FILE NAME: Asbestos in Hair Dryers (HD)

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UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

May 2, 1979

MEMORANDUM FOR: Dale Scott, CPSC

Attention: Gail Wyer

Through: William West,
Deputy AED (Engineering Sciences)

Walter G. Leight, Chief
Product Safety Technology Division

From: Sid Greenwald,
Product Safety Technology Division

Subject: Examination of Hair Dryers from CPSC (#7166 and #7167) for Asbestos

On March 26, 1979, the Consumer Product Safety Commission delivered two hand-held hair dryers to NBS and requested an examination to answer the following questions:

Q1. Does the insulating liner surrounding the heater element contain asbestos fibers?

A1. Scrapings from each dryer were immediately examined by electron microscopy and were found to be primarily chrysotile asbestos.

Q2. Does the effluent air from the operating dryer contain chrysotile asbestos fiber? (The switch setting giving the highest air volume rate would be used, since this would maximize any possible erosion from the surface of the liner material.) Quantitative results were not required, but it was requested that the size range of any detected asbestos fibrils, bundles, or clumps be noted.

A2. Small amounts of chrysotile asbestos were detected in the effluent from each of the hair dryers, some in the respirable size range. However, similar amounts and size distributions were found on control (blank) filters used to collect samples <u>without</u> hair dryers.

It should be noted that the results summarized in this memorandum and its attachments are based on limited experiments with but two hair dryers, both of which were brand new at the initiation of this task. Obviously, results cannot be generalized for other devices, nor is it possible to state at this juncture whether degradation might occur in the course of time.

The results of the investigation are given in the attached two part memo report. The first part deals primarily with the methods used to sample the air from the two hair dryers. In addition, some brief experiments were run, noting the effects of temperature on a typical insulating liner.

In the first sampling method used, only a very small percentage of the air coming from the hair dryer was captured by a polycarbonate membrane filter. The remainder of the output escaped to the open air. This method was employed because of back pressure and overheating difficulties originally encountered in trying to develop a total air capture system.

Four air samples were taken in this manner, and sent to the Gas and Particulate Science Division (GPSD) for analysis.

In the second method, all of the hair dryer output was captured by a 20 X 25 cm (8 X 10 inch) polystyrene filter. Four trials were run as follows:

Trial	Dryer	Time
1	Sample A (#7167)	4.5 hrs.
2	Sample B (#7166)	4.5 hrs.
3	Blank	16.0 hrs.
4	Blank	4.0 hrs.

The two blanks were run, each in a slightly different manner, in order to determine the asbestos background level. These would serve as the control.

All four samples were sent to the GPS Division for analysis.

Throughout the air sampling procedure, every effort was made to keep the filters as free as possible from any outside contamination.

The second part of this report deals with the results of the analysis made by scientists in the Gas and Particulate Science Division. The instrumentation involved both Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). The TEM is considered superior for this investigation because of its ability to detect smaller fibrils due to its higher resolution capability.

Attachments

cc: W. Porter - CPSC
S. Warshaw - NBS
J. Small - NBS
S. Toner - NBS
H. Rook - NBS
J. Hodgeson - NBS

REPORT ON HAIR DRYERS
TEST METHOD DEVELOPMENT

Prepared by
Samuel D. Toner, Div. 763
April 27, 1979

On March 26, 1979, two hand-held hair dryers were delivered by the Consumer Product Safety Commission. These dryers were said to contain a thermal insulating material composed, at least in part, of asbestos. The insulation in question was a cylindrical sleeve of paper-like material inserted in the section of the dryer barrel surrounding the heating element. NBS was requested to determine, if possible, whether asbestos fibers and/or fiber bundles are released from the insulating material and emitted into the air stream of the dryer during operation. In addition, estimates of the range of size of fibrils and bundles was desired.

For the purposes of this report, the two commercially available hair dryers are identified as Sample A (CPSC #7167) rated at 1200 watts, and Sample B (CPSC #7166) rated at 1000 watts. A third dryer, Sample C, produced by the manufacturer of Sample A, was obtained from the NBS Product Performance Engineering Division. These three dryers were sent to the NBS Fluid Engineering Division for measurements of the air flow capacity. These measurements were made using a Thermo-Systems Inc., Ionflo Meter, S/N 074, Range 0 - 150 cubic feet per minute 1). The results obtained at maximum air flow capacity were as follows: Sample A, 35.5 CFM; Sample B, 28.0 CFM, and Sample C, 25.0 CFM.

Insulating Material

There is some concern that, during the life of a dryer, any binder present in the insulation might be decomposed by the heat generated during normal use, thus possibly leading to an increase in the number of fibers that might be released into the air stream. Consequently, the insulating liner was removed from a new dryer identical to Sample C. When a piece of this material was subjected to a bunsen burner flame, charring occured immediately, indicating the presence of a binder. A few minutes of additional heating burned off the char, leaving the paper brittle and friable. A section of the insulation was dried to constant weight in a circulating air oven at 110°C. After one hour the material exhibited a weight loss of 0.37% and after an additional 0.5 hour at 110°C, exhibited a total weight loss of 0.38%. The specimen was then placed in a circulating air oven for 4 hours at 300°C. On removal, the material exhibited some slight discoloration, but no evidence of charring, and an additional weight loss of 2.78%. The specimen was reexposed for an additional 6 hours at 300°C, after which time the total weight loss was 2.88%, based on the constant weight after conditioning at 110°C. There was no apparent additional discoloration of the material. There was no apparent evidence that the insulation had become friable, a condition which might result in release of larger quantities of fibers with continued usage.

Thermal measurements were then conducted on Sample C, by placing a thermocouple against the inner surface of the insulating material, and measuring the temperature rise during normal operation of the dryer, with the controls set

for maximum temperature and highest flow rate. The temperature of the insulation surface did not exceed 38°C, achieved during the first 2 - 3 minutes of operation, for periods of up to 30 minutes of continuous operation. When the dryer was turned off, the surface temperature of the insulation surface rapidly rose to 50° - 55°C over the next 20 - 30 seconds, and then cooled to ambient temperature in approximately 10 minutes. Temperatures in the air stream of this dryer, measured at random points just inside the protective grill, were observed to be in the range of about 65° - 80°C. It was concluded that, if the insulation used in this dryer were typical to the dryer industry, then thermal decompositon of the binder due to dry heat alone was considered unlikely.

Test Method Development

Although several potential methods for collecting emitted fiber, if any, were considered, it appeared desirable to attempt to develop a system in which all of the air emitted by the dryer passed through a filter medium. Such a closed-system technique was expected to minimize potential loss of respirable fibers and fiber bundles, and to provide a better assessment of the amount and range of sizes of the fibers.

The NBS Gas and Particulate Science Division (GPSD) provided a polystyrene-fiber filter medium suitable for collecting respirable asbestos fiber and also amenable to further sample preparation procedure required prior to analysis by means of the electron microscope.

A new dryer, identical to Sample C, was used in developing the test method. The dryer was attached to one end of a section of rigid, 2-inch inside diameter tube. A water-filled manometer was attached to the tube as a means of monitoring any changes in the air flow capacity of the dryer that might result from the air impinging on the filter medium. Since the techniqes required to prepare a sample for the electron microscope are simplified by use of a small collection filter, the first attempt simply involved covering the open end of the tube with a piece of the filter. The available surface area of the filter was approximately 25.2 cm^2 (3.9 in^2). In this case, back pressure in the tube, created by the low air flow rate through the filter, caused rapid overheating of the dryer with subsequent activation of the thermal overload switch. This event occurred in about 7 - 8 seconds. The test equipment was then modified to accept a larger filter, about 73.6 cm^2 (11.4 in^2) in area. Although the back pressure problem was alleviated to some extent, the operating time prior to activation of the thermal overload switch was increased by only 6 - 8 seconds. Further increase in the size of the filter to about 171 cm^2 (26.5 in^2) in area did not result in a significant improvement in the procedure. Additional modification of the equipment involved the attachment of a section of 2-inch tube on the downstream side of the filter; a DC motor and fan assembly, removed from a dryer identical to Sample C, was sealed into the open end of the tube in an effort to induce a negative pressure on the downstream side of the filter as a potential means of balancing the pressure on the upstream side of the filter. This did not result in a significant improvement over the preceding methods. Substitution of a vacuum pump for the dryer motor/fan assembly also failed to solve the back pressure problem. Part

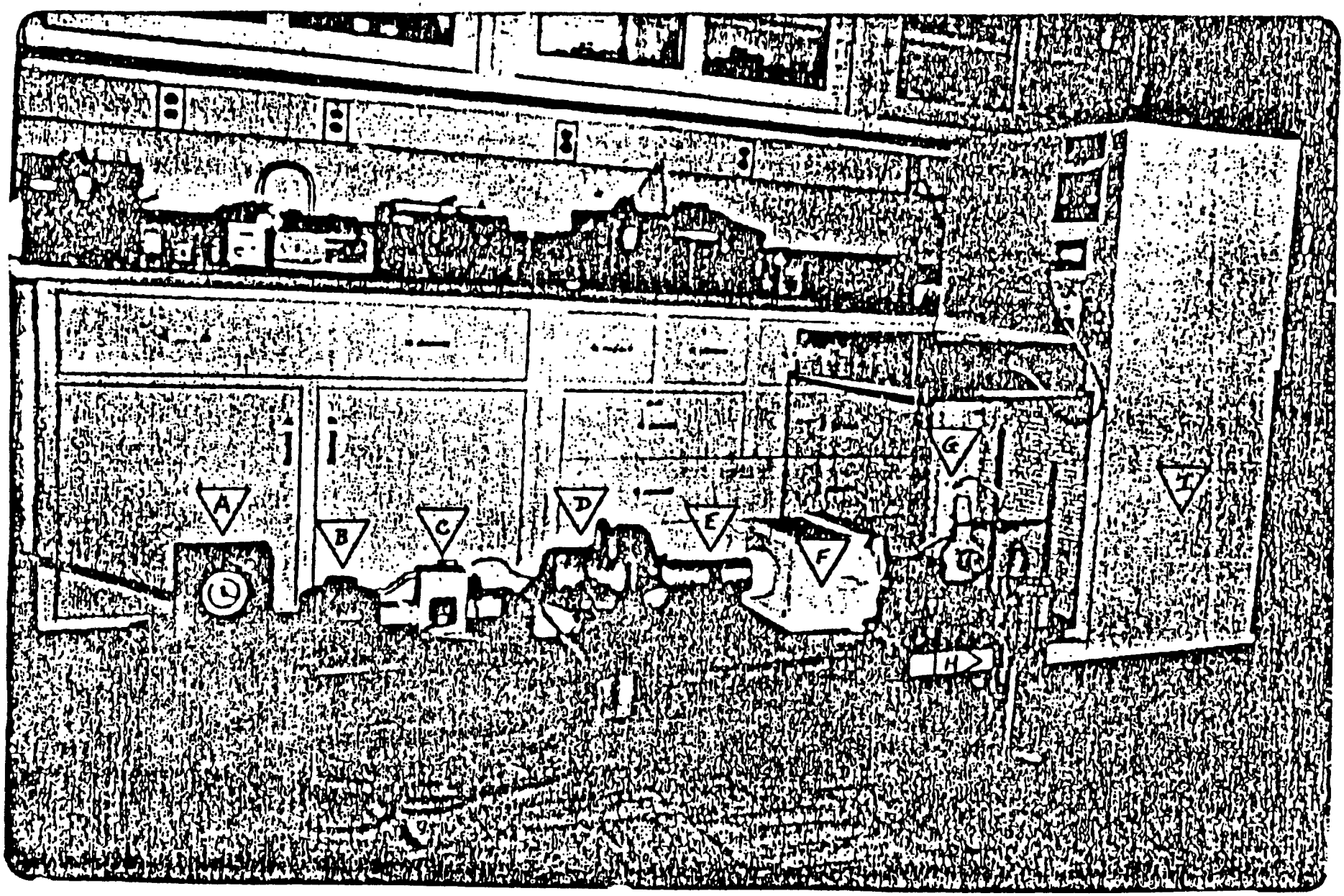
the problem seemed to be due to the difficulty in obtaining air-tight seals on the downstream side of the filter in this temporary set-up, and part appeared to be due to the difficulty in achieving a downstream air flow capacity of a sufficient nature to off-set the pressure drop across the filter.

At this point, work on the closed-system collection technique was temporarily abandoned at the request of CPSC staff members, in favor of a different collection procedure. Stipulations were made that tests be conducted by placing a filter in the air stream of the dryers, Samples A and B, in such a manner that the portion of the emitted air impinging on the filter would have no effect on the normal air flow capacity of the dryers, i.e., would not result in any back pressure on the dryer. These tests were conducted as follows. The hair dryer was placed in a hood capable of providing a positive flow of filtered air into the dryer intake vents. The dryer was pointed downward approximately 60° from the horizontal position. A filter holder, containing a polycarbonate membrane filter, was placed in the air stream of the dryer in such a manner that the filter surface was approximately normal to the direction of air flow and about 3 cm from the end of the dryer barrel. A vacuum pump attached to the filter holder provided a pressure drop across the filter. The effective collection area of the filter surface was of the order of 5.0 cm^2 (0.78 in^2). Dryers A and B were each operated for continuous two-hour periods, using membrane filters with a maximum pore size of 0.1 micrometer (μm). When an analysis by the staff of the GPS Division indicated the absence of any asbestos fiber, Sample A was then operated for a continuous 8-hour period using a membrane filter with a pore size of 0.8 μm.

Developmental work was then resumed on a closed-system collection technique. For these procedures, a high speed air sampling fan equipped with a filter holder was used. The sampling fan was reported to have air flow capacities of approximately 120 and 200 CFM. The accompanying filter holder required a nominal 8 x 10 inch piece of the polystyrene filter, and provides an available surface collecting area of 420 cm^2 (65 in^2). After some preliminary tests were conducted, it was found that the sampling fan/filter combination could be used in such a manner that the back pressure problem, previously noted, could be solved. Thus the tests could be conducted with the dryer functioning in its normal use mode. The final test set-up is described as follows: hair dryer - tube, manometer, cover plate assembly - filter and filter holder - a slotted tube-sampling fan (operated from a variable transformer). See the accompanying figure. The hair dryer was placed in the hood supplying filtered air. All components from the hair dryer to the slotted tube were sealed to provide a closed system. The slotted tube between the filter holder and the fan was critical to the success of this technique. When the fan was operating at the 120 CFM flow rate, it was capable of drawing more air through the filter than the air flow capacity of the dryer alone. The slotted tube, downstream from the filter, allowed some air to enter the system so that the negative pressure on the downstream side of the filter approximately balanced the pressure caused by the air flow rate of the dryer on the upstream side of the filter. Coarse adjustment of the size of the slot, coupled with fine adjustment of the fan speed by means of the variable transformer, allowed the air flow rate through the filter to be balanced so that the negative

pressure on the downstream side of the filter was only of the order of 1 - 2 mm of water pressure greater that the positive pressure produced by the air flowing from the dryer. Subsequently, tests were conducted on the dryers. Samples A and B were individually subjected to 4.5 hours of continuous operation.

Control tests to determine the presence of any background asbestos were also conducted. One of these tests was conducted for a period of 16 hours. In this test the dryer was replaced with an extension tube and a linear air flow meter, so that the air flow impinging on the filter surface was intermediate to that of Samples A and B. The second test was conducted for four hours. In this test, the cover plate was not used so that the entire available surface of the filter was exposed to the flow of filtered air emitted by the hood. All filters were sent to the GPS Division for subsequent analyses for the possible presence of asbestos.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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

REPORT OF ANALYSIS

of
Electron Microscopy
on
Lining Materials from Hair Dryers
and Filter Samples

Submitted by Sid Greenwald, Division 763

Laboratory Nos.: 553 39024 - 39029
Project No. : 763-1411
Requisition NO.: 763-0936
Analysts : John A. Small and Eric B. Steel

Request: The laboratory was requested to analyze the lining material from two hair dryers and determine if the material contained asbestos. In addition, the laboratory was also requested to determine if eight filter samples, four polycarbonate and four polystyrene, contain asbestos and to qualitatively estimate fiber loading and fiber size for each sample.

Sample Preparation:

Lining material. Each dryer was disassembled, and a piece approximately 5 mm^2 was removed from the insulating sheet. These pieces were placed in separate vials. Approximately 25 ml of ethyl alcohol was added to each vial. The vials were sealed and shaken both by hand and ultrasonically for a period of about 10 minutes, in order to free some of the fibers from the piece of insulating sheet.

Next, 200 mesh Cu TEM grids coated with 10 nm carbon foils were dipped into the solutions. After drying, one grid from each sample was investigated with a transmission electron microscope (TEM). The TEM was operated at 125 kV accelerating potential.

Polycarbonate filters. The polycarbonate filters were coated with approximately 20 nm of carbon. After coating, two 5 mm^2 portions were cut from each filter and placed in a Jaffe-Wick washer. One of the 5 mm^2 sections from each filter was placed in the washer with the carbon side up; the other was placed with the carbon side down. Once the filter material was cleared, the grids were investigated with the TEM.

Polystyrene filters. One-fourth of each 8" x 10" polystyrene filter was dissolved in approximately 500 ml of xylene. When the filter had completely dissolved, the solution was filtered through a 0.2 um polycarbonate filter, which was backed with a teflon filter. After filtration, the filter was washed with an additional 25 ml of xylene and allowed to air dry.

Next, the filters were carbon coated, and a 5 mm^2 portion of each filter was removed for scanning electron microscopy (SEM) analysis. The remainder of the filter was prepared on a TEM grid with a condensation washer. The grids were then analyzed at 125 kV with the TEM. There was no evidence of particle loss due to the condensation washing.

The 5 mm^2 portions removed for SEM analysis were mounted on aluminum stubs with double-sided tape and carbon coated with approximately 10 nm of carbon. The SEM was operated at 7.5 kV accelerating potential.

Results: The samples used in the TEM were scanned at about 5,000 to 20,000 times magnification for fibers. Those used in the SEM were scanned at about 1,000 to 10,000 times magnification for fibers. Fiber identification was based on morphology and selected area electron diffraction in the TEM, and morphology and energy-dispersive x-ray analysis in the SEM. Detailed analyses were not done on all fibers. Representative fibers from each sample were chosen at random for detailed analysis, and the remaining fibers were identified by morphology only.

Lining material. The lining material was analyzed by TEM only. The results are shown in Figures 1 - 4. Figures 1 and 2 show fibers with the characteristic morphology associated with chrysotile, very thin fibers (less than 50 nm wide) with hollow tubes running down the center. Figures 3 and 4 are selected area electron diffraction images of representative fibers. These images show the slurring of the diffraction spots which is also characteristic of chrysotile.

Nuclepore filters.

Sample	Label
1	CPSC 7167, 8 hr. test, 0.8 um filter
2	CPSC 7167, 2 hr. test, 0.1 um filter
3	CPSC 7166, 2 hr. test, 0.1 um filter
4	CPSC 7167, 1 hr. test, 0.8 um filter

The TEM and SEM results from these filter samples were inconclusive. A few fibers were seen on the TEM and identified as chrysotile. However, there were not enough fibers present on any of the samples to conclude that the loading was above blank values.

Delbag filters.

Sample	Label
5	CPSC 7166, 4.5 hr. test
6	CPSC 7167, 4.5 hr. test
7	Blank for Background Asbestos, 16 hr. test
8	Blank for Background Asbestos, 4 hr. test

All the samples and blanks showed the presence of small amounts of chrysotile, the fiber loading on Samples 5 and 6 was not significantly higher than on Samples 7 and 8.

The results from the SEM analyses are shown in Figures 5 - 8. The x-ray spectra show that the fibers contain Mg and Si. These two elements are the major constituents of chrysotile. In several of the fibers, however, the ratio of Mg to Si is, to a first approximation, higher than expected for chrysotile. This can be attributed to several factors such as the possibility of a binder material mixed with the chrysotile or residue from the filter dissolution. As before, the fiber loading on Samples 5 and 6 was not significantly higher than the loading on Samples 7 and 8.

Conclusions: From the results of the microscopic analyses, the following conclusions can be drawn.

1. The lining material in both the dryers is primarily chrysotile.
2. The polycarbonate and polystyrene filters, both samples and blanks, contain small amounts of chrysotile.
3. TEM and SEM analyses indicate that the polycarbonate and polystyrene filters from CPSC 7166 and 7167 do not contain a significantly higher loading of chrysotile than the blanks (polystyrene filter 7 and 8).
4. Based on the qualitative analysis, there was no apparent difference in the fiber size distribution between sample and blank.

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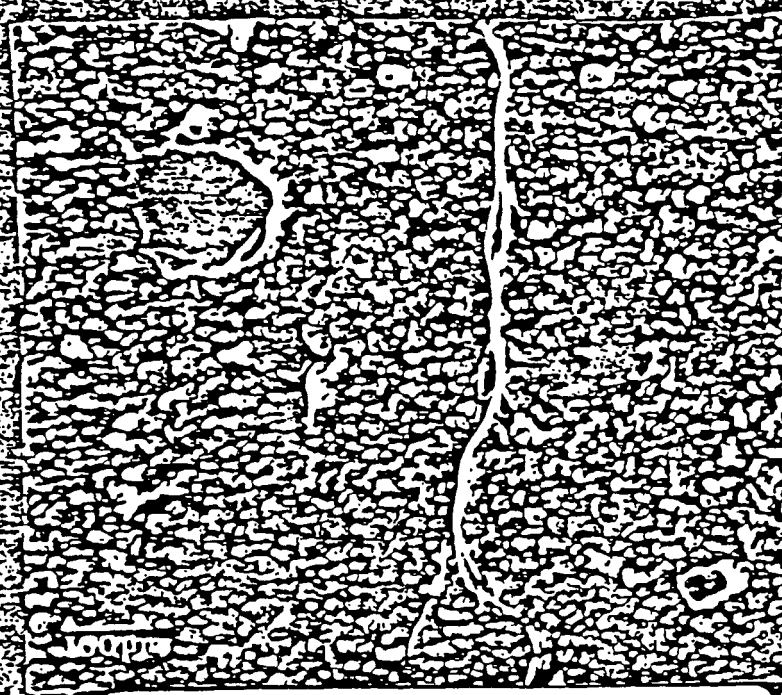

Figure 7: secondary electron image CPSC # 7166

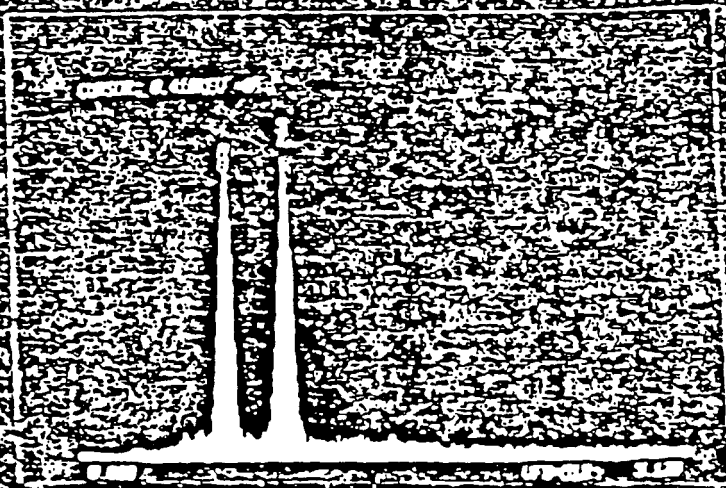

Figure 8: Energy dispersive x-ray analysis of fiber shown in figure 7

TEM analysis of hair dryer insulating material

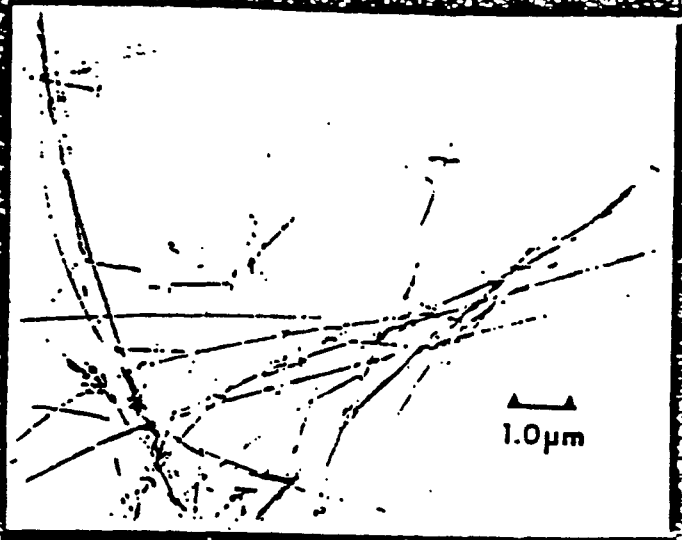

Figure one: TEM image of insulating material from CPSC # 7166

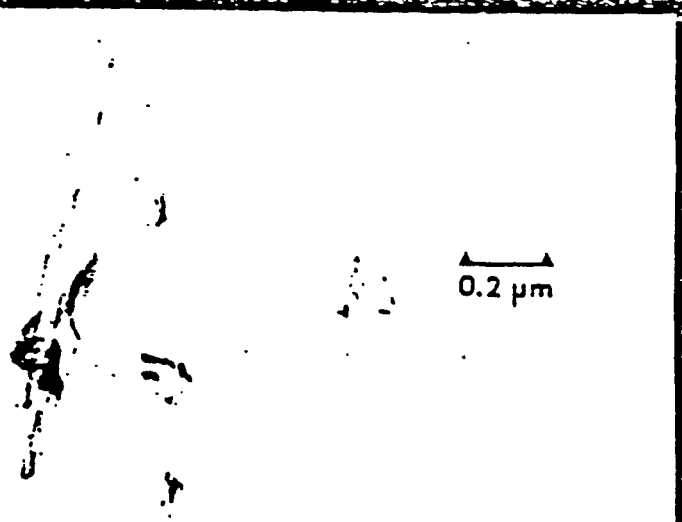

Figure 2: TEM image of insulating material from CPSC #7167

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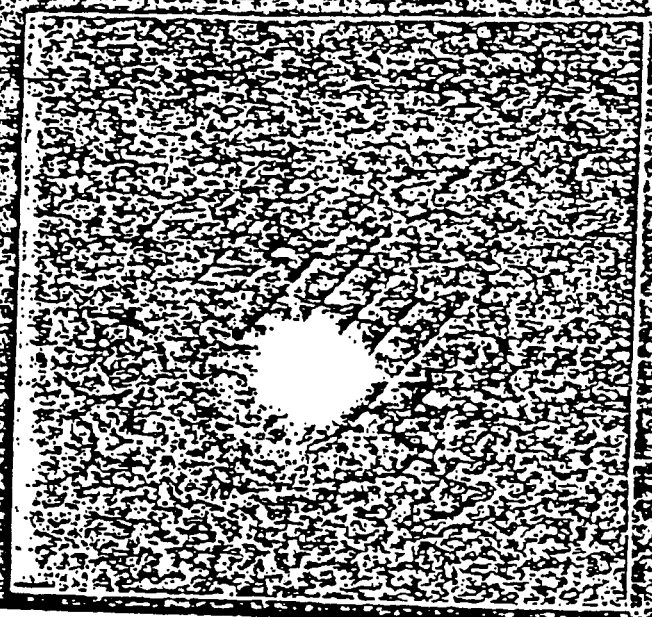

Figure 3: selected area electron diffraction image from CPSC # 7166

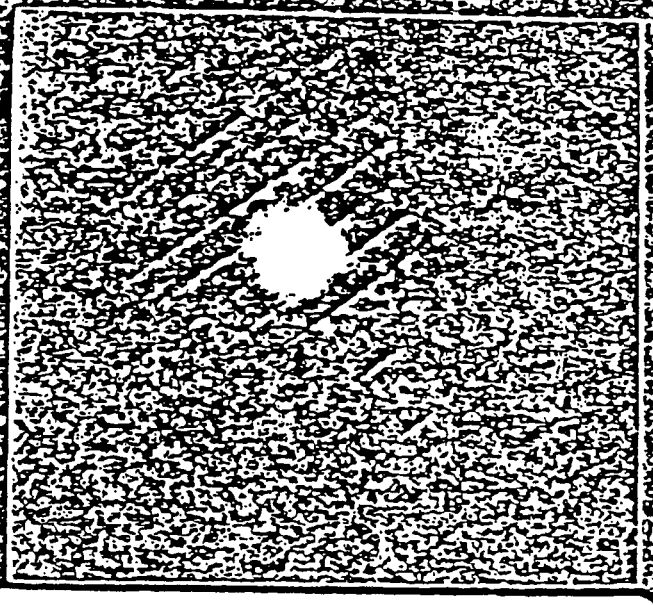

Figure 4: selected area electron diffraction image from CPSC# 7167