Institution: University of Oxford

Unit of Assessment: UOA13

Title of case study: Trace evidence analysis for Orchid Cellmark Europe Ltd

1. Summary of the impact

Material characterisation research in the UOA has helped Orchid Cellmark Europe Ltd (Cellmark) to deliver forensic services to 85% of the police forces in England and Wales. The work of the UOA has helped Cellmark to participate successfully in National Forensic Framework tendering exercises and to double their market share. The work of the UOA in partnership with Cellmark has been accredited by the UK Accreditation Service and the UOA now provides an average of 360 forensic glass analyses and 60 gunshot residue analyses to Cellmark each year. These analyses have secured, amongst others, convictions for perpetrators of serious gun crime.

2. Underpinning research

Crossley and Salter are employed by the UOA to undertake materials characterisation research and to lead and expand the UOA's materials characterisation work for industry. They have undertaken research that has extended the range of experimental methodologies available using scanning electron microscope (SEM) based analytical techniques. These new approaches have been applied both to further basic research and to support the UOA's service work for industry.

As direct outcomes of research projects undertaken since 2000, Crossley and Salter have developed a suite of approaches that laid the groundwork for improved SEM-based analysis in forensic science. This underpinning research is exemplified in two sets of publications:

- The use of EDX and WDX analysis of trace metals in carbon nanotube arrays [3.1, 3.2] that provided the platform for further development of the approach so that it could then be applied for forensic gunshot residue (GSR) analysis.

- Precise SEM/EDS analysis of insulating samples, including glass [3.3] and diamond [3.4], that led directly to the application of these techniques in forensic glass fragment analysis.

In both research areas, the research focused on extracting quantified information reproducibly and with high accuracy from traditionally "difficult" – chemically complex or insulating - samples, while maintaining the comparative convenience and fast turn-around of SEM based techniques vital to support the short timescales on which forensic data is required.

3. References to the research

The three asterisked outputs indicate the quality of the underpinning research applying SEM-based characterisation techniques to the analysis of a range of complex materials:

3.1 *Multiwalled carbon nanotubes with MoO_2 nanoplugs – new chemical nanoarchitectures by electrochemical modification*. K. Jurkschat, S.J. Wilkins, C.J. Salter, H.C. Levantis, G.G. Wildgoose, L. Jiang, T.G.J. Jones, A. Crossley and R.G. Compton. *Small*, **2** (2006) 95-98. [24 Citations]. doi: 10.1002/smll.200500129

*3.2 *Carbon nanotubes contain metal impurities which are responsible for the electrocatalysis seen at some nanotube-modified electrodes*, C.E. Banks, A. Crossley, C.J. Salter, S.J. Wilkins and R.G. Compton. *Angewandte Chemie*, **45 (**2006) 2533-2537. [275 Citations] doi:10.1002/anie.200600033

*3.3 *Advances in polychrome ceramics in the Islamic world of the 12th century A.D*. R.B. Mason, M.S. Tite, S. Paynter and C. Salter. *Archaeometry*, **43** (2001) 191-209. [13 citations]. doi: 10.1111/1475-4754.00014

*3.4 *Electroanalysis Using Macro-, Micro-, and Nanochemical Architectures on Electrode Surfaces. Bulk Surface Modification of Glassy Carbon Microspheres with Gold Nanoparticles and Their Electrical Wiring Using Carbon Nanotubes*, X. Dai, G.G. Wildgoose, C.J. Salter, A. Crossley and R.G. Compton. *Anal. Chem.*, **78 (**2006) 6102-6108. [97 citations] doi: 10.1021/ac060582o

4. Details of the impact

The domain of the impact of our research since 2008 has been in the area of commercial forensic science and analysis for Cellmark, and the use of these analyses supplied by Cellmark in police investigations and prosecutions across the UK. The measurement protocols based on research in the UOA has provided a new generic capability that has been exploited by Cellmark.

The path to impact: A legal requirement from Police Authorities is that all Forensic Science Providers (FSPs), and all sub-contractors to a FSP, must be United Kingdom Accreditation Service (UKAS) accredited for the forensic service provided. The UOA, through its materials characterisation service, secured UKAS 17025 accreditation for Forensic Glass Analysis in 2010. Although there are 25 accredited laboratories within universities in the UK, the UOA is the only university laboratory accredited for Forensic Glass Analysis, reflecting the UOA's in-depth and scientifically-based expertise in this field.
Key factors in the successful award of UKAS accreditation are the availability of both specialist research-led expertise and the management structures to deliver a high quality service within the requirements of the UKAS protocols. To achieve this, the UOA invested in a JEOL VP 6480 SEM equipped with an Oxford Instruments X-max 80 SDD detector that was critical in meeting Cellmark and Police Authority needs. By then developing *in-house* automated methods on this equipment to allow reliable 24 hour operation, and drawing on new analysis protocols based on our research, the UOA was able to dedicate up to 60% of the time on this instrument to Cellmark work in a cost-effective manner and with fast turn-around. The UOA also invested in a controlled environment room to implement robust anti-contamination and security procedures that are mandatory to meet the UK Forensic Regulator's and UKAS requirements for the delivery of forensic work to the UK criminal justice system.

Impact:

The following text describing the impact of the research has been provided by the Commercial Director at Cellmark.

"*Cellmark has over twenty five years' experience of providing police forces with high quality, specialist forensic services. Cellmark's reputation was built initially on the quality of its innovative DNA analysis and rapidly became one of the largest DNA testing companies in the world. Now Cellmark provides a comprehensive forensic analytical service, covering a range of biology and chemistry scientific disciplines for the investigation of an extensive range of criminal cases including burglary, assault, homicide and sexual offences as well as for the review of cold cases.*

Cellmark approached Dr Crossley in 2008 seeking collaboration in the analysis of trace evidence, recognizing the Oxford Materials Department's internationally-leading expertise in micro/nano analysis and a research-led forensic analysis track record, backed-up with appropriate equipment dedicated to specialised analysis. The key expertise Cellmark were seeking was the analysis of glass fragments using SEM/EDX for elemental composition analysis. This analysis is critical in both high volume crime such as burglaries and car theft but also low volume, serious crime such as GBH, homicide and murder where a trace evidence match between a fragment from a suspect and a crime scene or victim can make a significant contribution to Streamlined Forensic Reporting (SFR). Effective use of SFR, as described in Swift and Sure Justice: the Government's Plans for Reform of the Criminal Justice System (2012), leads to an improvement in the early guilty plea rate, resulting in fewer cases coming to trial unnecessarily, helping to ease the pressure of trial dates and associated costs.

Cellmark now sub-contracts forensic analysis work to the Materials Department, benefitting from the commitment of 30% of Dr Salter's time and his leading expertise in SEM-based analysis. Currently the UoA provides Cellmark with the data for all our 360 forensic glass cases each year

and an additional 60 GSR cases[1].

By partnering with the Materials Department to provide research-led analytical services, Cellmark has been able to increase its product offering to Police Authorities and generate new business. Last year Cellmark was awarded the largest share of the available police contracts for trace evidence analysis, including 100% of the Metropolitan Police Service's work, 90% of that of the West Coast Consortium Police Forces (14 police forces from Cumbria to Devon and Cornwall) and 70% of that of the South East Police Force consortium. With the Department's help, Cellmark were able to gain market share over other forensic science providers, in an overall market worth £80-100M per annum.

By itself, Cellmark's provision of the Metropolitan Police's trace evidence requirements represents 20% of the total UK police forensic spend. In particular, Cellmark supports the work of operation Trident that is focused on gang-related crime and has the highest UK requirement for gunshot residue (GSR) analysis, which is a particular speciality of the Materials Department's forensic analysis provision to Cellmark.

A specific example of the impact of the Department's research and the provision of forensic analysis to Cellmark relates to a shooting at a London nightclub on New Year's Day, 2012. Cellmark received a particularly large and complex case, which involved the submission of over 100 items for forensic analysis and interpretation. The Department assisted Cellmark's scientists with the extensive GSR work involved in the case and, in the absence of any DNA evidence, this GSR evidence was critical to the prosecution case. The main suspect was convicted of murder and sentenced to a prison term of 31 years. There are many other similar cases where the Department's work has been used as key evidence in major prosecutions."

5. Sources to corroborate the impact

The Commercial Director at Cellmark will confirm details of the impact that working with the UOA has had on the company.

[1] http://www.cellmarkforensics.co.uk/forensic_services/major_crime/forensic_chemistry/glass.html