

The Spectroscopic Detection of Drugs of Abuse on Textile Fibres after Recovery with Adhesive Lifters

Matthew J. West and Michael J. Went

School of Physical Sciences, University of Kent, Canterbury, Kent, CT2 7NH, UK

Corresponding author. Tel +44 1227 823540; fax +44 1227 827558

E-mail address: m.j.went@kent.ac.uk

Abstract

Fibres are one of the most common forms of evidence associated with forensic investigations. The use of adhesive lifters to recover fibres from crime scene samples has long been established as an effective method to recover such items of evidence. Once fibres have been lifted they are transferred to evidence bags for storage, safe transport and to preserve the chain of evidence. This study shows that when fibres are tape lifted particles of substances present trapped within those fibres are also lifted. Cotton, linen and wool fibres were examined in colours ranging from white to black. Samples of seized ecstasy, cocaine, ketamine and amphetamine were supplied by East Sussex Police and by the TICTAC unit at St Georges Hospital Tooting. The Raman spectra obtained showed that it is possible to identify drugs of abuse from particles trapped within fibres without interference from the fibre itself. It was also possible to obtain spectra after fibres were lifted with adhesive tapes without the detection process being compromised. Raman spectra from particles of drugs of abuse within fibres following tape lifting were also recorded through evidence bags. Again the detection process was not compromised. This initial study has shown that fibres have the potential to provide even more evidence than they do currently. Individuals that

have had drugs of abuse about their person may have trace amounts of these substances trapped within the fibres of their clothing. This may be of particular importance if drugs have been carried in pockets of a garment. This technique has the advantage of being non destructive, allows for re-testing, requires no sample preparation and also can be performed on samples without removal from the evidence bag thus removing any potential risk of contamination. It is important however to remember that when dealing with trace amounts of drugs of abuse the presence of such particles may be due to innocent transfer of such particles. Detection of particles of drugs of abuse on clothing does not necessarily indicate criminal activity in the absence of other evidence.

Keywords: Raman spectroscopy, drugs of abuse, textile fibres, adhesive lifters.

Introduction

In previous studies we have demonstrated the ability to use Raman spectroscopy to characterise drugs of abuse present in latent fingerprints following development with powders and recovery with adhesive lifters [1, 2]. Other work has shown that samples of pure drugs can be detected on clothing using Raman spectroscopy [3].

In this study we applied the same technique used previously, in order to detect drugs of abuse on textile fibres both before and after recovery with adhesive lifters and also from samples contained inside evidence bags. A fibre is any long thin flexible solid object with a high length to transverse cross-section area ratio [4]. This study focuses on textile fibres as these can potentially be of a very significant evidential value [6]. The term textile fibres relates to those fibres that can be or have been woven but is often also applied to include non woven fibres for example ropes [4]. Cotton, linen and wool fibres were used in a wide range of different colours.

Fibres are one of the most commonly encountered pieces of evidence found in forensic investigation and can be associated with almost any crime [5, 9]. Adhesive lifters have been successfully used as the method of choice for lifting fibres for many years [7]. It is a simple process whereby adhesive tape is pressed over a surface a number of times and then transferred to a clear backing sheet [8]. The collected material can then be examined under a low power microscope. In most cases the fibres will be so small they are not visible to the naked eye however if visible foreign fibres are observed on an item then they can be removed using tweezers after being photographed *in situ* [9].

In recent years there has been an increase in the importance of fibre evidence which for a time had often been overlooked as DNA evidence was considered to have rendered such evidence of little importance [5].

This work aims to show that fibres can provide us with even more evidence than they do currently. If an individual has had drugs of abuse about their person then it is possible that trace amounts of the drugs could remain on the fibres of their clothes. This could be particularly evident if drugs had been carried in the pockets of a garment. Such a transfer would be a typical example of Locard's exchange principle [10]. Fibres are often readily dislodged from clothing but in certain circumstances for example the death of an individual this is much less likely. This may also be the case with fibres from within a pocket.

Our previous studies have shown that it is possible to detect drugs of abuse through adhesive lifters and also through evidence bags [1,2]. The detection through evidence bags is of importance as this would allow evidence to be examined without removal thus reducing the possibility of contamination and also preserving the chain of evidence. This has been reported previously on bulk samples [11].

The materials used in this investigation were seized samples of ecstasy (3,4-methylenedioxy-N-methylamphetamine - MDMA), cocaine, ketamine and amphetamine with pure samples used as references. The use of seized '*street*' samples is important to this study as it reflects the typical samples that would be encountered in forensic casework.

The seized samples of drugs are by their definition not pure drug samples. Work carried out at St Georges Hospital using GC-MS has indicated that caffeine is a common adulterant especially in samples of amphetamine. Lidocaine and phenacetin were found in samples of cocaine powder and caffeine was found in some of the samples of MDMA. Other common cutting agents found in street samples include substances such as paracetamol, citric acid, glucose, lactose and other sugars [12].

Experimental

Pure samples of MDMA, cocaine, ketamine and amphetamine were obtained from Sigma-Aldrich Company Ltd, Poole, United Kingdom and were used as received. Samples of seized ecstasy, cocaine, ketamine and amphetamine were supplied by East Sussex Police and by the TICTAC unit at St Georges Hospital Tooting. The TICTAC samples were received as powders as the ecstasy tablets had been ground into powders as part of another project they had been involved in. These samples were used as received. The samples from East Sussex Police were in the form of tablets and were ground into powders to facilitate this study. It is important to note that the traces left by whole tablets will be very different to that of powders. Further work is needed to fully understand how whole tablets will transfer trace amounts of drugs of abuse to clothing.

A reference Raman spectrum was obtained for comparison purposes from a small sample of powder or powdered tablet that was placed on a clean glass slide. The samples of fibres were obtained from a local fabric supplier and the adhesive lifters from CSI Ltd. The adhesive lifters clear acetate lifters that were cut to a suitable size. The sheets also known as Cobex are a 175 micron optically clear film suitable for lifting a range of potential evidence. Tamper evident bags were also obtained from CSI Ltd which are manufactured from quality materials and are backed up with a quality assurance registration to ISO Standards.

The contaminated fibres were prepared by dipping the fibre into a sample of the powdered drug of abuse using clean tweezers. The excess drug was then removed by gentle shaking and the contaminated fibre was then transferred to a clean sample jar for storage. A Raman spectrum was obtained from each of the fibres by placing the fibre onto a clean slide using clean tweezers. When examined under the microscope small particles, typically 10-40 μ m, could be seen adhering to the fibres. The fibres were then tape lifted using adhesive tape and transferred to the clear backing sheet and then re-examined under the Raman microscope.

This study involved the examination of 30 different wool, linen and cotton fibres in colours ranging from white to black and 65 different seized drug samples (cocaine, ketamine, amphetamine and ecstasy). Spectra were obtained from multiple sites from each fibre and as the technique is non-destructive repeat analyses of the samples would be possible.

All Raman spectra were obtained using a Raman microscope, Olympus BX40, with a Uniphase (model 1145) helium-neon laser operating at a wavelength of 632.8nm with a fixed output of 35mW. The laser power at the sample is approximately 4mW and a 50X objective lens was used. The Jobin-Yvon 640

spectrometer incorporates a liquid-nitrogen cooled charge coupled device (CCD) detection array. Raman spectra were obtained for twenty accumulations with a 5 second exposure to the CCD detector over the range 3250-300cm⁻¹, which had been previously determined as the region that contained the Raman bands of interest for these samples. The spectrometer was calibrated by reference to a silicon wafer Raman band at 520cm⁻¹. Spectra were exported to OMNIC version 7.3 or Origin version 7.0 spectral manipulation packages for processing and presentation.

Spectra were initially compared by overlaying in Origin or OMNIC then following this they were compared to a library using OMNIC software. The library uses an algorithm that depends on computing a correlation coefficient that relates an unknown spectrum to each entry in the library. The entries are then ranked in descending order based upon the magnitude of the coefficient. The entries having the largest coefficient are reported as the spectra having the most similar to that of the unknown compound. The value of the coefficient has a minimum value of zero and a maximum of 100. A value of zero implies that there is no relationship between the unknown spectrum and any of the library spectra. Conversely a value of 100 would indicate that the unknown spectrum is identical to the matched library spectrum [16]. All the spectra presented gave a minimum percentage match of 80%. The percentage value calculated by the program is based on the following formula where r is the correlation coefficient, X is the vector representing the library spectrum and Y is the vector that represents the unknown spectrum. Note that X' and Y' represent the computed derivatives of the two spectra.

$$r^2 = [(X'*Y') (X'*Y')] / [(X'*X') (Y'*Y')]$$

Results and Discussion

The samples obtained from the TICTAC unit had undergone previous characterisation as part of another research project in addition to this the samples of ecstasy had been quantified. The samples obtained from East Sussex Police were from batches of seized drugs from police raids that had undergone forensic evaluation to determine the identity of the substance seized.

In our previous work we had already obtained reference spectra from all the seized samples [1, 2]. This also enabled us to remove from the study any samples with fluorescence problems that could not be diminished by photobleaching. The pure samples showed no fluorescence problems therefore this was attributed to other substances that were present in the seized samples which by definition would not be pure drug samples. Such substances may only be present at a very low concentration however if they are fluorescent they could interfere with the analysis. Substances are added to street samples often to bulk out the drug or they may arise as impurities from the crude manufacturing processes used. Sometimes substances are added that mimic the effects of the drug in question for example ephedrine is often found in seized samples of amphetamine. Any of these additional substances may be the source of fluorescence. The spectrometer used in this investigation has a single laser wavelength however the use of an alternative wavelength, for example a near infra-red laser, may have overcome this problem.

An additional issue with the seized samples not being pure drugs was that some of the particles found were not in fact the drug of interest. This meant that on some occasions several particles were examined before a spectrum of the drug was obtained; in such cases the detection process was lengthened. However in most cases it was possible to obtain a spectrum within 5 minutes without sample preparation.

Fig. 1 shows the Raman spectra obtained from samples of the pure drugs obtained from samples of the powder placed on clean glass slides. This clearly demonstrates that the Raman spectrum distinguishes between all of the drugs analysed. Previously it has been shown that Raman can be used to distinguish between a range of chemically similar substances including between different isomers of the same drug [13-15].

In Fig. 2 the results obtained from fibres contaminated with cocaine are presented. Fig. 2 (a) shows the spectrum obtained from a sample of pure cocaine powder on a glass slide. When a red wool fibre contaminated with a seized sample of cocaine was examined under the microscope small crystals could be observed. The spectrum of one of those crystals is shown in Fig. 2 (b) which clearly shows that the particle is indeed cocaine. There are no significant Raman bands associated with the fibre however if present these could be removed by spectral subtraction. Also the Raman scattering observed from the drug particles was more intense than that for the fibres. In addition to this care taken with focussing the laser beam allows focusing of the beam onto the particle largely avoiding the fibre itself. Therefore if the dyed fibre has significant Raman bands these are not detected if care is taken to focus the laser beam onto the drug particle. If however these bands are detected they can be easily removed using spectral subtraction. Next the fibre was lifted with adhesive tape onto a clear backing sheet and the fibre was re-examined. The resulting spectrum is shown in Fig. 2 (c) and clearly indicates that the lifting process has not interfered with the detection of the cocaine present on the fibres. The Raman spectrum of the adhesive tape prior to lifting showed no bands associated with background drugs traces. Fig. 2 (c) contains some additional bands associated with the lifting tape. There are 2 bands at 2800cm^{-1} and 2900cm^{-1} and also a further band at approximately 1400cm^{-1} . These

bands did not interfere with the detection process however if necessary these bands could be removed easily by spectral subtraction.

The same process was then repeated then repeated with samples of ketamine. Fig 3 (a) shows the reference spectrum obtained from pure ketamine. Again when a blue linen fibre contaminated with seized ketamine was examined crystals were seen and the spectrum obtained is shown in Fig 3 (b). Once again the fibre was lifted with adhesive tape and re-examined with the resulting spectrum shown in Fig. 3 (c). As with the cocaine samples it was possible to obtain spectra of ketamine without interference from either the fibre or the adhesive lifter.

In Fig. 4 the results obtained for MDMA are presented. As previously a reference spectrum was obtained from a pure sample of the drug and this can be seen in Fig. 4 (a). The spectra in Figs. 4 (b) and (c) show the results obtained from a black cotton fibre contaminated with seized MDMA and the same fibre after lifting with adhesive lifters respectively. It is again clear from these results that Raman microscopy can be used successfully to identify MDMA from fibres contaminated with samples of the seized drug.

The final drug to undergo examination was amphetamine and once again a reference sample of the pure drug was obtained first which is shown in Fig. 5 (a). An orange cotton fibre was contaminated with a seized sample of amphetamine and a Raman spectrum obtained both before and after lifting with adhesive lifters. The spectra obtained are shown in Figs. 5 (b) and (c) respectively. As with all the other drug samples examined in this study amphetamine was successfully detected on the fibre and again after the lifting process.

It was also of interest to determine if placing a lifted fibre into an evidence bag would interfere with the detection process. Fig. 6 (b) shows a spectrum obtained from

a blue linen fibre contaminated with a seized sample of ketamine after undergoing tape lifting and being placed into an evidence bag. Raman spectra of the evidence bag showed no background drug contamination. Fig 6 (c) shows a blue cotton fibre treated in the same manner but with an alternative seized sample of ketamine. As previously a reference sample of the pure drug is provided for comparison purposes (Fig. 6 (a)). The results clearly indicate that the evidence bag did not interfere with the spectrum obtained in any way. This is particularly useful as it means that evidence bags do not need to be opened in order for spectra to be obtained thus reducing potential for contamination and also importantly the chain of evidence remains preserved.

It is important to remember that we are dealing with trace amounts of drugs and as such these traces may be present due to innocent transfer. Further work is needed here in this area to determine the ease of such transfers and also the persistence of this type of evidence on clothing.

Conclusions

This study has shown that it is possible to obtain Raman spectra from particles of drugs of abuse that have adhered themselves to textile fibres. The detection process was not compromised by lifting the fibres with adhesive lifters or by the fibres themselves. If however additional Raman bands were observed due to either the fibre or the adhesive lifter then these could be removed simply by spectral subtraction. In addition to this it was also possible to obtain spectra from samples from within evidence bags. This is of particular importance as it means that items do not have to be removed from evidence bags to be examined thus reducing potential for contamination and also importantly the chain of evidence remains preserved.

These results indicate that it is may be possible to link items of clothing to drugs of abuse by tape lifting samples from their clothing and examination by Raman microscopy. However as we are dealing with trace amounts of drugs this does not necessarily mean that the garment or indeed the individual were involved in criminal activity.

The technique itself is non-destructive, rapid and requires no sample preparation. The technique also allows for samples to be re-examined at a later date. This gives some indication of the potential for this technique to be of forensic interest.

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References

- [1] M.J. West and M.J. Went, The spectroscopic detection of drugs of abuse in fingerprints after development with powders and recovery with adhesive lifters, *Spectrochimica Acta Part A.*, 71 (2009) 1984-1988.
- [2] M.J. West and M.J. Went, The spectroscopic detection of exogenous material in fingerprints after development with powders and recovery with adhesive lifters, *Forensic Sci. Int.*, 174 (2008) 1-5.
- [3] E.M.A. Ali, H. G. M. Edwards, M.D. Hargreaves and I. J. Scowen, In-situ detection of drugs of abuse on clothing using confocal Raman microscopy, *Analytica Chimica Acta*, 615 (2008) 63-72.
- [4] A.R.W. Jackson and J.M. Jackson, *Forensic Science*, Pearson Educational Ltd, Harlow (2008).
- [5] M. C. Grieve, Back to the future – 40 years of fibre examinations in forensic science, *Forensic Sci. Int.*, 40 (2000) 93-99.
- [6] E. Kelly and R.M.E. Griffin, A target fibre study on seats in public houses, *Science and Justice*, 38 (1998) 39-44.
- [7] M. Frei-Sulzer, Die Sicherung von Mikros Spuren mit Klebeband, *Kriminalistik* 10 (1951) 51.
- [8] F. Springer, *Collection of fibre evidence from crime scenes*, Forensic Examination of Fibres, Taylor & Francis, London (1999).
- [9] J. Robertson, M. Grieve Eds., *Forensic examination of fibres*, Taylor & Francis, London (1999).
- [10] E. Locard, *L'enquête criminelle et les méthodes scientifiques*, Flammarion, Paris (1920) 139.

- [11] H. Tsuchihashi, M. Katagi, M. Nishikawa M. Tatsuno H. Nishioka A. Nara E. Nishio and C. Petty, Determination of methamphetamine and its related compounds using Fourier transform Raman spectroscopy, *Applied Spectroscopy*, 51 (1997) 1796-1799.
- [12] R. Coomber, 'The "Cutting" of Street Drugs in the USA in the 1990s', *Journal of Drug Issues*, 29 (1999) 17-36.
- [13] S.E.J. Bell, D.T Burns, A.C. Dennis, and J.S. Speers, Rapid analysis of ecstasy and related phenethylamines in seized tablets by Raman spectroscopy, *The Analyst*, 125 (2000) 541-544.
- [14] S.M. Angel, J C. Carter, D.N. Stratis, B.J. Marquardt and W.E. Brewer, Classification of narcotics in solid mixtures using principal component analysis and Raman spectroscopy, *J. Raman Spectroscopy.*, 30 (1999) 795-805.
- [15] J.N. Willis, Jr., R.B. Cook and R. Jankow, Raman spectroscopy of some common barbiturates, *Anal. Chem.*, 44 (1972) 1228-1234.
- [16] Using OMNIC Algorithms, Thermo Electron Corporation, (2006).

Figure legends

Figure 1

Raman spectra obtained from

- (a) pure ketamine powder
- (b) pure MDMA powder
- (c) pure cocaine powder
- (d) pure amphetamine powder

Figure 2

Raman spectra obtained from

- (a) pure cocaine powder
- (b) red wool fibre contaminated with seized sample of cocaine
- (c) red wool fibre contaminated with seized sample of cocaine and tape lifted

Figure 3

Raman spectra obtained from

- (a) pure ketamine powder
- (b) blue linen fibre contaminated with seized sample of ketamine
- (c) blue linen fibre contaminated with seized sample of ketamine and tape lifted

Figure 4

Raman spectra obtained from

- (a) pure MDMA powder
- (b) black cotton fibre contaminated with seized sample of MDMA
- (c) black cotton fibre contaminated with seized sample of MDMA and tape lifted

Figure 5

Raman spectra obtained from

- (a) pure amphetamine powder
- (b) orange cotton fibre contaminated with seized sample of amphetamine
- (c) orange cotton fibre contaminated with seized sample of amphetamine and tape lifted

Figure 6

Raman spectra obtained from

- (a) pure ketamine powder
- (b) blue linen fibre contaminated with seized sample of ketamine, tape lifted and placed in an evidence bag
- (c) blue cotton fibre contaminated with seized sample of ketamine, tape lifted and placed in an evidence bag