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Simple, Rapid, and Unique Hand Techniques for Cross-Sectioning Fibers and Hair

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ABSTRACT: Three methods for hand cross-sectioning of textile fibers are described. The first is intended for usage with single fibers and involves "heat shrinking" a plastic capillary onto a previously inserted fiber. The second is intended for usage when the fibers are present in abundance. It involves repeatedly pulling the fiber bundle through melted wax to build up an embedding medium of sufficient thickness. The third is intended for usage with either a single or multiple fibers in special situations and involves laminating the fibers in thin sheets of cellulose nitrate. All three are designed for cross-sectioning by hand while observing through a low-power stereoscopic microscope. Quality cross sections are produced. The methods are simple, and two of the three are exceptionally rapid. All are equally applicable to the cross-sectioning of hair.

KEYWORDS: criminalistics, fibers, hair, cross-sectioning

The microscopic appearance of a fiber in cross section can serve to assist in its identification or characterize it beyond its generic identity. But fiber cross-sectioning is laborious for routine use by the forensic fibers analyst. It is rarely employed for the identification of natural fibers, although references to such an approach are given by Kraus [*1*] and Stoves [*2*] as an aid to the identification of animal hairs and for the differentiation of flax and hemp. Cross-sectioning of synthetic fibers has become increasingly important to the forensic scientist in the recent past as manufacturers of synthetic fibers introduce more versions of texturized fibers into their product lines to impart desired properties for specific customer end uses.

Microscopic examination of the fiber in its longitudinal view can be used as a basis for deducing the cross-sectional appearance by the experienced fibers analyst. This approach can serve for most purposes, but in circumstances judged to be exceptional it is best to do a cross section.

Cross-sectioning can be effected either by hand techniques or mechanical microtome methods. Hand techniques suffice when the amount of fibers is abundant. Such techniques include the cork method as described by Krauss, the metal plate method of Schwarz [*3*], and the cross-section devices of Hardy [*4*] as described by Stoves. Frei-Sulzer [*5*] advises that mechanical microtome methods be used when only single fibers are available.

In a manual available from the Metropolitan Police Forensic Science Laboratory [*6*], a technique for preparing fibers for cross-sectioning by mechanical microtoming is described. The principal thrust of the description is the casting of an embedding block using a metha-

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crylate resin in a cell prepared from pieces of glass microscope slides. Before pouring the embedding medium into the glass cell, the analyst aligns and stretches taut the fibers between two pieces of double-faced adhesive tape fixed to the bottom of the cell.

Grieve and Kotowski [7] describe a modification of this technique by using a two-component epoxy resin marketed in the United Kingdom under the name "Strongbond" as the embedding medium. If the epoxy resin is used, the long polymerization time as described in the Metropolitan Police manual [6] for methacrylate is reduced from in excess of 5 h to 15 to 20 min.

Methods for cross-sectioning hair by mechanical microtoming have been described by Rosen and Kerley [8], who use epoxy resin as the embedding medium and Pabst,[2] who uses nitrocellulose sheets to laminate the hairs in orderly rows.

However, the hand methods which have been described are not suitable for single fibers. The authors describe here a simple and exceptionally rapid method for hand-sectioning single fibers, capable of producing high-quality cross sections in reproducible thicknesses with relatively low risk of loss. It is believed to be unique.

Also, two other methods are described. One of these is intended for situations when the amount of fibers is in abundance and it is desired to gain quickly an insight into the diversity of fiber cross sections which can be present. The other is intended when the recovery of the fiber or fibers is important or it is desired to mount the fibers side by side for comparison.

Method 1: Single Fiber

A capillary is drawn from polyethylene plastic. This is done by heating a piece of polyethylene tubing over an open microburner flame. The authors use disposable polyethylene centrifuge tubes which are about 50 mm in length and 7 mm in outside diameter. The resulting capillaries—usually about 0.5 mm to 1 mm outside diameter—should be cut into short lengths of approximately 2 cm.

The capillary lengths are examined at approximately ×10 magnification under a low-power stereoscopic microscope for those which have bore diameters suitable for the insertion of the fiber which is to be cross-sectioned. These would be typically about 0.2 to 0.5 mm, that is, several times the diameter of the fiber. The analyst inserts the fiber into one end of the selected capillary with a jeweler's forceps while observing through the stereoscopic microscope.

The analyst then "heat shrinks" the plastic capillary containing the fiber by placing it on a preheated microscope slide which is atop a hot plate. The hot plate temperature control should be at its lowest setting to cause the plastic capillary to soften and shrink. The shrunken plastic capillary is then examined under the low-power stereoscopic microscope to determine its suitability for cross-sectioning. The fiber should be seen as firmly held through encapsulation by the polyethylene plastic.

Cross-sectioning is effected by hand using a *fresh* single-edge razor blade while viewing at approximately ×30 magnification through a stereoscopic binocular microscope. Cellulose acetate sheet plastic can be used as a cutting surface. Section thicknesses of approximately 30 to 40 μm should be readily achieved with practice. Several sections should be prepared and mounted under a coverslip in Permount® or similar permanent mount. Figure 1 shows fiber cross sections prepared as described.

[2]H. Pabst, "Making of High Quality Cross Sections of Single and Groups of Hairs," presented at the 10th Triennial Conference of the International Association of Forensic Sciences, Oxford, England, Sept. 1984. Reprints available from Dr. Herbert Pabst, Bayer, Landeskriminalamt, Maillingerstr. 15, 8000 Munchen 19, West Germany.

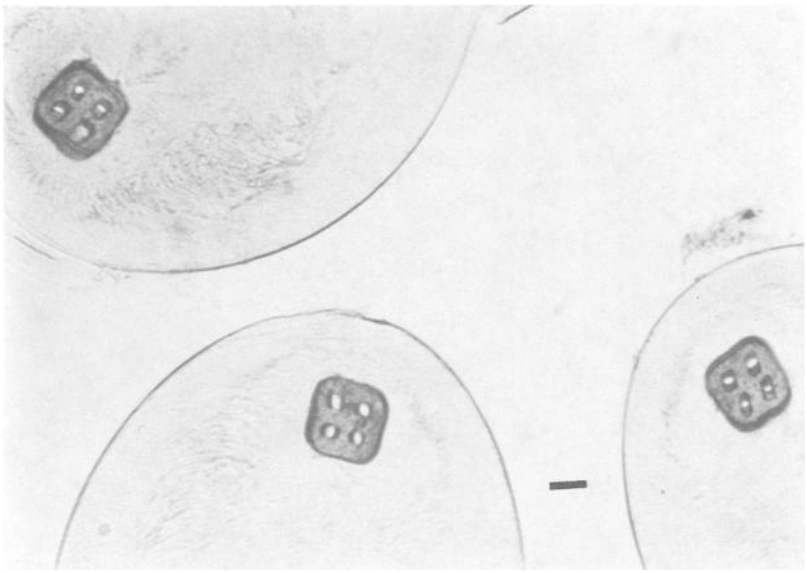

FIG. 1—*Three successive hand cross sections prepared from same fiber by Method 1. Fiber has the cross-sectional appearance of Antron Type 857 and is from the same carpet as fibers in Fig. 2. Bar length represents 20 μm.*

Method 2: Bundle of Fibers

Wax shavings from a block of carver's wax[3] are placed on a preheated microscope slide atop a hot plate. The hot plate temperature control should be at its lowest setting to cause the wax to melt.

A small bundle of fibers—while being held at one end—is pulled slowly through the melted wax several times. After a suitable buildup of layer thickness has been effected, the preparation is stretched taut from both ends while cooling. This has the effect of straightening out fibers, especially those which are crimped along their length. The stretched-out bundle of fibers in wax is now ready for hand sectioning as described under the procedure for a single fiber. Figure 2 shows a medley of fiber cross-sectional shapes from a carpet sample which was prepared in this manner.

Method 3: Plastic Laminate

Pabst describes a method for cross-sectioning hair which is intended for usage with a mechanical microtome. He aligns short lengths of hair on thin layers of celluloid plastic and then solvent welds the layers together to form a laminate which can be microtomed. The total thickness of his embedding block is at least 2 mm and more if several layers of laminated hairs are mounted.

His method is modified for hand cross-sectioning by using a laminate to mount the fibers which is 0.5 mm thick and prepared from pieces of cellulose nitrate which are 5 by 25 by 0.25 mm. This size is suitable for hand-sectioning under a stereoscopic microscope as previously described.

Pabst's method[2] should be consulted for details on technique.

[3]Available at lapidary supply outlets in grades of hardness identified by color. Either blue or green is suitable.

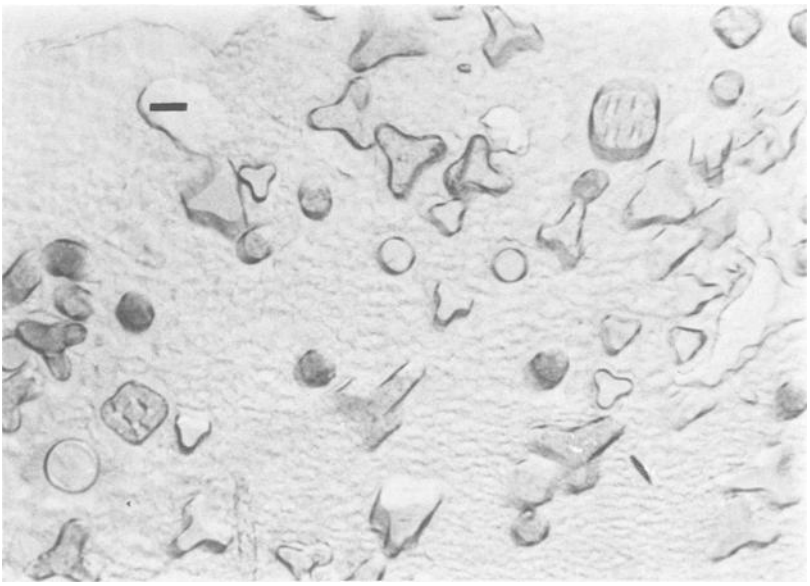

FIG. 2—*Hand cross section prepared from bundle of fibers from a carpet sample by Method 2. Bar length represents 20 μm.*

Discussion

Upon microscopic examination the cross-sectioned fibers will be seen to present their end views. This effect of upright orientation is the result of the base material surrounding the fiber or fibers being dimensionally in excess of the thickness of the section. The fact that the sections are thicker than those normally cut with mechanical microtomes is of no consequence.

Some sections will exhibit the effect of departure from proper alignment of the fiber with respect to the razor blade at the time of cutting. When the effect is pronounced, the microscopic appearance will be that of apparent three dimensionality and is easily recognized by the inability to focus the cross section across its breadth. This effect is virtually nonexistent with the single-fiber method because of the ease of cutting control. This ease makes for thinner sections and greater reproducibility in thicknesses as compared with Methods 2 and 3.

Methods 1 and 2 offer the advantage of exceptional rapidity in execution: 5 to 10 min is a reasonable estimate of required time. In addition, the method for a single fiber is relatively safe from loss of the fiber through mishap once it is entered into the capillary. Method 3 is not as rapid but offers the advantage of orderly side-by-side alignment of two or more fibers being compared and the ability to recover the remaining lengths of uncross-sectioned fiber through dissolving of the nitrocellulose film with acetone, if required. This method is NOT to be used with acetate or triacetate fibers. The analyst can recover the encapsulated fiber in Method 1 with the pointed end of a small scalpel blade and a jeweler's forceps while observing through the stereoscopic microscope. This is difficult but possible with carpet fibers. It is very difficult with fibers having small diameters. A better procedure is to cut from the single fiber a short length of approximately 1 to 2 mm for the insertion into the plastic capillary.

A hot plate surface temperature range of from 100 to 120°C gives the required amount of heat to cause flow of both polyethylene and carvers' wax. Fluidity is greater with the wax.

The authors use a 600-W Corning P-35 hot plate with the temperature control dial set at 2 to give this temperature range. Experimental work should be done with known fibers to assure that excessive heat is not being applied.

The refractive indices of the three base materials is in the range of 1.520 to 1.535. This is not the preferred range for achieving desired contrast for microscopical viewing or for photomicrography. However, it is believed that this is a small disadvantage.

Conclusion

The methods described are of such appealing nature that they encourage the making of fiber cross sections routinely. They are equally applicable to the cross-sectioning of hair.

They can be especially useful for those who are members of working laboratories which do not have mechanical microtomes. However, the resulting cross sections cannot be expected to exceed in quality those results to be obtained from methods involving mechanical microtoming.

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