REVIEW ARTICLE

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Evaluation of Textile Fiber Evidence: A Review

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ABSTRACT: The problem of establishing whether or not a certain fibrous textile is the source of a particular single fiber collected from a crime scene is discussed in this paper. A single evidential fiber present at a crime scene can be associated with four major events. These are fiber transfer, persistence after transfer, evidence collection, and fiber analysis. These events are reviewed by drawing on both published research and general scientific principles.

KEYWORDS: criminalistics, fibers

Textile fibers are involved in most human activity, and it probably is safe to assume that fiber evidence is present at most crime scenes. Because their ubiquity makes them one of the most common types of evidence presently available, skill should be developed in understanding each major aspect associated with fiber evidence so it may be effectively and efficiently utilized. A survey conducted in 1983 of all crime laboratories in the United States indicated that 79% of these laboratories examine fiber evidence [*1*]. Consequently, the potential benefit of better understanding of fiber evidence is great.

Although a large number of questions may pertain to fiber evidence, the discussion dealt with herein is limited to establishing whether or not a certain fibrous textile is the source of a particular single fiber collected from a crime scene. In this context, a single evidential fiber present at a crime scene may be associated with four major events. These are fiber transfer, persistence after transfer, evidence collection, and fiber analysis. It is important that one evaluates all of these four aspects when using fiber evidence.

Fiber Transfer

Fiber transfer refers to the release of a fiber from a textile and relocation of the released fiber to another object. Transfer of matter between two objects when brought into contact was first postulated in 1928 by Locard and has become known as Locard's Exchange Principle [*2*]. Although this principle has been assumed without proof to be true for most substances, experimental verification in the case of textile fibers has been obtained [*3,4*]. In view of the large number of textiles associated with victims and suspects of most crimes, some

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guidance is needed for evaluating the general propensity of textiles to transfer fibers. If the likelihood of fiber transfer could be assessed, fiber searches could be planned more logically and considerable savings of time could be achieved. More importantly, the results from fiber searches could be interpreted more intelligently. Unfortunately, specific experimental evidence is limited in view of the importance of fiber evidence. In the absence of much research data, one must rely largely on general scientific principles for guidance.

In a study by Pounds and Smalldon [*5*], the dominant means of fiber transfer were demonstrated to be mechanical rather than electrostatic and were shown to be the result of three different mechanisms. These are the classic shedding of loose fibers residing on the surface of a textile as described by Kirk [*6*], disentanglement and removal of whole fibers partially embedded in the yarn interior, and release of a fiber fragment by fracture of a whole fiber into at least two parts.

Examination of the available research studies of fiber transfer [*3-5*] and consideration of basic structural parameters of textiles lead one to expect that fiber transfer is controlled to a significant extent by fiber length. Textile fiber lengths are conveniently categorized into two groups: essentially continuous fiber lengths that run through an entire fabric width and relatively short fiber lengths ranging from a few millimetres to several centimetres.

To assign fiber lengths in textiles to one group or the other, a fabric may be folded and the folded edge examined. This may be done at a crime scene to provide guidance in evidence collection or it may be done in the laboratory with the aid of low power magnification. A fabric comprised of short fiber lengths is characterized by the presence of fiber ends protruding from the fabric fold as illustrated in Fig. 1. The shorter the lengths of fibers in textiles, the greater the number of protruding ends one will see. If no fiber ends are seen, the fabric surface examined is composed of continuous filament fibers. Figures 2 and 3 show two ex-

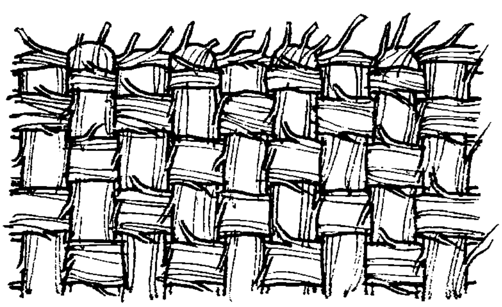

FIG. 1—*Illustration of a folded fabric comprised of staple fibers. Note fiber ends protruding from the fold surface.*

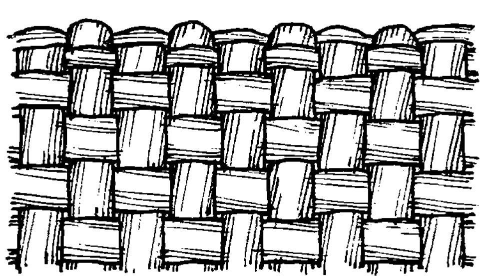

FIG. 2—*Illustration of a folded fabric comprised of untextured continuous filament fibers. Note absence of fiber ends protruding from the fold surface.*

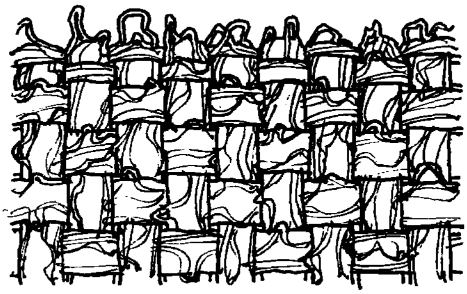

FIG. 3—*Illustration of a folded fabric comprised of texturized continuous filament fibers. Note the absence of fiber ends protruding from the fold surface.*

amples of fabric surfaces that are comprised of continuous filament fibers, with no fiber ends protruding from the fold edges. The important factor here is fiber length and not fiber type. Correlations of fiber transferability with fiber type result in part because some fiber types are available in a limited selection of lengths. For example, cotton fibers are only available in short lengths, and thus generally transfer readily, whereas man-made fibers may be produced in a wide variety of lengths and thus may exhibit a wide variety of transfer behavior.

Fibers of relatively short length, called staple fibers, usually are found in fabrics as staple yarns. The lengths of staple fibers within many textiles are distributed over a wide range. For example, fiber length coefficients of variation may be 10% for man-made staple fibers, 40% for cotton, and 50% for wool [7]. One would expect staple fibers to be transferred by all three mechanisms. Shorter fibers may more easily reside loose on textile surfaces than longer fibers and be capable of transfer by the shedding mechanism. Some shorter fibers also may be embedded within textiles for only a short distance, so transfer could occur easily by loosening the grip on the fiber ends embedded in the textile interior. In addition, transfer of fiber fragments could occur by breaking fibers once anywhere along a segment not embedded in the yarn interior.

Fibers of essentially continuous length are called continuous filament fibers and most often exist in fabrics as multifilament yarns. In general, one would expect these fibers to transfer less readily than staple fibers, since fewer and more complex transfer mechanisms are necessary for fiber release. Yarns are interlaced many times in textiles, and since continuous filament fibers travel across the whole fabric, they are mechanically held within the fabric structure at many points. Although release of some staple fibers also is restricted in the same way by yarn interlacings, the long length of continuous filament fibers results in interlacings at a great many more points along their lengths. As a result of these constraints, continuous filament fibers would not be expected to be transferred by shedding of whole loose fibers. Likewise, transfer would not be likely to occur by disentanglement of whole fibers partially embedded in yarn interiors. Transfer can occur by the fracture mechanism, but fibers must be broken twice rather than once as with staple fibers. In addition, the two breaks would not release a fiber fragment unless they occurred within close proximity to each other, since yarn interlacings may anchor the fiber fragments within fabric structures when the breaks were widely separated. For example, simple release of a twice broken fiber would happen only if both breaks occurred within the short distance occupied by a single interlacing of the yarns within a fabric. If a fiber is broken in such a way that the two breaks are separated by several yarn interlacings, additional mechanical stress is necessary for its release because each interlacing exerts pressure on the fiber and anchors it in the fabric structure (see Fig. 4).

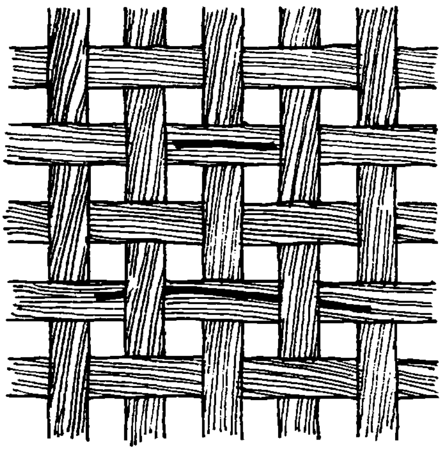

FIG. 4—*Illustration of a fabric made of continuous filament fibers but containing two twice broken fibers. Note that the fiber segment containing both breaks within one yarn interlacing could be released more easily than the other fiber segment.*

In the study by Pounds and Smalldon [*3*], it was shown that the relative importance of each of the three transfer mechanisms was somewhat dependent on the mechanical nature of the transfer event. However, the lengths of the majority of transferred fibers in each case was less than 5 mm, even though the mean fiber length in the donor textiles studied was several centimetres. This indicates that the dominant mechanism of transfer from these textiles must have involved at least one fracture per fiber transferred. This general conclusion also was reached in another study [*4*]. Thus, real fiber evidence resulting from fiber transfer usually is comprised of quite short lengths of single fibers.

The effect of fiber fractures resulting from general consumer use must be considered. Fiber fractures shift fiber length distributions to shorter values. Since transfer of shorter fibers is more likely than transfer of longer fibers, one would expect more transfer from textiles subjected to extensive consumer use than from the same textiles when new. This point is especially important when evaluating fiber transfer from continuous filament textiles, since their propensity to transfer might be estimated to be near zero, when in fact it may be substantial because of the presence of short fiber lengths resulting from fractures. The extent of fiber fractures (and thus propensity to transfer) can be roughly assessed, however, by examining folded edges of fabrics. Fiber ends protruding from the folds of continuous filament textiles indicate that fracture has occurred and fiber release is more likely than when the textile was new.

It is easy to appreciate that textiles having a greater number of interlacings per unit area (designated as thread count in woven textiles and as gauge in knitted textiles) would be less apt to transfer fibers than those having fewer interlacings, since fibers are anchored more extensively within textiles with more interlacings (see Fig. 5). Thus, one might expect a typical, low gauge, knitted wool sweater to transfer more fibers and longer fibers than typical, high thread count, woven trousers made from the same wool fibers.

It is well known that an important effect of twist on yarns is to increase lateral pressure on fibers [*8*]. This pressure acts to hold individual fibers within yarns and, thus, decreases the propensity of fibers to transfer. Highly twisted, continuous filament yarns such as those used in some crepe fabrics possess a considerable amount of lateral yarn pressure, which tenaciously holds individual fibers in the yarn structure. On the other hand, the small amount of lateral yarn pressure characteristic of low twist yarns, such as twistless staple yarns [*9*], holds

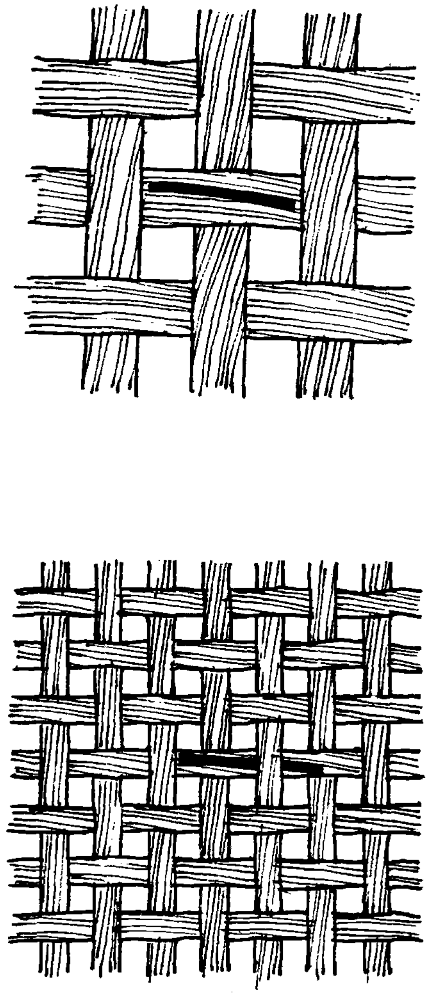

FIG. 5—*Illustration of fabrics of different thread count. Note that fabrics with a greater thread count anchor fibers more extensively.*

individual fibers less tightly. Consequently, one would expect low twist yarns to transfer fibers more readily than high twist yarns, if other structural factors are the same. In addition, one would expect the average length of fibers released from low twist yarns to be greater because the number of pressure points per unit fiber length is less than in high twist yarns.

The net result of considering fiber length, yarn interlacing, and yarn twist is that one would expect fiber transfer to occur more readily from textiles of low interlacing density, which are composed of low twist, staple yarns made with short staple fibers and less readily from textiles of high interlacing density, which are composed of high twist, continuous filament yarns. Of course, exceptional circumstances such as a severely abraded continuous filament textile in which structural parameters like fiber length have changed significantly would not behave in the manner predicted here, but these general principles still should provide helpful guidance in predicting the general propensity of textiles to transfer fibers.

Other factors may affect the likelihood of textiles to transfer fibers. For example, the presence of a backcoating such as that found on some drapery and upholstery fabrics, in which fibers on one side of the fabric are coated with an adhesive, would be expected to diminish greatly fiber transfer. Another factor affecting fiber transfer is seam finishing. If a seam allowance is "unfinished," fraying of the fabric at the seam could occur, and fiber or even yarn transfer from this edge could easily result. On the other hand, if a seam allowance is "finished" such as by multiple stitching along the seam allowance edge, fiber or yarn transfer would be expected to be largely reduced. Another factor affecting fiber transfer is the nature of the recipient object. For example, one might expect recipient textiles with a more three-dimensional texture to be able to concentrate the mechanical stress produced during contact to more localized areas of the donor fabric and increase the number of fibers released from the donor. This has been demonstrated in one study [*10*].

An important point that often is neglected somewhat when evaluating fiber evidence is two-way fiber transfer, that is, the transfer of matter in both directions between two objects. That is, Object A transfers fibers to Object B and Object B transfers fibers to Object A. Locard's Exchange Principle, of course, predicts exchange between both objects, although the probability of fiber release from two different objects is not necessarily identical. The strongest evidence of contact between two objects results when two-way transfer can be demonstrated. Similarly, evidence is weaker if transfer in only one direction can be demonstrated when two-way transfer is expected to have occurred.

The absence of evidence of fiber transfer may be just as important as its presence. Proper evaluation of fiber evidence involves examining the textiles presumed to be involved in a crime, assessing the general likelihood of one- or two-way transfer, and then looking for confirmation of the transfer(s). However, once released from a fabric, single fibers may be transported to many other objects. When a fiber is transferred to a second object after initial transfer through an intermediate object, the process is termed secondary transfer. Secondary transfer obviously may result in the loss of fibers from recipient textiles when their presence might otherwise be expected. Redistribution of fibers to other locations on a recipient textile also may result in fiber loss after initial transfer. It has been shown that many fibers redistribute during ordinary wear [*11*] or laundering [*12*]. It is especially important to note that some fibers seem likely to end up on undergarments even when they were originally deposited on outer garments [*11*].

Persistence After Transfer

Fiber persistence refers to the adherence of transferred fibers to recipient objects. The usual question of concern is how long the fibers would be expected to persist on objects to which they were presumed to have transferred. The reasonableness of claiming that a fiber has originated from a particular source, or of claiming that a source was never in contact with an object if no fibers from a particular source are collected from the object must include an evaluation of persistence as well as transfer. Unfortunately, specific experimental evidence here also is limited, so one must rely largely on general scientific principles for guidance.

Transferred fibers may have extremely great persistence if trapped by sticky substances such as dried blood or adhesive, or if trapped mechanically such as between fabrics of chair cushions. If the recipient object is a textile without one of these means of special entrapment, however, fiber persistence is surprisingly low. Mechanical interactions provide the dominant force adhering fibers to fabrics [*5, 13*]. Because fiber entanglements are responsible for mechanical bonding, one would expect persistence to increase as the surface texture of a recipient textile increases, because a change from a two- to a three-dimensional surface would allow for greater penetration and entrapment of transferred fibers. For example, a fuzzy wool sweater having a hairy three-dimensional surface texture would be expected to exhibit greater persistence towards a transferred fiber than a smooth silk blouse with essentially a flat, two-dimensional surface.

This expectation is supported in studies of fiber persistence [*10,13,14*]. Lower persistence rates have been observed for fabrics having finer textures. For example, coarse sweaters and jackets were found to exhibit the greatest persistence, a finer textured coat exhibited less persistence, and very low persistence was observed for a labcoat with a very smooth surface [*13,14*]. Persistence of the labcoat reached zero quite quickly. However, a small but finite asymptotic value of fiber persistence apparently was attained after a few hours of wear for the more textured fabrics. If such an asymptote is real and finite, it has very important practical implications, since it means that a small number of fibers are likely to persist on textiles subjected to ordinary consumer wear for long periods of time, if the surface of the recipient textile is sufficiently textured. A simple visual examination of fabric texture may be performed quickly to aid in more effective and efficient evidence collection. In addition, examinations of fabric texture may aid in interpretation of fiber evidence.

Without special means of entrapment, fiber entanglement is necessary for a transferred fiber to remain persistently on a textile, and a transferred fiber with a more three-dimensional texture would be expected to exhibit greater persistence than one with less texture. For example, a transferred fiber possessing a three-dimensional, helical crimp would be able to entangle with fibers of the recipient textile to a greater extent than a fiber possessing an uncrimped, one-dimensional linear configuration. In studies comparing the persistence of different textile fibers [*13,14*], little or no difference in the persistence of transferred wool or acrylic fibers was observed. However, acrylic fibers are used as a wool substitute and probably were very similar in texture to the wool fibers used in these studies. In one study, viscose fibers were observed to exhibit greater persistence than polyester fibers and this difference was suggested to have resulted from their differing texture [*13*]. One also would expect that, within limits, shorter fibers would exhibit greater persistence than longer fibers because shorter fibers can penetrate deeper into recipient textiles. This expectation has been supported by research studies [*12,13*].

Evidence Collection

Every study of the persistence of single fibers on fabrics subjected to typical consumer wear has found that persistence of single fibers on textiles is, in general, surprisingly poor. It was found that the majority of transferred fibers were shed (engaged in secondary transfer) after only a few hours of ordinary wear. This, of course, greatly diminishes the chance of recovering fibers several days after they were transferred to fabrics that subsequently were subjected to ordinary consumer wear. The common implication is that evidence collection preferably should be done as soon as possible.

The following basic facts should provide guidance in evidence collection: fibers are ubiquitous and present in enormous variety in most environments, the rate of secondary transfer is surprisingly rapid in many cases, and one usually experiences practical limitations of analysis time. These suggest that the number of fibers and textiles collected from a crime scene generally should be minimized, as long as an undue risk of missing important evidence is not created. General rules governing transfer and persistence should be taken into account. In general, fabrics should be considered to be fiber donors in a transfer event only if examination shows them to be reasonably likely to transfer fibers. Similarly, fabrics should be considered as recipients of transferred fibers only if they can be considered likely to hold fibers persistently under the conditions of the specific case. Fiber searching methods used in recovering single fibers from recipient objects have been discussed [*15,16*] and their effectiveness compared [*17*].

If a textile is considered to be a probable source of a transferred fiber, it must be thoroughly sampled to include fiber specimens representative of the wide variability in structure and properties generally characteristic of consumer-used textiles. For example, if a carpet was thought to be the donor of a fiber but knowledge of the specific location of the transfer on the carpet is unavailable, fibers should be collected from the carpet in many locations to include structural variations caused by sunlight near windows, heat near furnace registers, abrasion on pathways, soil in heavily used areas, and other stresses. This sampling is necessary to characterize adequately fiber variability in the textile. In summary, objects to be collected as evidence should be judiciously chosen but sampled thoroughly.

Analysis

Because of the way trace evidence presently is treated, analysis should involve two steps [*18*]. First, similarity or dissimilarity must be demonstrated between fibers constituting the suspected source textile and the particular single fiber presumed to have originated from it. Then, the evidential value of all similarities and dissimilarities must be evaluated. Both of these steps must be performed or the fibers do not have legitimate evidential value.

Determination of Similarity and Dissimilarity

An impressive variety of analytical techniques are available to demonstrate similarities or dissimilarities between textile fibers. A large number of micro- and ultramicro-analytical techniques have been demonstrated to be useful for comparing single fibers (see Refs *19* to *24* for a representative sampling of analytical methods). These techniques run the gamut of analytical science from nuclear to gross morphological measurements. Microscopy methods probably are the most commonly employed techniques and include examinations of gross structural features (length, breadth, cross-sectional shape, three-dimensional configuration, and surface texture), fracture morphology, inclusions (type, size, shape, amount, and distribution), refractive properties (refractive indexes and chromatic dispersion), crystal morphology, ultraviolet fluorescence, and elemental composition. In addition, spectroscopic methods are widely used and include infrared, visible, ultraviolet, X-ray fluorescence, neutron activation analysis, and mass spectroscopy. A variety of other techniques are used and include solubility, density, viscometry, melting point, glass transition temperature, shrinkage, light scattering, X-ray diffraction, pyrolysis-gas chromatography and thin-layer chromatography.

In general, the greater the number of independent analytical measurements that are employed, the greater the discrimination power the examination provides and the greater the evidential value all conclusions of similarity and dissimilarity possess. The general procedure usually followed in one form or another when applying each analytical technique for similarity/dissimilarity determinations is as follows.

First, one or more individual fibers within a suspected source textile are examined using a particular analytical technique. Second, a measurement is performed in an identical manner with the single fiber believed to have originated from the textile. Then, with regard to the measurement obtained, the single fiber is said to be similar or dissimilar to the suspected source textile after a decision rule is applied.

One decision rule involves determining if the single fiber measurement is reasonably near to one or more suspected source fiber measurements. If it is near, then the measurement indicates that the single fiber is similar to the suspected source textile. If it is not near, the single fiber is said to be dissimilar to the suspected source. Although this technique is simple and requires a minimum of only two measurements, a major shortcoming is that the error associated with each similarity/dissimilarity conclusion generally is unknown.

An alternative decision rule that provides an estimate of error is the range test. However, more measurements are required than with the previous decision rule. If the single fiber measurement lies within the range of several measurement values of the suspected source textile, the fiber is said to be similar to fibers of the suspected source, whereas it is said to be dissimilar if the single fiber measurement lies outside this range. An estimate of error associated with this similarity conclusion may be calculated, but a relatively large number of measurements are required to achieve small errors [25].

A third decision rule called the *t* test may be utilized. The *t* test uses more information from measurement distributions instead of using only one measurement value or merely the range of a distribution. The standard deviation and the mean of the measurement values from the suspected source textile are calculated and used along with the measurement value from the single fiber to conclude similarity or dissimilarity. This statistical technique makes more efficient use of data, so fewer measurements are required than when using the range test to obtain the same error level.

An important aspect of the range and *t* test is recognition of the variability inherent among fibers in textiles. Most textiles examined in forensic science cases have been commercially produced and used by at least one consumer. Consequently, the fibers have been subjected to a multitude of stresses, including those during fiber formation, conversion into yarn, manufacture into fabric, dyeing, finishing, cutting and sewing into usable objects, soiling, laundering, exposure to sunlight and weather, and abrasion. Many of these stresses do not act to the same degree on all fibers in a textile. Thus, a multitude of variations in the structure and properties of fibers within one textile would be expected. For example, sunlight would be expected to exert its influence primarily on fibers constituting a textile's surface that is directly exposed to the light rather than the fibers on surfaces facing away from the light. Consequently, to obtain a fair representation of the variation in measurements represented within the textile, similarity determinations should involve measuring a large number of different fibers in a textile with each technique employed. This may be accomplished with the range and *t* tests.

If this variability is ignored by not thoroughly sampling a suspected source textile, a conclusion of similarity or dissimilarity is misleading. A textile that is not thoroughly sampled will appear to have a smaller range of measurements than it actually possesses for each analytical technique employed. Consequently, a measurement from the single fiber being tested for similarity may not lie within the range of measurements apparently exhibited by the suspected source textile although it might if the textile were more thoroughly sampled. On the other hand, a claim of similarity with a textile characterized by an unrealistically small measurement range claims more evidential value than is legitimate, because a smaller population of other fibers in the crime scene environment would meet the criteria of similarity encompassed by this smaller measurement range.

A substantial time lag between the collection of two pieces of evidence to be compared presents a fundamental problem inherent in many analytical comparisons in forensic science. Obviously, many stresses may alter one or the other piece of evidence to be compared so the two pieces of evidence appear dissimilar, even though they were similar at the time fiber transfer actually occurred. The reverse also is true, that is, fibers may appear similar when they were not similar at the time of transfer. Sunlight, heat, moisture, gases, soil, and mechanical abrasion may contribute to this problem as well as stresses associated with laundering and other common consumer uses.

These things are known to alter the chemical and physical structure and, consequently, properties of fibers. Interestingly, structure and property differences are seldom reported in forensic science comparisons, except in the case of color changes. This is true even though substantial time lags often exist between collections of evidence, so differences in structure and properties of fibers would be expected. This probably reflects the relatively high level of discrimination power characteristic of some color comparisons and the lower discrimination power characteristic of most other common measurements. Many examples exist that illustrate the greater discrimination power of color comparisons (see Ref *26*, for example). There is an obvious need to increase our knowledge of the general effects of common consumer use on the structure and properties of textile fibers, so these can be considered when comparing fibers collected at different times. There also is a need to develop other analytical methods suitable for single fiber examinations, which possess the great discrimination power of color comparisons.

Determination of Evidential Value

If similarity between a single fiber and suspected source textile has been demonstrated, the next step is to determine the evidential value of the similarity. This is necessary and must be performed or the only conclusions one may reach are that a fiber "could have" or "may not have" originated from the suspected source textile. These conclusions have no value. This is obvious when one considers that these conclusions may be reached *without even conducting fiber analysis*.

Evidential value of fiber evidence usually is related to determining the number of possible sources of the transferred fiber at the specific crime scene. Obviously, the smaller the number of possible fiber sources in the environment, the greater is its evidential value.

There are several ways of determining fiber evidential value. The most rigorous way is to subject samples of all other fiber sources in the relevant crime scene environment to the same similarity testing procedure used in determining the evidence similarity. This procedure could provide a meaningful measure of evidential value, but is impossibly demanding of resources, except in unusual circumstances.

Another way of estimating evidential value is to estimate statistically the number of sources in the relevant crime scene environment by statistical extrapolation from a limited experimental sampling. In view of the very large number and diversity of textiles available in most crime scene environments, the sample size required for this procedure usually is prohibitively large. The main problem usually encountered here is designing an adequate sampling strategy so that the entire population of textiles is represented. For example, if wearing apparel is being examined, the sampling procedure should include new items currently available in stores as well as items no longer commercially available but housed in various residences in the relevant crime scene area. In addition, sampling from different locales should somehow be weighted in a way that represents their actual abundance in the whole population of wearing apparel in the crime scene area. However, exceptional circumstances occasionally may allow use of this method.

The method of determining evidential value that is most often successful is obtaining production or sales records and then estimating the number of textile items or fibers potentially available in the relevant crime scene environment. One must obtain information about the transferred fiber and suspected source textile to identify the fiber generic class, fiber producer, fiber type, or dye type under consideration. Of course, the more information there is available about a textile item, the greater is the potential evidential value, because the number of possible sources for the transferred fiber decreases. The first information that usually is obtained is generic class. Evidential value based on generic class can be estimated by reviewing commonly available fiber production records such as those regularly published in *Textile Organon*. Although evidential value based on generic class usually is low, one occasionally encounters a fiber generic class that is produced only in small amounts, so its evidential value is great.

If one is able to ascertain the fiber type of the single transferred fiber and suspected source textile using measurements such as cross-sectional shape, then evidential value is increased by narrowing investigation to a subset of the generic fiber class. Although considerable effort sometimes is required to obtain production records of fiber types, a reliable estimate of evidential value can be obtained. As with generic class identification, one should ascertain the fiber type of both the single fiber and suspected source textile independently, and conclusions obtained from the data of both analyses should be able to withstand scientific scrutiny independently. Although determinations of fiber type often are possible when a large number of fibers from a suspected source textile are examined, knowledge of fiber type of a single fiber cannot be claimed on the basis of measurements that do not discriminate among fiber types. Unfortunately, conclusive determination of fiber type from a short length of a single fiber or a fiber fragment originating from a consumer-used textile often is difficult or impossible.

A useful alternative to employ when fiber type of either the single fiber or suspected source textile cannot be ascertained is to identify the manufacturer of the fiber. Since many manufacturers place chemical "markers" in their products for their own use in identification, determination of these marker's presence may increase the evidential value of fibers substantially by identifying a subset of the generic class. As might be expected, detection problems may plague the analyst when attempting to demonstrate the presence of a manufacturer's marker in typical single fiber evidence. The situation can readily be appreciated by considering a single fiber with a mass of 1 μg and a marker concentration of one part per thousand. This would require detection of nanogram amounts of marker and require using the entire fiber. Nevertheless, analytical methods currently exist for measuring these low concentrations.

Another means of estimating evidential value is by relying solely on the experience of the analyst. This procedure often is used when the manufacturer or type of fiber cannot be ascertained, or the population of textiles in the crime scene environment is too large for an experimental sampling of the number of possible sources but it is felt by the analyst that the fiber is relatively rare. Although an analyst cannot objectively prove his personal assertion, he usually estimates the number of fibers examined during his career, and states that he has never (or rarely) examined a fiber of the type in question. The problem with this procedure is that it equates the population of fibers in the domain of the analyst's experience with the population of fiber sources in the crime scene environment. This is a dangerous assumption to make and the limitation imposed by one's own experience has been noted previously in the literature [*27*]. Another problem with this procedure is that it relys heavily on the recollection abilities of the analyst. While these abilities vary from individual to individual, the greater the elapsed time since the earlier examinations, the more suspect the recollections become. Because the experience of most analysts spans many years or decades, this procedure has questionable reliability.

Summary

Four general events associated with textile fiber evidence were discussed. These were fiber transfer, persistence after transfer, evidence collection, and fiber analysis. Ways of interpreting these events when evaluating fiber evidence were reviewed. Pertinent research studies and general scientific principles were cited to provide guidance in the use and evaluation of textile evidence.

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