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Analysis of mineral fibers used in the vintage speaker

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Abstract

Risk of Exposure to asbestos from unknown consumer products always has been worrying to consumers. Especially, consumer products manufactured before the asbestos ban would contain asbestos in their products. Consumers worried about exposure to asbestos from the vintage speakers manufactured before the asbestos ban during use or repairing. In this study, we have analyzed mineral fibers sampled from the AR-3a speakers which were manufactured in 1973. The mineral samples were collected when the speakers were repaired and analyzed by Transmission Electron Microscope (TEM) equipped with an Energy Dispersive X-Ray Analyzer (EDX) for their detained composition. The TEM-EDX analysis of the mineral fibers sampled from the speaker indicated that the fibers were glass wool, not asbestos fiber.

Introduction

Asbestos exposure always has been a social issue in Korea after banning of use, import and manufacturing more than 0.1% asbestos-containing products on Jan 1, 2009, according to Occupational Safety and Health Act [1]. Although the use of asbestos in Korea began in the 1930s, the widespread industrial use of asbestos began in the 1970s, when modem Korean industrialization had begun. The main uses of asbestos were for construction materials (82.3%), for friction materials such as brake lining (10.5%), and for asbestos textile had been propagated extensively into the living environment during the Saemaol Woondong (New Town movement) period from the early 1970s through the 1980s. Many Korean traditional roofs made of straw in rural areas had been forced to use slate roofs, containing asbestos, instead [2]. The use of asbestos increased from the 1980s to the 1990s as the Korean economy prospered. It reached 88 722 Mg (tons) by 1995 [3]. Although the banning of asbestos and removal of asbestos contribute to lower the risk of asbestos exposure, many Koreans have been, and are still being, exposed to asbestos in working and living environments.

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AR-3a speaker replaced AR-3 in 1969 with a new dome mid-range and tweeter reduced in dimensions, for even better mid and high-frequency dispersion [4]. The AR-3a is a three-way speaker and measures approximately 25" x 14" x 11½ " inches and weighs about 46lbs each (Figure 1A). Its cabinet is made of real walnut veneer, grills are mostly cream-colored. Each speaker has a 12-inch woofer, a dome midrange, and a ¾ inch dome tweeter. High and mid-frequencies can be additionally adjusted at the back of each speaker [4]. The speaker manufactured Oct 1973 (Figure 1B) purchased 70's and used until 1982 and stored until recently was sent to repair shop. The repair shop would like to charge more money because the speaker had a filler inside of the speaker, which was suspicious of asbestos. Thus, they would like to charge more money to manage the risk of exposure. After an internet search, several audio sites also mentioned about the presence of suspected asbestos inside of speakers, and earlier patents to a recent patent for loudspeaker described the use of asbestos for sound absorbing or diaphragm for speakers. Therefore, the filler sample obtained from the vintage speaker AR-3a was collected and analyzed for the identification of asbestos or any other mineral fibers. The sample was analyzed by Transmission Electron Microscopy (TEM) equipped with an Energy Dispersive X-Ray analyzer (EDX) for their composition and electron diffraction pattern to identify species of asbestos or mineral fibers.

A. Feature

B. Inspection label

Figure 1: AR-3a speaker

Materials and methods

Sample preparation

The vintage AR-3a loudspeakers which were manufactured and inspected in Oct 1973 were brought to a repair shop (Figure 1). During the repair of the speaker, a small amount of sample was obtained (Figure 2). The sample had a yellowish color and cotton shape (Figure 2). The sample was prepared according to the sample preparation method described by Sakai for electron microscopic examination [5-7]. The sample was broken into small pieces and then powdered using mortar and pestle. A very small amount (about 1mg) of the powder was suspended in 50 ml of distilled water and then ultrasonicated for 30 mins to disperse particulate evenly. Some of the mixture (5 ml) was filtered through a polycarbonate filter (Millipore #GTTP 02500, nucleopore filter, pore size 0.2 µm, diameter 25 mm). After drying, the filter was coated with a thin layer of carbon in a vacuum evaporator (EMITECH, K950, Kent, UK), and then cut into a piece of 3mm^2. A piece of the filter was placed on a carbon-coated nickel grid (EMS, diameter 3 mm, 200 mesh, Hatfield, PA) and then dissolved with chloroform vapor, and left overnight to dry.

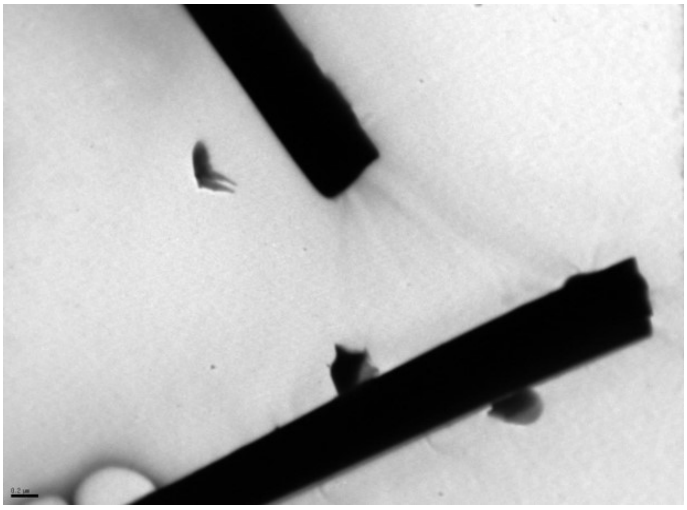
Figure 2: Filler sample obtained from the speaker

Analysis of mineral fibers

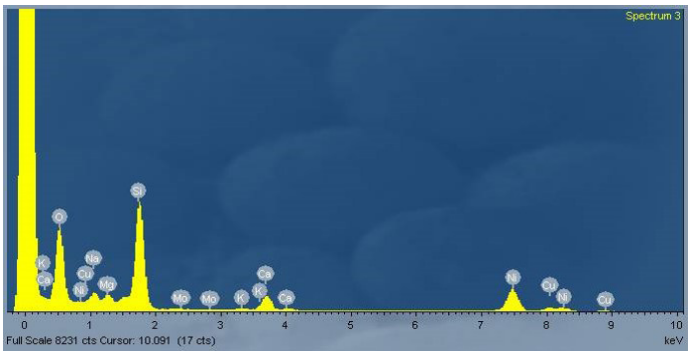
The samples were analyzed using a TEM (Transmission Electron Microscope, H-7100FA, Hitachi, Japan) equipped with an EDS (Energy Dispersive X-ray Spectrometer, EX200, HORIBA, Japan) at an accelerating voltage of 100kV.

Results

The mineral fibers analyzed by TEM-EDX was identified as glass wool with shape and composition (Figure 3), not asbestos fibers. The diameter of this fiber was 0.6µm. The composition of fibers is a typical range of glass wool described in the Toxicological Profile for vitreous fibers [8]. Also, the fibers had a similar shape and composition previously we have analyzed for glass wool (Figure 4).



A. Electron micrograph of the sample

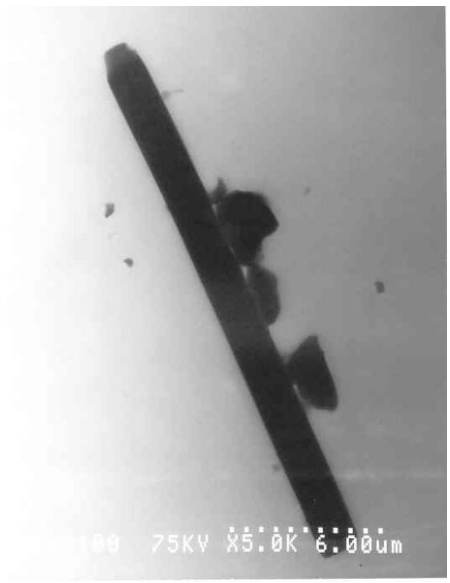


B. TEM-EDX profile

Element	Na K	Mg K	Si K	Ca K	Total
Atomic %	8.52	6.29	73.68	11.51	100%

C. EDX analysis

Figure 3: TEM-EDX analysis of the sample



A. Electron micrograph of glass wool

Element	Na K	Mg K	Si K	Ca K	Total
Atomic %	7.08	4.99	77.00	10.93	100%

B. EDX analysis of glass wool

Figure 4: Analysis of glass wool by TEM

Discussion

Asbestos was banned in 1989, July 12 by the Asbestos Ban and Phase-Out Federal Register Notices [9]. In April 2019, EPA issued a final rule to ensure that asbestos products that are no longer on the market cannot return to commerce without the Agency evaluating them and putting in place any necessary restrictions or prohibiting use. Also, asbestos such as chrysotile, crocidolite, and amosite was banned in Korea in 2009. Recently, to evaluate asbestos-containing material in home appliances, 414 household products manufactured between 1986 and 2007 were examined using polarized ling microscopy and stereoscopic microscopy. The results showed that large-sized electric appliances (refrigerators and washing machines) and household items (bicycles, motorcycles, and gas boilers) contain asbestos material and small-sized electric appliances do not contain asbestos material. All appliances with detected asbestos material showed typical characteristics of chrysotile (7–50%) and tremolite (7–10%). Speaker was not investigated in this study [10]. They also reported that asbestos fibers were not released from the appliances when they were operating.

The speaker analyzed for in this study was manufactured during 70' when the asbestos ban was not effective. Therefore, many users of the speakers which were manufactured before the asbestos ban were worried about the exposure to asbestos during use or repairing speakers. Especially, vibration energy from of speaker could split or break asbestos fibers and may release the fibers if speakers were not properly encapsulated. Several earlier patents on the speaker indicated that asbestos might have been used for sound-absorbing materials or diaphragm in speakers [11-13]. Our results indicated that asbestos was not used in the AR-3a speaker, instead, glass wool was used for sound dampening materials. Glass wools are some of the most widely used insulating materials in homes and buildings. Most synthetic vitreous fibers used as insulation in homes and buildings, such as fiberglass wools and stone wools, are more readily dissolved in lung fluid than are refractory ceramic fibers, which are used in insulation materials for furnaces. IARC (International Agency for Research on Cancer) also determined that insulation glass wool, stone wool, and slag wool, and continuous filament glass were not classifiable as to carcinogenicity to humans (Group 3) because of inadequate evidence of carcinogenicity in humans and the relatively low biopersistence of these materials [14]. To avoid the risk of exposure to glass wool from speaker repairing work, the use of proper personal protection equipment and local exhaust ventilation are strongly recommended.

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