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Applications of Raman Spectroscopic Techniques in Forensic and Security Contexts. The detection of drugs of abuse and explosives in scenarios of forensic and security relevance using benchtop and portable Raman spectroscopic instrumentation

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ABSTRACT

Drug trafficking and smuggling is an ongoing challenge for law enforcement agencies. Cocaine smuggling is a high-value pursuit for smugglers and has been attempted using a variety of concealment methods including the use of bottled liquids, canned milk, wax and suspensions in cans of beer. In particular, traffickers have used clothing impregnated with cocaine for smuggling. Handling, transportation or re-packaging of drugs of abuse and explosives will inevitably leave residual material on the clothing and other possessions of the involved persons. The nails and skin of the person may also be contaminated through the handling of these substances.

This research study describes the development of Raman spectroscopic techniques for the detection of drugs of abuse and explosives on biomaterials of forensic relevance including undyed natural and synthetic fibres and dyed textile specimens, nail and skin. Confocal Raman microscopy has been developed and evaluated for the detection and identification of particulates of several drugs of abuse and explosives on different substrates. The results show that excellent spectroscopic discrimination can be achieved between single particles and substrate materials, giving a ubiquitous non-destructive approach to the analysis of pico-gram quantities of the drugs and explosives *in-situ*. Isolating the particle in this way corresponds with an analytical sensitivity comparable with the most sensitive analytical techniques currently available *e.g.* the highly sensitive, yet destructive ionization desorption mass spectrometry. With the confocal Raman approach, this work demonstrates that definitive molecular-specific information can be achieved within seconds without significant interference from the substrate. The potential for the application of this technique as a rapid preliminary, forensic screening procedure is obvious and attractive to non-specialist operators as it does not involve prior chemical pretreatment

or detachment of the analyte from the substrate. As a result, evidential materials can be analysed without compromising their integrity for future investigation.

Also, the applications of benchtop and portable Raman spectroscopy for the *in-situ* detection of drugs of abuse in clothing impregnated with the drugs have been demonstrated. Raman spectra were obtained from a set of undyed natural and synthetic fibres and dyed textiles impregnated with these drugs. The spectra were collected using three Raman spectrometers; one benchtop dispersive spectrometer coupled to a fibre-optic probe and two portable spectrometers. High quality spectra of the drugs could be acquired *in-situ* within seconds and without any sample preparation or alteration of the evidential material. A field-portable Raman spectrometer is a reliable instrument that can be used by emergency response teams to rapidly identify unknown samples. This method lends itself well to further development for the *in-situ* examination by law enforcement officers of items associated with users, handlers and suppliers of drugs of abuse in the forensics arena.

In the last section of this study, a portable prototype Raman spectrometer (DeltaNu Advantage 1064) equipped with 1064 nm laser excitation has been evaluated for the analysis of drugs of abuse and explosives. The feasibility of the instrument for the analysis of the samples both as neat materials and whilst contained in plastic and glass containers has been investigated. The advantages, disadvantages and the analytical potential in the forensics arena of this instrument have been discussed.

Key words: Raman spectroscopy; drugs of abuse; explosives; forensics.

List of Publications

Sections of this research work have been published

Papers

1. “ Raman spectroscopic investigation of cocaine hydrochloride on human nail in a forensic context ” Esam M. A. Ali, Howell G. M. Edwards, Michael D. Hargreaves and Ian J. Scowen, *Analytical and Bioanalytical Chemistry* , 390 (4),2008, 1159-1166.
2. “ *In-situ* detection of drugs-of-abuse on clothing using confocal Raman microscopy ” Esam M.A. Ali, Howell G.M. Edwards, Michael D. Hargreaves, Ian J. Scowen, *Analytica Chimica Acta* ,615, 2008, 63-72.
3. “ Detection of explosives on human nail using confocal Raman microscopy ” Esam M. A. Ali, Howell G. M. Edwards, Michael D. Hargreaves and Ian J. Scowen *Journal of Raman Spectroscopy*, 40(2), 2009, 144–149.
4. “In-situ detection of single particles of explosive on clothing with confocal Raman microscopy ” Esam M.A. Ali, Howell G.M. Edwards and Ian J. Scowen , *Talanta* , 78 (3), 2009, 1201-1203.
5. “Raman spectroscopy and security applications: the detection of explosives and precursors on clothing” Esam M. A. Ali, Howell G. M. Edwards and Ian J. Scowen *Journal of Raman Spectroscopy*, 40(12), 2009, 2009-2014.
6. “*In-situ* detection of cocaine hydrochloride in clothing impregnated with the drug using benchtop and portable Raman spectroscopy” Esam M. A. Ali, Howell G. M. Edwards, Michael D. Hargreaves and Ian J. Scowen, *Journal of Raman Spectroscopy*, 41(9) , 2010, 938-943.
7. “Rapid in-situ detection of street samples of drugs of abuse on textile substrates using microRaman spectroscopy” Esam M. A. Ali, Howell G. M. Edwards and Ian J. Scowen, *Spectrochimica Acta*, under review.

Published Abstracts and Posters

1. Proceedings of the EUROanalysis XIV, 9-14 September 2007, Antwerp, Belgium

“ Raman Spectroscopic Investigation of Cocaine Hydrochloride on Human Nail in a Forensic Context” E.M.A.Ali, H.G.M. Edwards, M.D. Hargreaves, I.J. Scowen (invited talk)

2. Proceedings of the International Conference on Raman Spectroscopy (ICORS XXI), 17-22 August 2008, Uxbridge, West London, UK.

“Raman spectroscopy in forensics and security: drugs of abuse and explosives on clothing” Esam M.A.Ali, Howell G.M. Edwards, Michael D. Hargreaves, Ian J. Scowen (abstract and poster)

“Raman Spectroscopic Investigation of Cocaine Hydrochloride on Human Nail in a Forensic Context” Esam M.A.Ali, H.G.M. Edwards, M.D. Hargreaves, I.J. Scowen (abstract and poster)

3. Proceedings of the GeoRaman 2010, June 28 – July 2, 2010, Sydney, Australia.

“Interrogation of Drugs of Abuse and Explosives in a Forensic Context: Raman Spectroscopic Applications” Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen (invited talk)

“*In-situ* detection of cocaine hydrochloride in clothing impregnated with the drug using benchtop and portable Raman spectroscopy” Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen (abstract and poster)

List of papers to be submitted for publication

1. The detection of drugs of abuse on human skin using confocal Raman spectroscopy, Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen.
2. *In-situ* detection of single particles of explosive on human skin with confocal Raman microscopy, Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen
3. A new portable Raman spectrometer equipped with 1064nm excitation: feasibility for the identification of drugs of abuse and explosives, Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen.
4. *In-situ* detection of drugs of abuse in clothing impregnated with the drugs using benchtop and portable Raman spectroscopy, Esam M.A.Ali, Howell G.M. Edwards, Ian J. Scowen.

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