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Synthetic flock fibres: A population and target fibre study

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ABSTRACT

One hundred garments were examined for synthetic flock fibres. Flock fibres were found on 82% of garments. The majority of flock fibres were nylon (6 or 6,6) with a round cross-section, a diameter between 15 and 20 μm and a length between 0.5 and 1 mm. Black pigmented flock fibres (polyester or nylon) were present on 33% of garments. Each garment was examined for several target automotive flock fibres from the glove compartments and window channels of a range of vehicles. None of the dyed target flock fibres were found on the garments. The black pigmented target flock fibres were found on 3–4% of the garments examined.

1. Introduction

Several target fibre studies or fibre population studies have been carried out in the past. The motivation to carry out such studies is to assess the likelihood of finding specific fibre types on specific surfaces at random. This then assists in assessing the evidential value of fibre evidence in a particular case. Examples of such studies include looking for specific fibre types on items of clothing [1,2], or examining specific surfaces to see what types of fibre are present, such as outdoor surfaces [3], car seats [4] or clothing [5]. In none of these studies has a reference been made to flock fibres and their occurrence on these surfaces.

Flocked material is made by propelling short (0.5–4 mm) monofilament fibres directly onto a substrate that has been previously coated with an adhesive. The process electrically charges the flock fibres, causing them to "stand-up" so that they stick into the adhesive at right angles to the substrate [6]. Since the fibres adhere to the surfaces of the adhesive, rather than penetrate or imbed in it, fibres are shed readily from the surface of the flocked material. By virtue of the high shedding property of this type of material and its many applications – inside vehicles, on clothing logos, jewellery box linings, picture frame backings; as decorative features on stationery and wallpaper to name but a few – one would expect that this type of fibre is present on surfaces at random. This study aims to clarify this point by examining one hundred garments specifically for flock fibres.

Flock fibres are regularly encountered in cases involving vehicles where they can be used to provide a link between someone's clothing and the interior of a vehicle. In a previous study [7] the general location of flocked material in the interior of vehicles as well as the types of flock fibres used in the interior of vehicles was identified. The majority of flock fibres used in vehicles are polyester or nylon (6 and 6,6). By far the majority of flock fibres viewed in the study were black pigmented polyester or nylon fibres, however a high proportion of dyed nylon fibres were also present. The discrimination level of dyed nylon fibres from vehicles was found to be 0.974. This indicates that although dyed flock fibres are used in many vehicles on our roads, those used in one vehicle can be easily discriminated from those used in another vehicle. This is not necessarily the case for black pigmented flock fibres as they are used in the majority of vehicles and are generally difficult to discriminate [8].

By comparing the flock fibres found on one hundred garments to a number of target flock fibres from the samples acquired in the initial study [7] we were able to assess the likelihood of finding flock fibres that are indistinguishable from those used in the interior of a specific vehicle on a garment at random.

2. Experimental method

2.1. Tapings

Garments worn by one hundred people (one garment per person) were taped using low adhesive tape-lifts which were secured to clear plastic sheets. One tape-lift was used to tape the front of a garment and one to tape the back of a garment. It is accepted that some of the people in this study may share similar environments such as work-place, home or transport.

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In the laboratory, the tapings were examined using a Leica MZ16 stereomicroscope (magnification range ×7.1–115). All fibres with the appearance of synthetic flock were removed from the tape and mounted on microscope slides in Entellan® under glass cover-slips. In this study viscose or cotton flock fibres were not investigated, firstly as they were not found to be significant components of flocked material in vehicles and secondly as it was considered to be too difficult to determine whether these fibre types had been flocked (cut) or were simply short broken fibres.

If a population of flock fibres with a similar appearance was present on the tapings of a garment only a sample (10–20 fibres) of the population was mounted for further examination.

2.2. Fibre identification and classification

A Leica DM EP polarised light microscope (PLM) was used to examine the flock fibres at magnifications between ×100 and ×400. Information about the colour, morphology, length, diameter and lustre of the fibres was recorded and the birefringence characteristics were used to give an initial identification of the fibre type. Any fibres from a particular garment that had a similar microscopic appearance were classed as a population. This was not confirmed by thorough microscopic comparisons.

2.3. Target flock fibres

The target flock fibres were chosen from the samples of flock fibres taken from a range of vehicles in the previous study into automotive flock [7]. All of the vehicles were models registered in 2008. Table 1 describes the target fibres in more detail and Fig. 1(a–e) shows the microscopic appearance of some of the target fibres.

1. Carbon black pigmented polyester from the window channel of a Ford Focus.
2. Blue–grey nylon from the window channel of a Toyota Prius.
3. Grey–brown nylon from the glove compartment of a VW Golf.
4. Orange nylon from the glove compartment of a VW Golf.
5. Green nylon from the glove compartment of a VW Golf.
6. Carbon black pigmented nylon from the glove compartment of a Vauxhall Antara.
7. Grey nylon from the glove compartment of a Vauxhall Antara.

In the previous study samples of flock fibres from vehicles were compared to each other. The target fibres have been chosen specifically to cover a range of these fibres. Targets 1 and 6 were not compared to the other black pigmented fibres as it is expected that owing to the low discrimination power of carbon black fibres one would find coincidental matches, as such they are considered to be regularly encountered automotive flock fibre types. Target 2 matched the flock fibres from two other vehicles (Toyota Verso and Renault Laguna). As such, target 2 may be considered to be a more common type of automotive flock in that it was present in 5% of vehicles. Targets 3 and 4 matched the flock fibres from one other vehicle (VW Eos and VW Scirocco respectively). Both of these targets were found in 3% of vehicles examined, however these were all VW models from 2008. Targets 5 and 7 were not found in any of the other 57 vehicles examined.

2.4. Comparison microscopy

A Leica FS 4000 comparison microscope was used to compare flock fibres under transmitted white light (bright field) and reflected incident light (equipped with Leica narrow banded excitation filters UV (A) and Blue (I3)). Flock fibres with similar morphological characteristics to the target flock fibres were compared using these methods.

2.5. FTIR analysis

The chemical composition of some of the flock fibres was determined using a Thermo Nicolet iN10 Fourier Transform Infra-red (FTIR) spectrometer. Fibres were flattened using a diamond window and placed into the path of the IR beam. Spectra were obtained over a range of 4000–650 cm^{-1}.

3. Results

3.1. Population study

Out of the one hundred garments examined, eighty two garments (82%) contained at least one synthetic flock fibre on their surfaces. Nineteen garments (19%) had a single flock fibre on their surfaces and sixty three garments (63%) had at least two flock fibres present. Carbon black pigmented polyester flock fibres were present on twenty garments (20%) and carbon black pigmented nylon flock fibres were present on thirteen garments (13%).

Sixteen garments (16%) contained populations of flock fibres (at least two microscopically similar flock fibres). Ten garments (10%) had one population of synthetic flock fibres and six garments (6%) had more than one population of synthetic flock fibres on their surfaces. See Table 2 for details of the types of fibres present and the number of such fibres found on the garments.

Of all the synthetic flock fibres recovered from the garments, 84% were nylon; 15% were polyester and 1% of the fibres examined were other polymer types (PAN or oxidised PAN). Of the seventeen nylon fibres that were analysed using FTIR microspectroscopy twelve were nylon 6,6 and five were nylon 6.

The majority of flock fibres had round cross-sections, although nylon fibres with triangular cross-sections were also found. The diameter of the flock fibres ranged from 10 to 30 μm although the majority of flock fibres had a diameter of approximately 15–20 μm. The length of the flock fibres ranged from 0.3 mm to 2.1 mm, although the majority of flock fibres were between 0.5 and 1.0 mm long. It was also noted that within a population of flock fibres the length varied by at least 0.1 mm.

3.2. Target fibre study

No flock fibres that matched the dyed target fibres (2, 3, 4, 5 and 7) were found on any of the garments examined in this study.

Table 1
Description of the target flock fibres.

Target number	Flock description					
	Polymer type	Microscopic colour	Lustre	Approximate diameter (μm)	Approximate length (mm)	Distinctive characteristics
1	Polyester	Carbon Black	Pigmented	17.5–20	0.6–0.8	–
2	Nylon	Blue–grey	Semi-dull	20	0.8	–
3	Nylon	Grey–brown	Semi-dull	20	0.9–1.0	Ring-dyed
4	Nylon	Orange	Semi-dull	20	0.9–1.0	Ring-dyed
5	Nylon	Green	Semi-dull	20	0.9–1.0	Ring-dyed
6	Nylon	Carbon Black	Pigmented	20	0.8–0.9	–
7	Nylon	Grey	Semi-dull	20	0.7–0.8	–