Chemicals & Plastics in 1967, but it continued to be located at the Niagara Falls plant site.

The object of this report is to record my contributions to the study of chrysotile properties. My data are presented in detail with specific comments about them, and an over-all description of the asbestos system is given under the section on Discussion. Where I have not personally studied areas critically important to an understanding of the system, I have liberally quoted results and conclusions from the works of Mumpton, Dresher, Naumann, and Park, and from the literature. It should be cautioned that some of the data reported have been submitted to us on a personal basis, and those data from publications are the property of the publishers, so permission must be obtained from these people before public use can be made of them.