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Examination of Asbestos Floor Tile by White Light Interference Microscopy and Scanning Electron Microscopy

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KEY WORDS

Surface profiler, depth, white light interference, floor tile, VAT, asbestos

ABSTRACT

This study involved the application of a scanning white light interference microscopy (SWLIM) surface profiler and scanning electron microscopy in the examination of the surfaces of asbestos-containing floor tiles after abrasion. Although asbestos-containing floor tiles are non-friable when new, it is evident that asbestos fibers are released from the tiles under certain circumstances. The mechanism involved in the release of asbestos fibers from a product in which a vinyl or asphalt binder is present has not been fully described. The results described here demonstrate the use of complimentary microscopy techniques to assess a mechanism by which asbestos fibers can be liberated from floor tile due to foot traffic.

INTRODUCTION

Vinyl asbestos tile (VAT) was manufactured by mixing dry ingredients, polyvinyl chloride (PVC) resin, copolymers, limestone filler, pigment (usually titanium dioxide), and asbestos fibers. The materials were heated and mixed with metal blades. Once the mixture reached a specified temperature and degree of plasticity, it was rolled to a predetermined thickness and cut to size. A similar manufacturing process was used to make asphalt asbestos tile.

Although asbestos-containing floor tiles are non-friable (not easily crumbled to dust under hand weight) when new, it is evident that they wear with use (Figure 1).

In 1982, French researchers (1) published the first measurement of elevated concentrations of indoor airborne asbestos associated with the weathering of asbestos floor tiles during their service life. They concluded that the short chrysotile fibers present in the air of the building had escaped from the vinyl matrix of the floor tiles. The fact that the highest concentrations were measured in the workshop on the third floor, where the activity was greatest, reinforced their conclusion. They hypothesized that, in this workshop, breakdown forces such as walking and other activities were higher. A study in 1984 also reported that increased airborne asbestos fiber concentrations could be present in buildings where the only known source of asbestos is floor tile (2).

The release of asbestos fibers from the matrix of vinyl or asphalt tiles that have been partially pulverized during sawing, drilling and chipping has been well documented. Work practices to prevent fiber release during these activities have been issued by the United States Environmental Protection Agency (3) and others (4-7). Less abrasive procedures such as buffing have also been shown to cause increased airborne asbestos concentrations (8, 9).

The fact that the matrix does not totally encapsulate asbestos fibers in a product where a vinyl or asphalt binder is present has been noted previously (10). Although the outside of a fiber bundle or clump may be coated with the binder; once the coating is broken, asbestos fibers are available to be released upon further abrasion. In one study, the researchers found that: "Surface adhesive lift and cross-sectional bulk sample analysis indicated that the wax layer which had accumulated and had been replenished

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periodically on the surface of the VAT served as a sink or reservoir for asbestos structures and matrices which may have migrated from the tile as a result of physical wear and abrasion. The surface analysis clearly revealed the presence of free asbestos structures in the wax layer on the surface of the VAT."(11)

STUDY PROCEDURES

This study used a scanning white light interference microscopy (SWLIM) surface profiler and scanning electron microscopy to examine the surface of floor tile for asbestos fibers after abrasion.

The investigation of floor tile asbestos fiber release involved two studies. In the first, floor tiles removed from buildings were subjected to a simulation of abrasion (scratching and gouging by dirt particles). In the second, floor tiles extracted from buildings after a period of normal use were examined for evidence of abrasion. Both vinyl asbestos (VAT) tiles and asphalt tiles were tested.

Study 1

Floor tiles that had been identified as having been manufactured by a number of companies were obtained from state and local government buildings. Samples of dirt were also obtained from those buildings, or immediately outside the buildings. In performing the abrasive testing process of this study, a researcher wearing a moistened, flat, leather soled shoe stepped into dirt. With some dirt on the bottom of his shoe, the researcher then stepped onto the tile with weight measured to be approximately 100 pounds and rotated his foot ninety degrees ten times. He then stepped into dirt again and repeated the activity. The abrasive testing process was repeated 3 times for a total of 30 rotations on each tile. The tile surfaces were photographed at intervals during the process. After the testing process, portions of each tile were examined microscopically for information about the depth of scratch and pitting penetration and evidence of asbestos fibers protruding.

Study 2

Floor tiles were extracted from buildings belonging to a state government. These tiles had been in place for a period of years and had seen the wear and tear of normal use. Portions of each tile were examined microscopically for information about the depth of scratch and pitting penetration and evidence of asbestos fibers protruding.

METHODS AND EQUIPMENT

The tile and dirt material samples were analyzed for asbestos by polarized light microscopy (PLM) utilizing an Olympus BH-2 polarized light microscope. Transmission electron microscopy was used to analyze some of the floor tiles for asbestos.

After the shoe abrasion testing, the tile sample surfaces were examined by stereomicroscopy utilizing a Zeiss Stemi 2000 stereomicroscope and by scanning electron microscopy (SEM) using a JEOL 6400 coupled with an x-ray energy dispersive spectrometry (EDS) Noran Voyager system. Measurement of the depth of some of the indentations in the tested tiles was performed using a WYKO scanning white light interference microscope (SWLIM) surface profiler operated in the vertical scanning mode at a magnification of 2.5 (12 and 13). The vertical scanning technique has a 500 μm range with a lateral resolution of 15 μm and a vertical resolution of 1 nanometer.

RESULTS

Samples of dirt were composed primarily of soil mineral and plant fragments. Some shards of glass were seen. No asbestos-containing material was detected. All the floor tiles used in the study were found to contain asbestos. It was found that floor tiles were damaged by a dirty shoe under weight. Particles in the dirt caused grooves to be ground into the tile surfaces (Figures 2 and 3). The light interference microscope scans showed varying depths of the grooves caused by abrasion testing. Surface scratches and gouges over 10 μm were common (Figures 4 and 5). In addition to similar scratches and gouges, as seen in the simulation study, the normal use tiles examined in Study 2 showed evidence of pits which were over 40 μm deep (Figure 6). In the scanning electron microscope images, uncoated chrysotile fibers were visible in some grooves of the tiles (Figures 7 and 8). Some tiles in which shorter asbestos fibers were present required more analysis time than tiles that had longer fibers. The microscopical findings were similar for the floor tiles in Study 2 where the tiles had been subjected to normal use in state buildings.

DISCUSSION AND CONCLUSIONS

Wax layers are reportedly 3 μm thick (14). Therefore, even with two layers of wax, the scratches and gouges occurring from the interaction between a floor tile and dirt on a shoe is sufficient to reach the

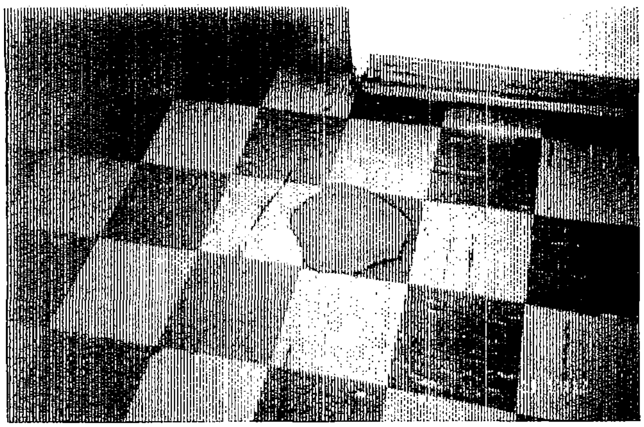

Figure 1. An example of an area of asbestos-containing floor tile that had worn away completely.

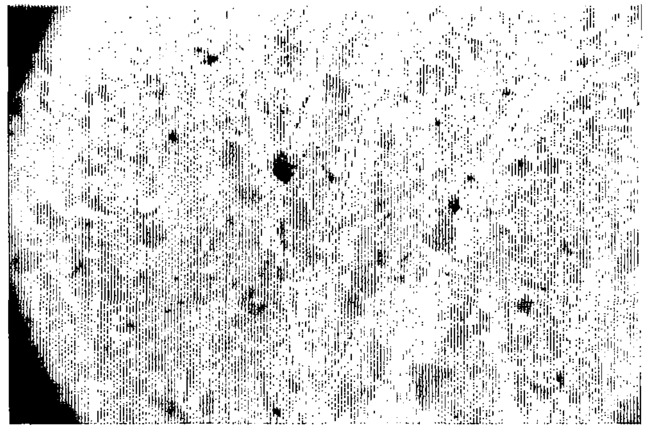

Figure 2. View of scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight. Magnification = approximately 30x.

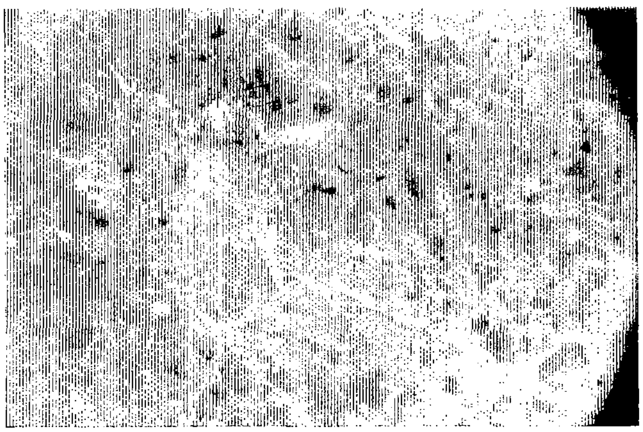

Figure 3. View of scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight. Magnification = approximately 30x.

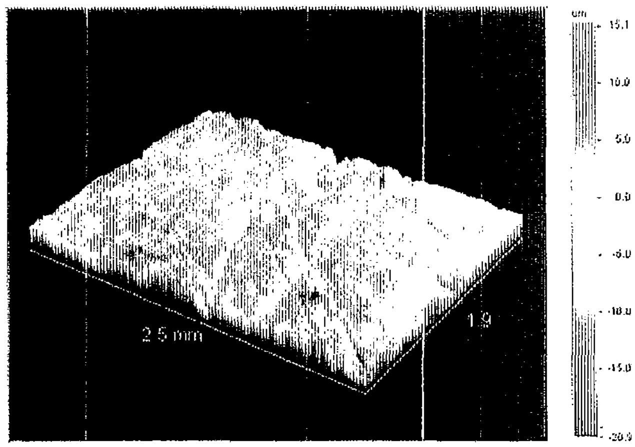

Figure 4. Scanning white light interference microscope view of scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight.

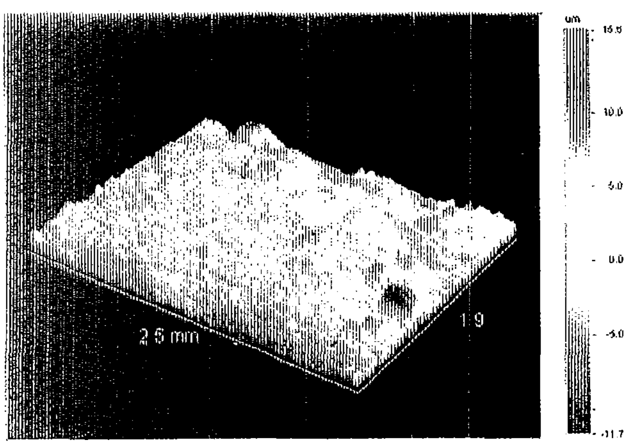

Figure 5. Scanning white light interference microscope view of scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight.

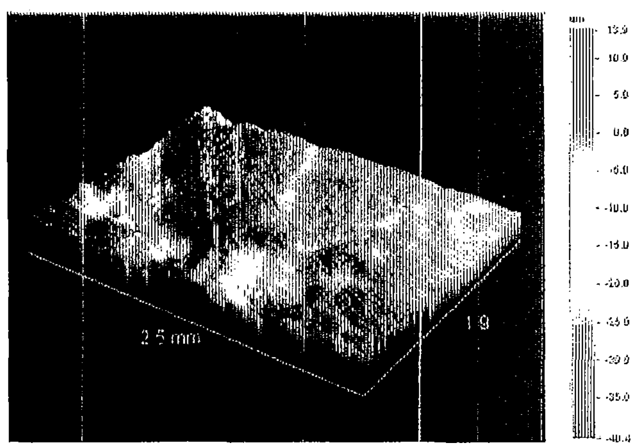

Figure 6. Scanning white light interference microscope view of a pit and scratches on a floor tile surface from a tile taken from a building after years of normal use.

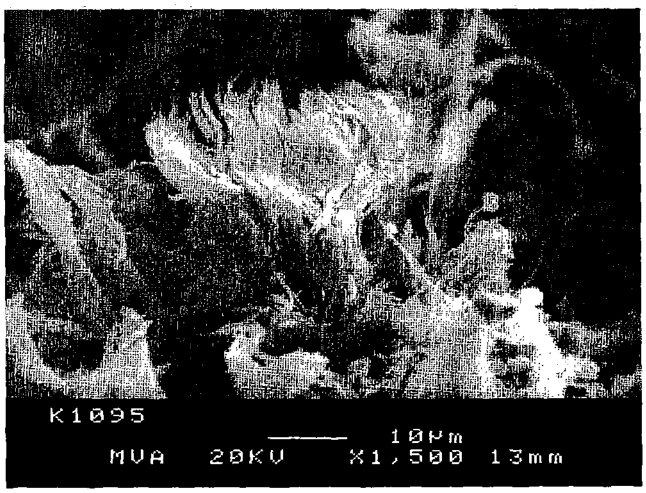

Figure 7. Scanning Electron Microscope view of uncoated asbestos fibers in scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight.

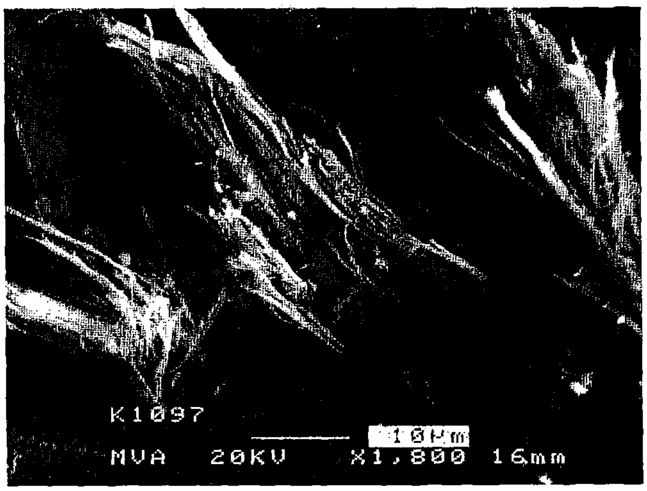

Figure 8. Scanning Electron Microscope View of uncoated asbestos fibers in scratches on a floor tile surface caused by a dirty shoe under approximately 100 pounds weight.

asbestos fibers in the floor tile matrix. Pits and scratches occurring during the normal use of floor tiles can be deeper than the layers of wax that might be put on a tile. Asbestos fibers observed in the scratches, grooves, gouges and pits were not completely coated by the floor tile binder material. Breaking off of these fibers through additional wear of the tiles is one possible explanation for the increased airborne asbestos fiber concentrations reported in buildings where the only known source of asbestos is floor tile. This study demonstrates a mechanism by which asbestos fibers may be liberated from floor tile due to normal foot traffic.

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periodically on the surface of the VAT served as a sink **METHODS AND EQUIPMENT**