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A study of black fleece garments: Can fleece fibres be recognized and how variable are they?

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ABSTRACT

Fleece garments are very popular nowadays. This is reflected in forensic fibre cases where fleece garments and especially black colored items are frequently encountered. For this study 201 black and dark colored fleece garments were collected from co-workers, friends, family and shops. The constituent fibres were analyzed with common methods used in forensic fibre analyses: microscopy (bright field, polarized light, fluorescence); microspectrophotometry (MSP-visible range); infrared spectroscopy (FTIR) and comparison microscopy. Almost all fleece fabrics were made of 100% polyester fibres. The most abundant fibre type involved polygonal polyester fibres. The appearance of typical fleece-features was explored. It was found that fleece fibres would shed easily, resulting in many long polyester fibres. In many cases these fleece fibres showed typical "mushroom-ends" and in some cases a few thicker fibres that originated from the inner "base layer" of the fleece fabric were also found providing a second fibre type that can be lost from fleece fabrics.

Most of the black fleece fabrics could be discriminated with the analytical techniques, the discriminating power DP was found to be 0.9985. This was despite the fact that most of the absorption spectra showed similar features in the visible range. They were denominated as TYPE 1 MSP-spectra and displayed 2 absorption bands at 450 nm and 600 nm.

1. Introduction

Fleece textiles and fibres originating from fleece fabrics are frequently encountered in forensic fibre cases. Fleece garments such as sweaters and jackets are mostly used for outdoor activities but fleece can also be very popular for blankets, scarves, gloves and lining. Fleece fabrics owe their success to a combination of properties such as a soft touch, a warm feeling and light weighted fabric [1]. Polar fleece was first produced by Malden Mills in 1979 [1,2]. This American brand is now called Polartec, hence the name polar fleece, and is still the main producer of fleece materials around the world.

Fleece fabrics are usually constructed out of 100% polyester fabrics. It consists of a knitted fabric, typically a standard jersey (the "base layer") and an upper layer of fuzzy fibres (the "fleece layer") (Fig. 1). This upper layer originates from an additional yarn that is knitted together with the original jersey. The additional yarn forms bigger loops that stand out of the surface of the fabric. These loops are broken into a fuzzy layer during a napping process where the fabric is moved over spinning cylindrical brushes. Finally, the fleece surface is sheared with spiraling blades to obtain a uniform fabric thickness and to prevent pilling. It is the additional fuzzy layer that gives fleece fabrics its typical soft and warm properties.

For the present study 201 black and dark colored fleece garments were collected from coworkers, shops, family and friends (Table 1). The collected fleece garments were mainly fleece jackets, sweaters and gloves. The fibres from these garments were analyzed with the recommended techniques for fibre examination [3]: microscopy (bright field, polarized light and fluorescence), microspectrophotometry (visible range) and infrared spectroscopy. One of the aims of this study was to identify fibre properties that are characteristics for fleece fabrics. This could provide crucial information for fibre-examiners when they are working on a case with no comparison material and where the goal of the examination is to provide information about the textile materials that could have been in contact with the victim during the offense. If an important population of polyester trace fibres is found a likely source could be a fleece material. Secondly, in this study the degree of discrimination between black fleece fibres was determined. How variable are the black fleece fibres and therefore how useful are they as target fibres in a comparative fibre case?

Over the last 15 years, several papers have been published that focus on a specific fibre type and the degree of discrimination but none of them involve black polyester or fleece fibres [4–12]. Background information on the identification and differentiation between different polyester fibres by several analytical techniques is also available [13–17].

Among the available data in the literature, most related to the topic of this paper is a study by Grieve et al. on the individuality of blue polyester fibres [7]. In this paper a large amount of different types of blue

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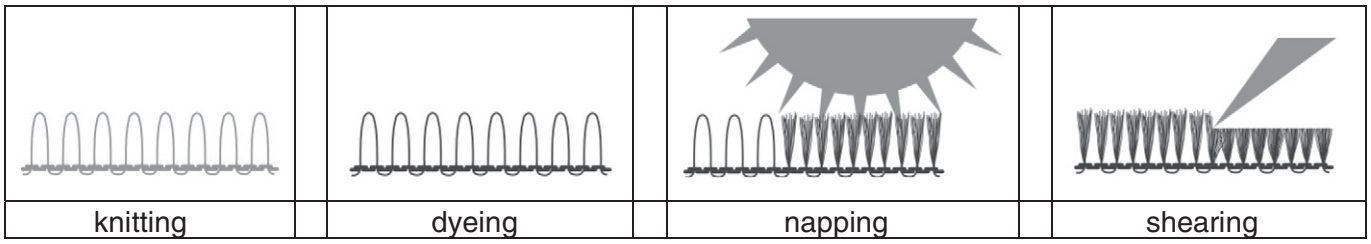

Fig. 1. Schematic representation of the production of fleece fabrics.

garments constructed with polyester fibres were analyzed. The results indicate a high variety among blue polyester fibres with semi-dull circular fibres being the most common fibre type (186 out of 263 samples).

2. Experimental

2.1. Materials and sample preparation

201 black or very dark fleece materials were collected from coworkers, shops and relatives. Each garment was described, photographed and cleaned with a tape at the surface of interest. A tuft of reference fibres was taken with a pair of tweezers from the outer surface, the "fleece layer" (where possible on the upper right front side of the textile). The fibres were mounted on a glass microscopy slide using Histomount resin (National Diagnostics) and a droplet of xylene. For some of the fleeces, fibres from the inner surface and the interior of the fabric ("base layer") were also taken and analyzed. The sheddability of the textile was evaluated by application of a high-tack tape on the upper right front side of the fleece and comparison of this tape to a home-made scale ranging from 0 "no fibre loss" to 5 "high fibre loss" [18]. The fleece fibres were subsequently analyzed by several methods.

2.2. Microscopy

The fleece fibres were observed at 400× magnification using a DMRXP research microscope (Leica, (40× objective with NA 0.65). The fibre properties such as the type of cross section, the presence of delustrants, pigments, ring dyeing, zone dyeing and/or melted ends and polymer class and fluorescence were described in brightfield, polarized light and fluorescence illumination modes and documented with a Nikon DS-Fi2 camera.

2.3. Comparison microscopy

Matching fibres were observed side by side at 400× magnification using a DM4000B FSCB comparison microscope (Leica, 40× objective with NA 0.65) and documented with a Nikon DS-Fi1 camera.

2.4. Microspectrophotometry

The fibres were measured with microspectrophotometry using a Tidas 800 microspectrophotometer (J&M) coupled to a Zeiss microscope (Axioplan 2) and a photodiode detector (type MCS 1024, range 190–1020 nm). The spectra were collected in the visible range (380–800 nm) with an integration time of 350 ms and 5 accumulations. The measurement was performed in the middle of the mounted fibre at 400× magnification and with a measuring window equal to 5 × 30 μm. Reference spectra were collected for each absorption measurement at an area next to the fibre. 5 spectra were taken for each sample. No further data treatment was carried out. Comparison of the spectra was based on a visual comparison using the overlay technique.

2.5. Infrared spectroscopy

FTIR spectra were taken from all samples using a FTIR spectrometer Vertex 70 (Bruker) coupled to an IR microscope Hyperion 2000 (Bruker). The transflection modus was selected and the range was set at 400–4000 cm^{-1}. From each fleece material 5 fibres were measured (first squeezed on an aluminum pellets). For practical reasons, some fibres were mounted from the tapings. They were first washed with xylene to remove residual glue from the tape.

3. Results and discussion

An overview of the collected items can be found in Table 1 and summarized according to textile type in Fig. 2. Fleece jackets were the most common type of garments analyzed for this study (28% of the total items), followed by sweaters and gloves. Other types of garments that were collected involve lining, scarves and hats. Out of the 201 collected fleece samples, 183 are purely black and 17 are dark blue or green fleece items. On a microscopic level, the fibres from the purely black items were easily distinguished from the fibres originating from the dark colored (blue or dark green) by their color. Therefore, it was decided that for further comparison the conclusions will be based solely on the purely black items.

A summary of the morphological fibre features of the collected black fleece garments can be found in Table 2. 178 out of 183 black fleece materials consisted out of 100% polyester fibres. 4 items were made of 100% polyamide fibres. These items (fleece nr 94, 96, 97 and 98) correspond to fleece materials from one and the same brand (B. Twin cycle decathlon) and involve smooth sportswear with a thin fleecy layer on the inside of the fabric. Only 1 out of 183 fleece items was (partly) made of acrylic fibres. This item involves a fleece hat with a fleece lining. The main fabric of the hat was made of 100% polyester fibres, whereas the fleece lining was composed of acrylic fibres. To resume, 97% of all fleece materials consisted out of 100% polyester fabrics. The identification of the polymer class was carried out by using polarized microscopy (crossed polars) and confirmed by FTIR.

3.1. Recognition of the fleece fibres

The sheddability of the collected fleece items was assessed on a scale from 0 to 5, where 0 corresponds to almost no fibre loss and 5 to a great fibre loss. The average sheddability was found to be high. However, a large amount of the fleece items involved new clothing that was never worn (44 out of 201, see Table 1). The sheddability of new fabrics is typically higher (in average 4 in the case of the fleece garments) as many of the sheared fibres still remain on the surface. Discarding the sheddability of the 'new' fleece items, the average sheddability of a fleece fabric was 3 on a scale from 0 to 5.

Fibres from fleeces 1–43 were studied regarding specific properties that can be related to fleece fabrics. It was noticed from the shedding test that in some cases thicker fibres with the same color were also shed from the fleece fabric. For some of the fleeces (11 items) fibres from the "base layer" as well as from the outside of the fabric (the