TECHNICAL NOTE

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A New Method for Cross-Sectioning Single Fibers

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ABSTRACT: A procedure for the cross-sectioning of textile fibers is described. The fibers are placed in microlitre pipet tubes to which a mounting medium is added. After the mounting medium has dried, the tubes are cut with a razor blade. The method is quick and simple, usable on almost all types of fibers, and usable on fibers as short as 1 mm. The method also allows for easy recovery of the cross sections and the whole fiber from the mount and for the subsequent determination of denier.

KEYWORDS: forensic science, fibers, cross-sectioning

While most textile fibers can be readily identified in a whole mount by polarized light microscopy, examination of the cross section provides additional information which can aid in the comparison of two fibers, the identification of a fiber subclass, or the determination of an end use. While some features of the cross section are discernable in a longitudinal view, to obtain exact information it is necessary to examine an axial cross section. The simple categorization of a fiber as trilobal or multilobal may neglect potentially useful information.

A number of methods have been described for the preparation of fiber cross sections. The metal plate method [*1-3*], the Hardy microtome method [*1,2,4*], the cork method [*2*], and simple imbedding and use of a microtome [*1-3*] are four of the most popular. These methods suffer from various disadvantages, including trouble in preparation, difficulty in recovering the intact fiber after sectioning, and poor adaptability to a single, short fiber. In forensic science work, where fibers less than 1 cm in length are the rule rather than the exception, this last drawback can be especially serious. While Culliford [*5*] has described a method for cross-sectioning single fibers by imbedding them in a sheet of cellulose acetate and slicing with a microtome, published methods are generally not ideally suited to the samples encountered in forensic science casework.

In this paper, a new method for the sectioning of fibers is described which offers the following advantages: (1) it can be used on single fibers as short as 1 mm in length; (2) it allows the fiber to be easily recovered from the mount, and allows for recovery of cross-sectional slices for use in melting point determination, solubility tests, or other microanalyses; (3) mounting of the fiber takes minimal time and skill; (4) very little special or elaborate equipment is required; and (5) the method can be employed on virtually all types of natural

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and synthetic fibers, and also allows for the determination of denier (the weight in grams of 9000 m of a fiber), which can be helpful in determining the end use or manufacturer of a fiber [6].

Materials

Oxford 810-μL pipet tips were used as mounting tubes for the fibers. Pro-texx® was used as the mounting medium. When an adhesive was necessary to secure the fiber to the tube, Hard as Nails® nail strengthener by Sally Hansen® was used. The photomicrographs were taken on a Leitz Wetzlar polarizing microscope with camera adaptor and Leica 35-mm camera. A Polaroid camera is convenient to use for the denier determination photographs. The materials used may be varied somewhat, depending on what is available in the individual laboratory (see section below).

Procedure

Mounting

The fiber to be sectioned is placed with forceps into the narrow end of the mounting tube (see Fig. 1). This operation is best performed under a stereoscope, with the tube mounted in a ball of clay. The amount of fiber used will depend on availability. As little as 1 to 2 mm can be mounted effectively, but if there is sufficient sample, 5 mm is a more convenient length to work with. There should be as little fiber protruding from the end of the tube as possible. One or two drops of Pro-texx are then dripped into the wide end of the tube with an applicator stick or a pipet and allowed to flow down until the narrow end is filled (see Fig. 2). Surface tension prevents the Pro-texx from flowing out the opening. In most cases, if the tube is carefully handled, even in a vertical position, the fiber will not fall out, nor will the flow of Pro-texx push it out. In a few cases, however, the fiber will need to be secured to the tube before Pro-texx is added (see Fig. 3). This is done by first resting the fiber against one side of the opening after it has been placed in the tube, applying a small amount of adhesive to the other side of the opening, and carefully pushing the end of the fiber into the adhesive

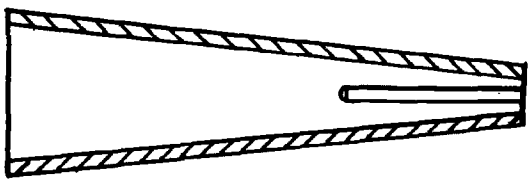

FIG. 1—*Insertion of fiber.*

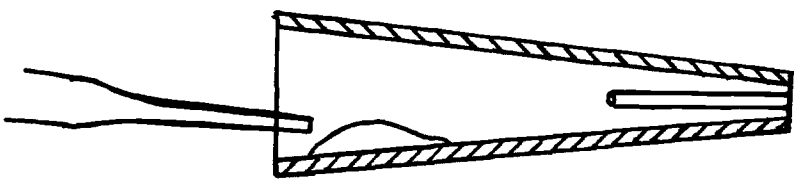

FIG. 2—*Addition of Pro-texx.*

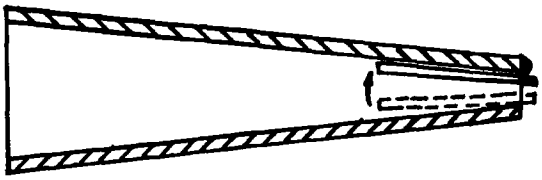

FIG. 3—*Gluing fiber to tube.*

with forceps or a dissecting needle. Once the fiber is secured, the Pro-texx is then added as above. The tube is then placed in an upright position for 12 to 18 h (overnight) in a 58°C oven to accelerate the drying. Three to four days are required to achieve sufficient drying at room temperature.

Cross-Sectioning

After removing the tube from the oven, a razor blade is used to cut off the very end of the tube, along with any protruding fiber or adhesive. A single edged razor blade suitable for shaving is easy to handle and gives good results, while a scalpel was found to be less effective. Using the razor blade, four or five cross sections are cut and placed on a single microscope slide. With practice and use of the stereoscope, cross sections 0.1 mm in thickness are readily obtainable. Each cut should be made perpendicular to the fiber axis, which may require cutting at an angle to the axis of the tube. The cross sections are then examined under a higher power microscope and the best are saved for photomicroscopy (see Figs. 4, 5, and 6).

Recovery of Cross Section and Whole Fiber

The following operations are again most easily performed under a stereoscope at ×20 to 30. With smaller samples, higher magnifications may be necessary.

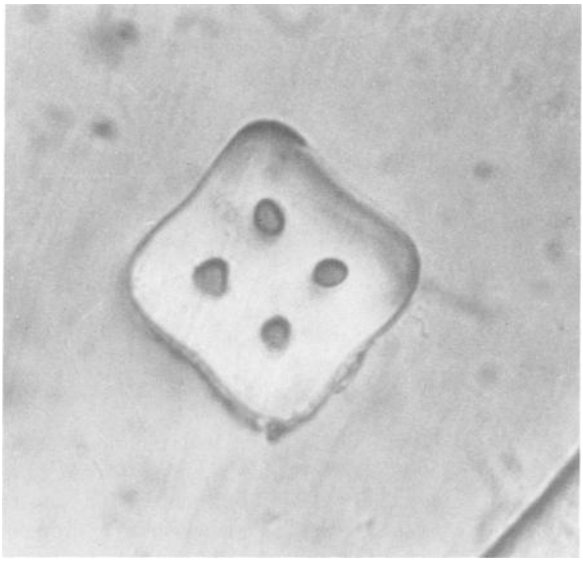

FIG. 4—*A cross section of a tetralobal Antron® nylon fiber (×40).*

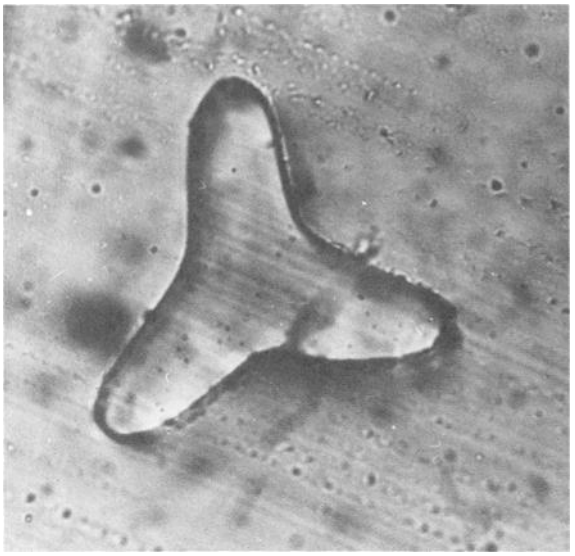

FIG. 5—*A cross section of a trilobal nylon 6,6 fiber (×40).*

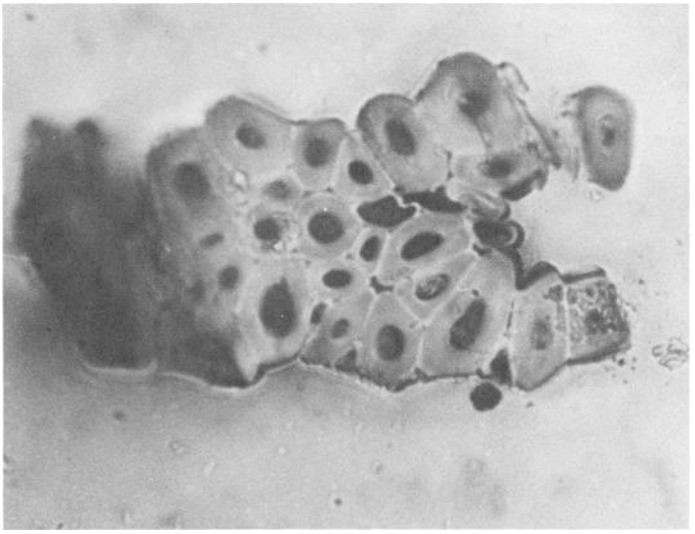

FIG. 6—*A cross section of a jute fiber (×40).*

To recover a cross-sectional slice for melting point determination, one of the cross sections is placed in a drop of water on a slide and the Pro-texx plug is removed with forceps and a dissecting needle. The plug is placed on a clean slide and drop of xylene is added to dissolve the Pro-texx. The fiber slice is removed from the xylene, rinsed in drop of fresh xylene, and placed on a hot stage slide. Before adding a cover slip, it is helpful to circle the fiber slice with a felt tip marker to aid in relocating it under the hot stage microscope. Melting point is

then determined as usual. If desired, additional cross-sectional slices may be recovered for microsolubility testing, diamond cell infrared, or other microanalyses.

To recover the whole fiber, the tube is cut as follows.

1. One cut is made longitudinally to a point just past the end of the fiber, as close to the middle of the tube as possible without cutting the fiber itself (see Fig. 7).
2. One cut is made laterally, perpendicular to the first cut. The cut should be almost, but not quite, all the way through the tube (see Fig. 8).
3. The top section of the tube is then removed (see Fig. 9).

The Pro-texx plug containing the fiber is then removed with a dissecting needle or forceps. The plug is dissolved by immersing it in xylene, and the fiber, once released, is rinsed in fresh xylene, then remounted as desired.

It is recommended that the whole fiber not be removed from the mount until all desired operations (photography, melting point, and so forth) have been performed on the cross sections, in case additional cross sections are needed.

Denier Determination

Using the microscope with a camera attachment, a cross section of the fiber to be measured is focused with an objective of about ×40 and the cross section is photographed. The

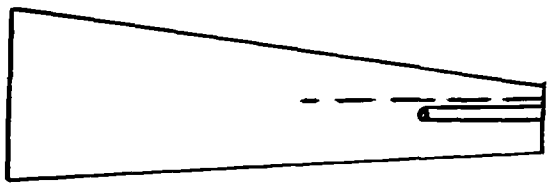

FIG. 7—*Longitudinal cut.*

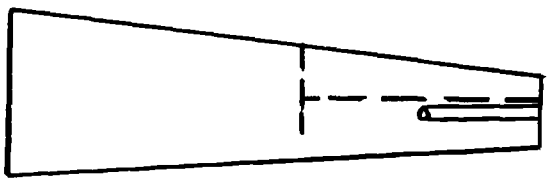

FIG. 8—*Lateral cut.*

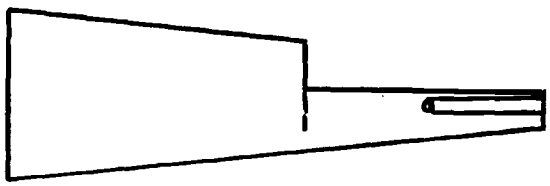

FIG. 9—*Removal of a top section.*

degree of enlargement must be determined by either including a scale in the photomicrograph or by photographing a scale separately and developing it under the same conditions. The outline of the fiber is then traced from the photograph onto a piece of thin paper, and the outline is cut out and weighed. A piece of the paper of known area must also be weighed to determine its weight per square centimetre.

Denier can then be calculated from the following parameters:

C = weight of cutout tracing of cross section,
S = weight of 1 cm^2 of tracing paper,
MF = linear magnification factor (determined from scale photograph), and
D = density of fiber in g/cm^3 (determined from references after the generic class of the fiber has been identified).[2]

The *actual* cross-sectional area of the fiber will be:

$$\frac{C/S}{(MF)^2}$$

$$\text{Denier} = (\text{Volume of 9000 m of fiber})(\text{Density of fiber})$$

$$\text{Denier} = \frac{9 \times 10^5(CD)}{S(MF)^2}$$

(9000 m is converted to 9×10^5 cm to ensure agreement of units)

Comments on Materials and Conditions

Choice of a mounting medium for this procedure will depend on what is available in the individual laboratory. Other media besides Pro-texx may be suitable. However, Permount was found to be unsatisfactory since, when dry, it tended to crack and craze upon being cut, making visualization of the cross section impossible. Other types of pipet tips should also be suitable although they should ideally be colorless and fairly clear, and have as narrow an opening as possible. A very sharp razor blade is essential to cutting good sections. Since only a small area is being cut, one razor blade can be used many times all down its length, but it is recommended that one area of the blade be used for no more than ten cuts. The drying time and temperature are somewhat flexible, the only caution being not to overdry, since this may render the mounting medium difficult to cut. Some trial and error may be necessary to determine the optimum drying time for a particular mountant. Almost any sticky substance will do as an adhesive to secure the fiber to the tube when necessary. Xylene was preferred over toluene as a solvent for the mounting medium because of its lower volatility.

Comments on Application of the Method

Since xylene at room temperature will soften or dissolve vinyon, the method is not usable with this particular fiber. This is not a major drawback, since vinyon is not a commonly encountered fiber. Saran and olefins may dissolve in hot xylene, but room temperature xylene will not affect them.

When comparing known and questioned fibers in cross section, caution must be exercised when attempting to base an exclusion on minor differences in cross-sectional shape between

[2]In case of some fiber classes, the density is obtainable only as a range, unless a subclass can be determined.

the two fibers. With some types of fibers, there may be a significant variation in cross-sectional shape, even among samples from the same source. A similar caution applies when comparing the cross sections of certain natural fibers, such as flax and jute, whose diameters are not uniform. This nonuniformity of diameter may also make the denier determination procedure unusable for such fibers.

Acknowledgments

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References

[1] *Identification of Textile Materials*, The Textile Institute, Manchester, England, 1965.
[2] Luniak, B., *Identification of Textile Fibres*, Sir Isaac Pitman and Sons, London, 1953.
[3] *Methods of Forensic Science*, Vol. IV, A. S. Curry, Ed., John Wiley and Sons, London, 1965.
[4] Wildman, A. B., "The Identification of Animal Fibres," *Journal of the Forensic Science Society*, Vol. 1, No. 2, March 1961, pp. 115-119.
[5] Culliford, B. J., "The Multiple Entry Card Index for the Identification of Synthetic Fibers," *Journal of Forensic Science Society*, Vol. 4, No. 2, Dec. 1963, pp. 91-97.
[6] Mitchell, E. J. and Holland, D., "An Unusual Case of Transferred Fibers," *Journal of the Forensic Science Society*, Vol. 19, No. 1, Jan. 1979, pp. 23-26.

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