THE EVIDENTIAL VALUE OF BLACK COTTON FIBRES

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ABSTRACT: The comparison of wool and cotton fibres relies heavily on the comparison of the colourant. A big disadvantage is that it is not possible to identify the dye from the amount present on a single fibre. Despite this the forensic scientist is faced with the problem of estimating the frequency of fibres recovered in casework, in relation to those in the general population. One way that this can be done by considering the degree of spectral variation that occurs within a "block of colour". When a spectral type occurs with a high frequency, the evidential value of the fibres may be so low, that it is not worth considering them as target fibres. Using uv-visible range microspectrophotometry (MSP) spectra were recorded from 73 known black cotton dyes and 158 samples of black cotton taken from various textiles. It is possible to recognise spectra originating from sulphur and with very few exceptions from reactive dyes. Direct and Vat dyes present more difficulty. The degree of spectral variation and consequent discriminating power of MSP was investigated within the various dye classes. A high degree of individuality was observed in the spectra from black reactive dyes giving a discriminating power (D.P.) of 0.91 in contrast to Sulphur dyes where the D.P. was only 0.18. Within the few direct dyes (10%) that were encountered one basic spectral form predominated, but a large number of minor variations to this were also seen.

KEY WORDS: Fibres; Cotton; Black dyes; Spectra; Frequency.

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INTRODUCTION

According to the BKA Catalogue Data Base, 62% of all garments recorded contain cotton, and 20% of all those that are unit-coloured garments are black or grey. Here are some percentages from common textile items which help to explain why black/grey cotton is so often seen in casework:

- jeans 53%,
- casual trousers 62%,
- T-shirts 28%,
- shirts 22%,
- sweatwear 35%.

Black cotton is also common in underwear. For a few years now, at least in Germany, black has been very much in vogue as a fashion colour.

As with all natural fibres, cotton suffers from a relative lack of comparative characteristics. This means that a heavy reliance is placed on colour comparisons to decide whether or not fibres may have a common origin. In forensic science, after brightfield and fluorescence comparison microscopy, objective colour comparisons can be made using microspectrophotometry, or thin layer chromatography or a combination of both techniques. Sulphur and vat dyes are non-extractable, placing heavy reliance on TLC.

The frequency with which spectral or TLC patterns are seen can be taken as representative of the frequency of occurrence of particular dyes or dye mixtures.

Various classes of dyes can be used for the coloration of cotton. The figures in 1993 were:

- reactive 33%,
- sulphur 21%,
- direct 18%,
- pigment 13%,
- vat 6%,
- azoic 5%,
- indigo 4%.

By far the most common are reactive, sulphur and direct. For environmental reasons, there has been an increasing tendency in recent years for sulphur dyes to be replaced by reactive ones. Pigment and indigo dyes are recognisable microscopically. Vat dyes are often used for industrial clothing and the use of naphthol azo dyes has been reduced for health reasons.

Because black cotton occurs so frequently – various population studies also reflect this – it has often been postulated by forensic scientists that black cotton fibres are so common, that they cannot have any value as evidence of contact. This study was carried out in an attempt to clarify the situation.

The objectives were to determine whether:

1. The dye class is recognisable by the spectral form.
2. The spectra from black cotton fibres can be classified into groups, and if so, what is their relative frequency?
3. Can individual dyes/dye mixtures be recognised from their spectrum?

EXPERIMENTAL

The examination of 88 known black cotton dyes from manufacturers shade cards – 39 reactive, 18 vat, 19 direct and 10 sulphur and 2 mixtures – showed that:

1. The spectral pattern IS characteristic of the dye class for direct, reactive and sulphur dyes.
2. The spectra CAN be classified into groups showing the same pattern.
3. Some patterns occur very frequently e.g. reactive black 5 (12) and reactive black 8[1] (5).

Most of you will probably be familiar with the spectrum produced by sulphur black 1 (Figure 1) and be aware of the degree of variation that can occur in different fibres from within one textile that have been dyed with this dye. Figure 2 shows the spectra of 4 reactively dyed black cotton fibres. None of them are the same, but you can see that the patterns are similar (2 main variations are represented among these). Figure 3 shows the spectrum of a commonly used direct dye (direct black 22) and you can see that the form differs quite clearly from that of the sulphur or reactive dyes.

You may rightly ask if the classification of dye class from the spectra is reliable. The dyes from 22 samples were classified by extraction and examined by thin layer chromatography. In all cases the spectral classification had been correct.

The next step was to look at the dyes from 225 samples of cotton taken from black textiles. These were assembled thanks to exemplary co-operation from within the following laboratories: FSANI – Belfast, FSS – London, IPSC – Lausanne, LKA – Baden-Württemberg, NFI – Rijswijk, WD – Stadtpolizei Zurich.

Thanks must also be given to the various dye companies involved, particularly Ciba and BASF and to the Society of Dyers and Colourists.

So... what information could we gain from the results?

This fell into three categories:

1. Information on the frequency with which different dye classes are used within different garment categories e.g.:
   Jeans: Sulphur 61% Reactive 19.5% Direct 14.6%
   T-shirts: Sulphur 36% Reactive 49% Direct 13%
2. Recognition of commonly occurring spectral patterns- which must represent dyes in frequent use – and how these relate these to different garment types;
3. An awareness of spectral varieties which were only seen very occasionally.

Here is some more detailed information:

– We found that the discriminating power for sulphur dyes was very low, c. 0.13.

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[1] Reactive black 8 is mainly used for printing, not dyeing.

- 36% of the total population examined, 51% of the jeans and 36% of the T-shirts produced typical sulphur black 1 spectral curves.
- The evidential value of black sulphur dyed cotton fibres is really very low, especially when the difficulties caused by wide intro sample variation are taken into account that make matching of recovered fibres to control material difficult.

It is a different story with reactive dyes. 99 samples yielded at least 40, in some cases closely related, but distinguishable spectral varieties. This equates to a conservative estimate of the discriminating power being 0.93. Incidentally, about 20% of all the reactively dyed samples included in our study produced a spectrum consistent with their being dyed with a mixture of reactive black 5 and reactive orange 72.

Among the reactively dyed samples, the spectra obtained from pure dyes were rarely seen – probably due to the addition of shading colours. Most of the spectral variance results from additives, which are generally colourless, emphasising the importance or recording spectra in the UV-visible range.

We found that direct dyes appeared to be seldom used, occurring in about 11.5 % of all samples, 13% of T-shirts and 14.6% of jeans among our samples. The spectra had a high degree of individuality, but were basically similar to the direct black 22 pattern. We can see that jeans and T-shirts dyed with direct dyes are nowhere near as common as those dyed with reactive or sulphur dyes.

As a result of the information derived in this study we can formulate the following conclusions concerning the evidential value of black cotton fibres.

It will depend on:

1. The dye class of the colourant used.
2. The degree of spectral variation within that dye class (the greater the variation, the greater the chances that certain varieties will only be seen occasionally).
3. The frequency of use of that dye class and of that dye/dye mixture in the potential source garment type plus: the number and distribution of the found fibres, the circumstances, and the nature of the surface from which they have been recovered.

Among the three commonly used dye classes, direct dyed fibres (with the exception of direct black 22) may have the highest e.v., as there is a relatively high discriminating power among a group in which the total usage is fairly low. It is certainly worth while comparing black cottons that are reactively dyed, as the discriminating power (and hence the potential for elimination) is very good. Those dyed with sulphur black 1 will normally have very little evidential value, unless they are recovered under noteworthy circumstances.

Of course, it is still necessary to make a determination of the dye class from the known sample to estimate whether or not it is worth using the fibres as "targets". Using a DAD spectrometer, this can be done very rapidly.

All of the direct dyed fibres were found to exhibit dichroism, which did not occur with either sulphur or reactive dyes. Some of the vat dyes were also dichfoic.

The full report on this topic has been submitted to *Science & Justice* for publication.