

# Selected Aspects of the Forensic Examination of Textile Traces

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## Abstract

*For years the practice of examining fragments of single fibres separated from textile products and transferred onto other (foreign) surfaces has been applied in order to establish a link between a person or persons and an object or the scene of a criminal event. These fibres are imperceptible or barely perceptible to the naked eye and can only be revealed through the use of certain techniques of securing such material. The evidential value of transferred fibre traces, possibly coming from a known source and recovered in the case of a specific criminal event, depends on a number of factors. The particular circumstances of the event, the way in which evidence is gathered at the crime scene, the precision of laboratory tests, the colour and type of fibres recovered, and the measurable effects of destructive processes can all enhance or lessen the evidential value of such material. In this publication, the results of multi-aspect research conducted in the area of forensic examination of fibres are presented, concerning questions relating to the interpretation of analytical results. This research has helped to illustrate how important trace fibre evidence can be in clarifying the circumstances of a wide range of crimes.*

**Key words:** single fibre, fibre trace, forensic examination, evidential value.

## Introduction

Various apparel, furniture, vehicle upholstery and other textiles, which are part of a person's immediate surroundings, can also "participate" in a crime. Textiles, their component fibres and even small fragments of these fibres can constitute a part of forensic evidence (i.e. the change of objective reality that may form a basis on which to recreate the course of an event [1]) that is of great significance to a forensic investigation. This kind of evidence can consist of some element of a victim's or suspect's clothing: a part of the garment (e.g. single fibres recovered from a knife blade); imprints (e.g. of a material's texture left on plastic elements of an automobile's interior); a chemical or biological substance (e.g. a bloodstain on the upholstery of the boot of a vehicle); or chemical and/or physical changes to a given article (e.g. a burnt cap found in ashes from a furnace).

Fibre traces (usually no more than a few millimetres long) has been the subject of intense analysis since the 1970's [2 - 4]. The forensic analysis of fibre samples taken from textiles and transferred to a different (foreign) surface is based on a theory first formulated by Edmond Locard [5], which posits that if two objects come into contact with each other, there will always be some trace of this contact in the form of mutually transferred material. Unfortunately, it's not always possible in practice to conclude that contact did indeed take place, as the number of fibres that might be transferred, for example, is so insignificant that finding and/or identifying them is impossible using cur-

rently available methods of securing and examining evidence [6 - 9]. The speed at which a transferred trace - like a single fibre - is lost may also be significant enough to render it unfindable, even very shortly after the event [10 - 13].

Due to their tiny size, single fibre traces removed from textile products are usually imperceptible - or at best barely visible - to the naked eye, and determining their presence is only possible once certain evidence collection techniques, as well as magnification, have been applied. Fibre traces are most often recovered using transparent adhesive tape [3, 14 - 19], which also helps to protect this type of evidence from contamination.

Fibres transferred from an offender's clothing to that of a victim, and vice versa [20 - 23], as well as fibre traces present on a body - under a victim's fingernails, for example [24], or in their hair [25] - are most often sought in order to establish whether or not physical contact took place between individuals, as in cases of murder, sexual attacks, beatings, etc.

To establish whether or not someone was present at the scene of a crime, the edges of all manner of obstacles negotiated by the perpetrator when committing the crime - particularly sharp edges of glass, synthetic materials, metal and wood [26, 27] - are checked for fibre traces. In determining who may have been driving a motor vehicle when a given event took place, the driver's and passengers' seats, as well as other elements of the vehicle's interior, are also checked for fibre traces [28 - 30]. Single fibre traces from vic-

tims' clothes are frequently found on the tools used by a perpetrator (e.g. knives, scissors, axes), or - as in cases where a pedestrian was hit by a car - on the exterior of vehicles, most often the areas that sustained damage in the accident [30, 31].

Fibre traces can also provide valuable forensic evidence in a currently high-priority area of analysis for both law enforcement authorities and Courts - that of terrorist crimes. In Germany, Great Britain and the U.S. (data provided concerning material evidence obtained in Iraq), there have been several cases where fibre evidence was recovered that came off the clothing of individuals preparing explosive devices with adhesive tape - which is often used to wrap the wiring of such devices [32, 33]. Routine searches for fibre evidence possibly coming from suspects' clothing along their probable escape routes from the area of the explosion, or inside the vehicles they used have been conducted many times by fibre analysis experts working with the European Fibres Group (EFG), which operates under the aegis of the European Network of Forensic Sciences Institutes (ENFSI) [32, 34].

Forensic examination of single fibres leads to establishing their characteristic features (colour, shape, surface characteristics, thickness, crystallinity, fluorescent qualities, chemical composition), and on that basis to their identification - i.e. classification according to a specific type, variety and/or assortment of textile products. In the course of the production process, a single fibre generally does

not acquire any features characteristic enough to allow for the identification of a specific textile product; all that can be established is that it may have come from a set of similar products (known as forensic group identification).

### **Evaluating the evidential value of a single fibre**

In any forensic examination of a fibre, an assessment must first be made, based on the evidence and comparative materials gathered in a case – specifically in terms of defined fibre categories (allowing for type as well as colour) – as to whether or not it is possible to establish that the transference of any fibre took place. The colour and type of fibres recovered are of great importance in evaluating how significant this type of forensic evidence may be [35, 36]. There are certain categories of fibre that are extremely common and used in the manufacture of huge numbers of different products, which are of negligible value as forensic evidence. Among these are mainly white (i.e. usually colourless under a microscope) cotton fibres that can come from a great variety of products, including apparel, bedding, decorative textiles, etc. Moreover, there is no other primary factor present in these types of fibres that would differentiate them to the extent that colour does.

For certain reasons some fibre types can be classified as rarely encountered (not in widespread use). These may have a highly atypical morphology, for example, or have been produced in limited amounts within a very brief time period in a specific geographic region, or they might have been manufactured in now obsolete facilities [37, 38]. Unfortunately, the average consumer and researcher rarely deals with such categories of fibre.

Information concerning the prevalence of fibres dispersed in the environment can only be obtained based on the results of population studies that define how frequently certain fibre types are encountered within a given geographical area [25, 39 - 48]. A court-appointed expert tasked with the evaluation of evidence materials consisting of products of the textile industry may also use marketing and sales data in order to provide Courts with information concerning an analysed product's availability on the market, as well as the frequency with which it was purchased by consumers during a speci-

fied period of time, so as to establish a link between the product and a specific individual who acquired it.

Considering fibre type exclusively, it should be emphasised that cotton fibres are among the most ubiquitous in the environment, which is also borne out by research conducted by this author [39]. Moreover, these fibres are difficult to distinguish from one another due to the fact that they have very few differentiating features, which are mainly morphological [49 - 51]. By contrast, wool fibres are characterised by a varied morphology, while synthetics are diverse in their chemical structure [51, 52]. Consequently, in many cases the detection and recovery of less commonly encountered synthetic fibres (e.g. polyolefine, modacrylic) very often results in this type of forensic material having greater evidential value [53].

The colour of certain types of fibres also plays a very substantial role in assessing their evidential value, for example blue cotton fibres are usually more frequently encountered than red or green ones due, among other things, to the production of and demand for large amounts of blue denim apparel [39, 54 - 56]. Beyond the microscopic and micro-spectrophotometric techniques routinely applied in fibre colour testing [57, 58], other methods of analysis which would yield information about the dyes used in them have been intensively sought in recent years [59 - 61].

When considering the evidential value of particular categories (colour and type) of fibres, attention should be paid to certain aspects of recovered synthetic fibres. The same dye that is used on a synthetic fibre may be used to produce an enormous amount of shades of a given colour, in addition to which mixtures of dyes are often used. Thus, if the subject of analysis is a coloured synthetic fibre, the evidential value of the recovered forensic evidence should not be low, despite the mass production of synthetic fibres as well as the dyes used in them. This thesis is supported by the lower prevalence of synthetic fibres in relation to natural ones in the environment as well as on the textiles market, and the ease with which differences in their colour and construction can be determined. It is also supported by data from research in which fibre samples were collected from various places with the aim of finding synthetic fibres of specified colours and chemical/

structural features among those dispersed in the environment – known as target fibre studies. In order to find one category of red acrylic fibre, tens of thousands of fibre samples collected from about 500 different types of surfaces were subjected to analysis. These tests were conducted in cooperation with the EFG, which meant that in practice the target fibre was searched for in close to twenty European countries, including Poland [62]. In the entire collection of samples examined, little more than a single fibre was found that was consistent with the colour and chemical/morphological characteristics specified.

A similar result was obtained for the more frequently occurring category of fibre that is blue wool. An insignificant number (< 5) of the target fibres were recovered from amongst close to twenty thousand samples taken from chairs used by the public in Northern Ireland [63]. In this case, however, the area in which the fibres were sought was limited.

Some of the latest comparative research, which involved blue polyester fibres taken from various sources, also showed that the chances of finding two identical categories (colour/type) are very low [64].

### **Influence of destructive processes on the evidential value of a fibre trace**

Any kind of damage sustained by a textile product through use, lowering its aesthetic and practical value, is disadvantageous from the user's as well as the producer's perspective. However, forensic material that has some sort of characteristic damage can have greater evidential value. If the constituent fibres of a specific element of clothing show detectable signs of discolouration [65, 74 - 76], thermal changes (melting, burning, charring, effects of the shock wave of an explosion, etc.) [66 - 72, 76] or biodegradation [73], their value as evidence is then considerably higher. For this reason, research into the destructive processes that act on a textile product in the course of its use, or damage due to the effects of specific chemical and physical factors, is important from a forensic standpoint as well, since it can help in the process of ascertaining the course of events and circumstances of a crime. Knowledge of the kinetics of changes that take place in a textile product, fa-

miliarity with the individual life cycle of a product, and the possibility of assessing its physiochemical analytical parameters at various stages of the cycle allows for proper verification of its evidential value.

The first of a fibre's physiochemical characteristics that is subject to verification in forensic examinations is its colour. Eventual colour differences between evidential (e.g. recovered at the scene of the crime) and comparative (e.g. taken from the suspect's clothing) materials suggest that the fibres cannot have come from the same source, which renders further testing pointless. In many instances the comparative material is secured by law enforcement agencies several months after the crime has taken place (which can be mitigated by new factors arising in the case). This is also why knowledge of the successive colour changes fibres undergo as clothing is subjected to continued wear (e.g. multiple launderings) can be of crucial importance in assessing the consistency between evidential and comparative materials, thereby making the correct determination in a case. Changes in the initial fluorescence of a fibre can be influenced, among other things, by heat, sunlight, the long-term effects of atmospheric factors (e.g. rain) [13], or the conservation of a product. However, there is an example documented in forensic literature of an analysis of cotton fibres secured as evidence in a murder case in Seattle, which despite presumably (according to the suspect's testimony) having come into contact with laundry detergents (optical brighteners), showed no signs of having absorbed them [57]. Tests conducted by this author concerning the kinetics of colour change in fibres treated with laundry detergent solutions show that the short-term action of detergents on a cotton product does not necessarily result in the fibres absorbing optical brighteners [74, 76].

Thermally altered fibres – recovered mainly in cases involving fires, arson, explosions and traffic accidents – are of substantial evidential value in clarifying circumstances surrounding events, and confirming the presence of a specific person at the place of their occurrence. In these types of cases, the fibres the expert is dealing with have been significantly transfigured several times, thus reconstructing and establishing their original shape, colour and chemical structure is a difficult or impossible undertaking without detailed knowledge of the mecha-

nisms involved in such changes and experimental verification of their effects [66 - 72, 76].

## Summary

The usefulness - presented in abbreviated form in this publication - of the examination of single fibres, particularly concerning questions connected with interpreting the results of analyses, indicates that this type of forensic evidence can be immensely important in clarifying the circumstances surrounding a number of crime-related events.

The evidential value of trace fibres, possibly from a known source, transferred during the committing of a crime and subsequently recovered depends on a large number of factors. The particular circumstances of the event, the way in which evidence is gathered at the crime scene, the precision of laboratory tests, the colour and type of fibres recovered, and the measurable effects of the destructive processes can all enhance or lessen the evidential value of such material. If indeed the transference of trace fibre material has taken place between the clothing of people who are complete strangers, when a few categories of similar transferred fibres are recovered, and if the evidence was collected a very short time after the event, then the probability of the fibres having come from a random source not connected in any way with the crime is very low.

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