Fibers and Fiber Evidence

World of Forensic Science, 2016

A fiber is the smallest portion of a textile material. Whether synthetic (e.g., rayon) or natural in origin (e.g., cotton), all fibers share the trait of being very much longer than their diameter. A short length of sewing thread is a good visual analogy of a fiber. The different origins of the materials that make up a fiber, and the differing ways that a fiber can be formed together to create the finished fabric, are all important in identifying the fiber.

Fibers are one of the several pieces of forensic evidence known as trace evidence. Even though fibers are small and can be difficult to detect, their importance can be considerable. For example, textile fibers from an article of clothing can be influential in linking a suspect to the scene of a crime.

Fibers in Forensics

Analysis of fibers that are found on a victim will involve determining the types of fibers present at the scene. For example, a fiber can be transferred from a carpet to a body. This fiber will not be as significant as a fiber found on a victim that is not present anywhere else at the scene. If a similar fiber is found on a suspect, this can be a powerful piece of evidence linking the suspect to the scene.

Context is also very important in these situations. Where was the body found? On the carpet? Somewhere else? If the victim was found out in the woods and has three different kinds of fibers that are also present in the carpet this may be very significant. If only two of three carpet fibers are found on the victim they may still be important because of selective or differential shedding. Fibers tend not to cling to other fabric tenaciously. Thus, forensic examiners must handle a victim with care, to minimize fiber loss. Retrieving the victim's clothing as soon as possible is a prudent step to preserving as many fibers as possible.

Fibers are typically collected using adhesive tape. The strips of tape are examined for fibers that match the fibers that are thought to be a normal part of the crime scene. This collection and analysis of fibers are tedious tasks.

Natural Fibers

Among the natural fibers, cotton and wool are the most popular. Other examples include flax, jute, hemp, and kapok. Each type can present a different appearance under an examination technique such as polarized light microscopy (PLM). Different fibers will refract light differently. Depending on a fiber's shape, the fiber can appear brighter along the edges than in the middle. Natural fibers tend to be circular when viewed in crosssection. In contrast, synthetic fibers can have a variety of shapes.

Fiber Identification

The number and location of fibers on a victim and a suspect are important in connecting the individuals together, especially if the fibers match. Matching fibers involves comparing the fiber type, color, and type of dye used. The latter can be especially significant, given the nearly unlimited number of dye combinations that are possible. Color is determined using a visible light microspectrophotometer or by thin-layer chromatography, which separates the various dye components. Synthetic fibers can also be examined by infrared spectroscopy, which can also yield information on the chemical makeup of the fiber.

Using PLM, many different kinds of fibers can be identified. It should be noted that examination by PLM is not done for contrast purposes, although certain kinds of fibers often stand out nicely against a dark field, depending on their orientation. This is essentially the same examination via optical properties used by geologists for mineral identification.

Micro-Fourier transform infrared spectroscopy (or Micro FTIR spectroscopy) also gives forensic scientists specific information about fibers and their makeup. Micro FTIR produces an infrared spectrum of the fiber that is used for identification. Ordinarily, the instrument is purged with nitrogen to eliminate carbon dioxide and water.

Synthetic Fibers

Fibers can be made of a natural material (i.e., wool) or a synthetic compound or blend. The differentiation of these fibers' types can be important. Most synthetic fibers are polymer-based, and are produced by a process known as spinning. This process involves extrusion of a polymeric liquid through fine holes known as spinnerets. After the liquid has been spun, the resulting fibers are oriented by stretching or drawing out of the fibers. This increases the polymeric chain orientation and degree of crystallinity, and has the effect of increasing the modulus and tensile strength of the fibers.

Artificial Fiber Manufacture Classifications

Fiber manufacture is classified according to the type of spinning that the polymer liquid undergoes, melt spinning, dry spinning, or wet spinning.

Melt spinning is the simplest of these three methods, but it requires that the polymer constituent be stable above its melting temperature. In melt spinning, the polymer is melted and forced through the spinnerets, which may contain from 50 to 500 holes. The diameter of the fiber immediately following extrusion exceeds the hole's diameter. During the cooling process, the fiber is drawn to induce orientation. Further orientation may later be achieved by stretching the fiber to what is known as a higher draw ratio.

Melt spinning is used with polymers such as nylon, polyethylene, polyvinyl chloride, cellulose triacetate, and polyethylene terephthalate, and in the multifilament extrusion of polypropylene.

In dry spinning, the polymer is first dissolved in a solvent. The polymer solution is extruded through the spinnerets. The solvent is evaporated with hot air and collected for reuse. The fiber then passes over rollers, and is stretched to orient the molecules and increase the fiber strength. Cellulose acetate, cellulose triacetate, acrylic, modacrylic, aromatic nylon, and polyvinyl chloride are made by dry spinning.

In wet spinning, the polymer solution is spun into a coagulating solution to precipitate the polymer. This process has been used with acrylic, modacrylic, aromatic nylon, and polyvinyl chloride fibers. Viscose rayon is produced from regenerated cellulose by a wet spinning technique.

Collecting Artificial Fibers

Forensic analysis of fibers is conducted in several ways. Synthetic fiber polymers can be suited to examination using infrared spectroscopy. Specified guidelines exist for this type of examination, which makes the technique standard and so more easily legally admissible. SWGMAT Forensic Fiber Examination Guidelines for training purposes can be found on the Web site, http://www.swgmat.org/ .

The constituents of the dye that has been used to color fibers can be separated using chromatography, which can separate compounds based on differences of size or charge.

WORDS TO KNOW

Dry spinning—The classification of fiber manufacture by which polymer is first dissolved in a solvent, which is then extruded through the spinnerets and evaporated with hot air and collected for reuse.
Melt spinning—The classification of fiber manufacture (and simplest method) by which the polymer is melted and forced through the spinnerets, which may contain from 50 to 500 holes, with the result being the diameter of the fiber immediately following extrusion exceeding the hole's diameter.
Wet spinning—The classification of fiber manufacture by which the polymer solution is spun into a coagulating solution to precipitate the polymer (this process has been used with acrylic, modacrylic, aromatic nylon, and polyvinyl chloride fibers).
Artificial fibers can also act as lenses, by virtue of the drawing out process of manufacture. Based on the optical properties of a fiber, shining a light on it will either focus the light toward the center or the edge of the fiber. This can aid in identifying the nature of a fiber sample.