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FIBROUS MINERAL CONTENT OF CONSUMER TALC-CONTAINING PRODUCTS

A. N. Rohl and A. M. Langer

Environmental Sciences Laboratory, Mount Sinai School of Medicine, City University of New York, New York, New York 10029

INTRODUCTION

Approximately 800,000 tons of raw talc are produced annually in the United States. Talc is used in a number of industries, for a variety of purposes, e.g., the manufacture of ceramics, paints, paper, rubber, roofing, insecticides, stucco, plastics, textiles and soaps (Wells, 1978). Pulverized talc is also used, on a much smaller tonnage basis, as an ingredient in such consumer products as cosmetic talcums, paper mache and modeling compounds, in spackling, patching compounds and putties, in automotive and boat body repair fillers and caulking compounds. The uses of talc in food products include rice coating, peanut polishing, candy molding and salami dusting. It is also used as a filler and excipient for pharmaceutical pills, and for dusting contraceptive diaphragms. Undoubtedly, there are other uses of talc in consumer products which are not generally known. Each product carries with it a distinct and individual inhalation and/or ingestion potential of the mineral components.

The present report will deal with our studies of four types of these products, specifically talcum powders, spackling and patching compounds, talc-coated rice, and modeling materials. We have studied talc in other types of consumer products, but these four categories represent the varietal range of applications. It was our purpose to examine these materials to determine the presence or absence of minerals with known or suspected disease potential, specifically the fibrous amphiboles, quartz, and the asbestos of mineral chrysotile.

GEOLOGICAL OCCURRENCE OF TALC

Talc rocks occur fairly commonly in nature, and are formed as the result of two important geological processes, i.e., the hydrothermal alteration of ultramafic rocks and the low grade thermal metamorphism of silica-rich dolomite, $CaMg(CO_3)_2$. These metamorphic processes frequently result in the formation of an assemblage of co-existing minerals, principally hydrous magnesium silicates, but also hydrous calcium-magnesium-iron silicates. Some of these are the magnesium and calcium amphibole minerals, which include anthophyllite and tremolite; and the serpentine minerals, including chrysotile asbestos. Depending on the nature of the parent rock, varying amounts of mica minerals (e.g., chlorite), quartz and carbonates may also be found (Table 1). Although pure talc deposits exist, very frequently the mineralogically complex deposits are used to provide "talc" for both industrial and consumer products. The mineral talc is a layer-type sheet silicate with the empirical chemical

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TABLE 1. Minerals which are commonly found in talc deposits

	Mineral	Ideal formula
Carbonates	Calcite	$CaCO_{03}$
	Dolomite	$CaMg(CO_3)_2$
	Magnesite	$MgCO_3$
Amphiboles	Tremolite	$Ca_2Mg_5Si_80_{22}(OH)_2$
	Anthophyllite	$(FeMg)_7Si_80_{22}(OH)_2$
Serpentine	Antigorite	$Mg_3Si_20_5(OH)_4$
	Chrysotile (uncommon)	$Mg_3Si_20_5(OH)_4$
	Lizardite (uncommon)	$Mg_3Si_20_5(OH)_4$
Others	Quartz	$Si0_2$
	Mica, e.g. Phlogopite	$K_2(Mg,Fe)_6[Si_6Al_20_{20}](OH)_4$
	Chlorite, e.g. Penninite	$(Mg,Al,Fe)_{12}[Si,Al)_80_{20}](OH)_{16}$

formula, $Mg_3Si_40_{10}(OH)_2$. However, aluminum (Al) or titanium (Ti) may substitute for silicon (Si), and iron (Fe) manganese (Mn), nickel (Ni), chromium (Cr), cobalt (Co), etc., may substitute for magnesium. Trace metal contamination is common. One talc deposit in the eastern United States, containing up to 0.2% Ni and substantial amounts of Cr and Co, has been used as a source of consumer talcums for many years. The layers of talc are very weakly bound to one another, and this accounts for the ease with which it breaks into sheets or platy fragments. This excellent cleavage, combined with high surface area, softness and light color make talc important as both an industrial and consumer material. The geology and mineralogy of talc have been extensively reviewed elsewhere (Rohl and Langer, 1974; Rohl *et al.*, 1976).

ANALYTICAL TECHNIQUES FOR IDENTIFICATION AND QUANTIFICATION OF FIBROUS MINERALS IN TALC

Techniques which have been successfully used for the analysis of mineral fibers in talc products include optical microscopy, x-ray diffractometry and electron beam instrumentation.

The use of polarized light optics has long been a standard technique for the identification of minerals. By using immersion oils of known refractive indices, for example, the optical properties of unknown crystalline particles can be determined. However, there are a number of conditions which limit the usefulness of optical microscopy. The accurate determination of refractive indices is extremely difficult when applied to particles less than 1 μm in diameter. The optical properties of fibrous minerals frequently obviates full characterization of their optical constants. In consumer talc products, most of which are finely pulverized powders, the particle

identification very difficult, if not impossible. Large numbers of fibers may go undetected when this technique is used exclusively (Stanley and Norwood, 1973). However, it may be useful in some cases, at least as a screening or preliminary technique.

X-ray powder diffraction has been used in both the continuous scan and step-scan modes of operation for the identification and quantitation of fibrous minerals in talc (Rohl and Langer, 1974; Rohl *et al.*, 1976; Stanley and Norwood, 1973). This can be achieved by comparison of dilutions of known minerals in a talc matrix with unknowns. Quantitative analysis using this technique requires (1) a talc standard or matrix completely free of contaminating minerals and pure standards of fibrous minerals for preparing talc-fiber dilution standards; (2) a preparation method which is both sensitive and reproducible; and (3) selection of diagnostic x-ray reflections for quantitative analysis of specific minerals. X-ray diffraction in the step-scan mode is used for quantitative determination of tremolite, chrysotile and anthophyllite in talc at levels as low as 0.1%, 0.25% and 2.0%, by weight, respectively (Rohl and Langer, 1974; Rohl *et al.*, 1976). These minerals are often found as fine-grained and intimate components of talc rock, and they are of particular concern as constituents of consumer talc products because of their biological potential (Daymon, 1946; Dreessen, 1933; Dreessen and Dalla Valle, 1935; Kleinfeld and Messite, 1960; Kleinfeld *et al.*, 1955, 1967, 1973; Mclaughlin *et al.*, 1949; Millman, 1947; Noro, 1946; Porro and Levine, 1946; Porro *et al.*, 1942; Reichman, 1944; Schepers, 1965; Siegal *et al.*, 1943). The major limitation of x-ray diffraction analysis is its inability to distinguish between different morphological habits of the same mineral. For example, short tremolite fragments and long fibers of asbestiform tremolite give virtually identical x-ray patterns. To distinguish between different habits or shapes of the same mineral, including asbestos minerals, requires microscopic techniques.

Transmission electron microscopy, used in conjunction with selected area electron diffraction (SAED), provides the resolution capability to visualize all particles and, in many cases, to identify them. For example, at magnifications of about 25,000x, or greater, chrysotile fibers may be identified on the basis of their unique morphology. In some instances, the morphological similarities between fibrous talc and amphibole fibers may be close enough to preclude the unequivocal identification of the latter on the basis of such characteristics as cleavage, diffraction contrast figures and aspect ratios. However, talc fibers can be easily distinguished from amphibole fibers on the basis of SAED patterns.

CONSUMER PRODUCTS STUDIES

Consumer Talcums and Powders

In a paper published in 1976, we reported a mineral and chemical chacterization of 20 consumer talcums and powders obtained in New York city during the period 1971-1975 (Rohl *et al.*, 1976). Where known, all were formulated prior to 1973. Of the twenty products, 10 contained either tremolite or anthophyllite or both. The proportions, determined by step-scan x-ray diffraction ranged from 0.1% to over 14%, by weight. No attempt was made to distinguish proportions of fibrous and non-fibrous morphological phases, although every sample contained fiber. Two contained detectable amounts of chrysotile. The presence of these



FIGURE 1. Electron photomicrograph of amphibole fibers in cosmetic talcum powder. x25,000



FIGURE 2. Electron photomicrograph of amphibole fibers in cosmetic talcum powder. x52,000

Quartz was found in eight samples, with seven ranging from 2 to 5%, and one as high as 35%. Chemical determinations, including bulk chemistry and trace metals, were also made on the twenty samples. Four samples showed systematically high levels of nickel, chromium and cobalt, with average values, in parts per million, of 890, 518, and 57, respectively. The mean concentrations of nickel, chromium and cobalt in the other 16 samples were 18, 29, and less than 3, respectively.

A study, by this laboratory, of cosmetic talcums purchased during the period 1975-1978 is in progress. Preliminary results suggest that fewer products contain fibrous minerals.

Spackling and Patching Compounds

Spackling and patching compounds consist of fine-grained powders or premixed pastes. The ingredients usually are plaster of paris, limestone, talc, clays, micas or some other type of pulverized rock filler. Chrysotile is added to some products to provide reinforcement, and to control shrinkage and cracking as it cures. Fibrous amphibole minerals are found in some products because they occur naturally in talc, carbonates and other raw materials. In a paper published in 1975, the mineral content of 15 consumer spackling compounds purchased during the period 1972 to early 1974 was reported (Rohl *et al.*, 1975). Two products contained talc as major components, and one of these also contained about 4 to 6%, by weight, of tremolite. Chrysotile was found in three products, ranging from 5 to 10%, by weight. Another product consisted principally of anthophyllite (10-12%) and quartz. Quartz was found in nine products, in proportions ranging from 5 to 70%, by weight. Optical and electron microscopic analyses showed that the asbestos and other mineral fibers ranged in length from 0.25 to 8.0μm (Figure 3). Almost all were shorter than 5 μm in length, which is of respirable size, yet they were not detected by optical microscopy. The paper also reported the results of mineral analyses of 10 industrial taping compounds used in drywall building construction. Nine of ten contained chrysotile in about the same proportions (5-12%) as the consumer products. Air measurements made during mixing, sanding and clean-up of drywall taping showed that airborne concentrations of two fibers per milliliter of air, or more, were common. Electron microscopic analyses of the air samples showed that, for every fiber visible by light microscopy (x400 magnification), from 200 to 1,000 fibers could be seen at magnifications of x 25,000. In the follow-up to this study, during 1975, five different consumer spackling compounds were obtained and analyzed. Of the five, four had talc present as a major phase, and also contained tremolite or anthophyllite, ranging from 2 to 12% by weight. Chrysotile was also found in three of the five products in proportions ranging from 5 to 15% . The latter concentrations reflect chrysotile as an additive, not as a talc contaminant.

Talc - Coated Rice

The practice of coating short grain and medium grain rice has been common in the United States for over 50 years. Several explanations for this practice have been advanced. The principal reason given for coating rice is to give an appealing smooth and shiny luster to the product. Puerto Rican, Oriental and Hawaiian consumers reportedly show a decided preference for coated rice. It has also been claimed that coated rice better withstands insect and fungal infestation and maintains moisture stabilization.

The U.S. Department of Agriculture statistics indicate that about 300 million



FIGURE 3. Electron photomicrograph of chrysotile fibers in consumer spackling compound. x52,000 magnification. The fibers are all less than 5μm in length. Other particles are plaster of Paris, talc and mica

that an additional 470 million pounds were distributed to the Territories and the State of Hawaii that year (Federal Register, 1977). The total of 700 million pounds of coated rice represents about one-third of the rice sold in the United States and its Territories annually. Approximately, one pound of talc is used for coating 100 pounds of milled rice.

Two samples of talc powder which are used for the coating of rice, that is, raw powders, were obtained from rice dealers. Five samples of talc-coated rice were purchased from local grocery stores. Three duplicate purchases were made. Standard weights of rice samples were washed twice in known volumes of water. Prior to rinsing, the water used for washing the rice was passed through an absolute filter to remove any adventitous mineral contamination. After each rinse, the wash water was passed through a 0.4μm membrane filter to remove insoluble material.

The material retained was dried, weighed and ashed in nascent oxygen to remove organic substances, then reweighed. These residues and the two raw talc powders were prepared and step-scanned for diagnostic asbestos reflections by x-ray diffraction according to procedures described by Rohl *et al.*, (1976). In addition, polarizing optical microscopy, transmission electron microscopy and microprobe techniques were used to verify and further characterize the minerals present.

Quantitative analysis of talc coating showed that one of the two samples of talc powder contained tremolite on the order of 5% by weight. Three of the eight rice coating residues were also found to contain tremolite and anthophyllite, up to 6%, by weight, and averaging about 3%. Another rice residue contained about 20% of a fibrous amphibole mineral, with a chemical composition similar to glaucophane. In four samples amphiboles were not detected by x-ray diffraction. However, analyses by transmission electron microscopy and microprobe showed that three contained trace amounts of asbestiform amphibole minerals. Chrysotile was not detected in any samples. Eleven samples of short-grain rice were purchased by colleagues in various cities in the United Kingdom, where much of the rice is imported from Australia and Italy. The washings of these samples of rice were found to contain no talc. One sample coating was found to be calcium carbonate.

Talc-containing Modeling Materials

Arts and crafts or modeling materials consist of dry powders, often mixtures of plaster of paris or gypsum, or calcium carbonate, or talc with fibrous minerals including chrysotile, tremolite and anthophyllite. These powders are mixed with water, and then cast, or shaped, into figures.

In the school year 1971-1972, The New York City Board of Education had purchased 50,000 packages of paper mache'-type material, each package containing five pounds. The product, upon analysis, was found to contain about 50% chrysotile. As a result, use of the product was discontinued in New York City schools. The material which was subsequently submitted for it consisted of a mixture of plaster and talc, including 15% to 20% tremolite and anthophyllite. Thereafter this material was discontinued as well.

Six other commerical samples of arts and crafts materials, some marketed specifically for grade-school children, were analyzed for their mineral content. Of the six, three contained talc, and also tremolite and chrysotile. The asbestos and



FIGURE 4. Electron Photomicrograph of asbestiform amphiboles in dry mix-type modeling compound.

CONCLUSIONS:

Some of the studied consumer products which contain talc have been found to contain varying amounts of natural mineral contaminants, some of which have been demonstrated to be biologically active in humans. These minerals include chrysotile, anthophyllite, tremolite, and quartz. In addition, a number of trace metals were detected in forms essentially unknown. It is therefore recommended that:

1. The significance of these materials in consumer products be evaluated on a systematic clinical or epidemiological basis. Heavy intermittent or habitual use of these products with high levels of fibrous mineral fibers may produce disease. For example, recognition of this possibility has led to efforts by the cosmetic talcum industry to reduce or eliminate contaminated products by changing their sources of raw materials;

2. Air measurements taken during drywall construction suggest that using consumer spackling and patching compounds during home repair work could expose members of entire households to high concentrations of dust. An assessment of the risk to consumers was made by the Consumer Product Safety Commission in proposing rules to regulate patching compounds (Blejer and Arlon, 1973). It was calculated that, for a conservative yearly exposure of four six-hour days, the increased risk of death from respiratory cancer from even such a modest exposure would be unacceptable;

3. While some investigators have proposed that the ingestion of fiber-contaminated talc products may pose a hazard of increased neoplastic risk, especially of the gastro-intestinal tract (Hammond *et al.*, 1965; Henderson *et al.*, 1975; Matsudo *et al.*, 1974; Merewether, 1930; Selikoff *et al.*, 1967), this disease potential is presently unknown. Talc-coated rice frequently constitutes a staple of the diet of many Americans, and one kilogram per week of talc could be consumed by some individuals. Since several of the talc coatings analyzed contained up to 5% and 6% amphibole minerals, some individuals could ingest about 600 milligrams per week of these mineral contaminants. Approximately 9.4 grams of talc would be ingested at the same time. The coating of rice with talc should be reviewed with the aim of eliminating it, or substituting coatings that do not contain these suspect minerals;

4. The presence of unbound asbestos, fibrous, and quartz minerals of respirable size in arts and crafts materials, especially those used by children with their long life expectancy, represents in our view an unacceptable exposure. These should be eliminated from such products immediately. Artists, artisans and hobbyists may also be exposed to these materials, as well as to similar dusts generated during sculpting of talc or steatite rock. These individuals should be made aware of hazards associated with such exposures, and should protect themselves accordingly.

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