Institution: WestCHEM
Unit of Assessment: Sub-panel 8 – Chemistry
Title of case study: Illicit drug analysis as a tool to combat global organised crime

1. Summary of the impact

Global drug crime involving the illicit production of synthetic drugs and the emergence of new legal highs has a detrimental effect on our society and its citizens at all levels. In order to address this global problem, research was conducted that resulted in three significant impacts over the assessment period. These were:

(1) New capability for law enforcement agencies by provision of new tools to identify specific manufacturing routes of illicit drugs and link this back to criminal intelligence data,

(2) Improvement in the accuracy and reliability of identification of legal highs for use by legal practitioners, and

(3) The influencing of policy and protocol for the United Nations Office on Drugs and Crime on addressing legal high drug identification.

The research has underpinned the implementation of new analytical methodologies now routinely used in Malaysia and in over 900 drug sample identification cases in Scotland alone across the assessment period.

2. Underpinning research

Context

The architecture behind the global production of illicit synthetic drugs is complex and multi-faceted. It involves a series of autonomous chemical production phases, each servicing the supply of the next and is overarched by connection to complex organised crime networks. The normal phases of illicit drug production include: chemical synthesis of pre-precursor materials followed by synthesis of the desired compound through a variety of routes; sample dilution with 'cutting' agents; and finally introduction of the illicit drug samples into the dealer/user distribution networks. Due to the differences in chemical synthesis deployed, 'families' of impurities and side products become associated with these illicit drugs and can be used to profile and map which synthetic route has been used. Additionally, and in some circumstances, the chemical synthesis route categorisation can be tentatively aligned to a geographical area. An extension of characterising illicit drug production is the ability to rapidly identify and quantify the controlled materials at point of seizure. This pervasive problem can be a barrier to successful litigation and investigative work particularly in, but not limited to, developing countries where access to rapid response forensic science services can be restricted.

Recent attempts to circumvent the criminality relating to illicit drugs have seen the rapidly growing emergence of so called 'legal high' compounds. Many of these compounds circumvent the existing drug legislation and pose a significant risk to the general population. Methods to identify accurately the presence of such materials are vital to allow the development of the legal framework surrounding these contentious compounds. One of the major challenges to the legal environment is that the compounds emerge into society so rapidly and thus to identify them accurately is very difficult. To overcome this, the legal highs in question need to be synthesised in a pure and accurate form to allow standardised analytical methodologies to be verified and validated for use within law enforcement.

Key Researchers

WestCHEM academics have been involved in the preparation, characterisation, and continued development of analytical methods for the investigation of synthetic controlled drugs since 2006. Professor Niamh NicDaeid (appointed June 1994, Senior Lecturer from April 2001, Reader from

April 2009 and Professor from September 2011) is one of the leading authors in the world in this area and has led the research since 2006. Prof William Kerr (appointed as Lecturer, WestCHEM, October 1989, Senior Lecturer from April 1997 and Professor of Organic Chemistry from April 2002), has been involved in supporting the synthetic phase of the work (2006-2011) and Dr Oliver Sutcliff (Lecturer WestCHEM from September 2007–January 2012, and holding non-salaried Visiting Scholar appointment since then) has been directly involved in the legal high research (2010-2012).

Key Research Findings

The identification and characterisation of synthetic routes for illicit drug production

The disruption of the clandestine manufacture of illicit materials, primarily the manufacture of amphetamine type stimulants, such as 3,4-methylenedioxymethylamphetamine (ecstasy) and methylamphetamine, is vital in attempting to control and restrict these illicit materials. The large-scale production, distribution and sale of such drugs is estimated to be worth hundreds of billions of dollars *per annum* and affects over 315 million people worldwide. To address this, a body of research undertaken at WestCHEM from 2006 onwards developed chemical analytical methods for synthetic illicit drugs for use by global law enforcement agencies. More specifically, the research focused on the preparation of ecstasy and methylamphetamine under precisely controlled synthetic conditions. This facilitated the understanding of the chemical signature data derived from three complementary instrumental techniques, GCMS, IRMS, and ICPMS for these compounds (1,2,3,6). The understanding of the derived data has been reinforced by multivariate chemometric techniques that included the novel application of artificial neural networks (1). The outcome from the research was a framework for the development of a structured and focused approach that allowed specific samples to be classified according to their synthetic methodology of production.

In parallel, point of seizure identification and quantification of illicit drugs was also researched. This resulted in a very simple field test using a semi-quantitative approach (5), which is currently being linked to a smartphone using GPS positioning of the point of interrogation. This research has focused on both opiate drugs as well as amphetamine-type stimulants given their global prevalence.

The identification of legal highs

Legal highs are predominantly cathinone based synthetic compounds designed to give a similar physiological effect to an illicit drug, but without the criminal implications. Many compounds have not been fully tested in terms of their short- and long-term health implications and the ability of healthcare and law enforcement agencies to deal with this problem is significantly compromised by their inability, in some cases, to identify the legally controlled component. In order to address this, a body of research to synthesise specific legal high compounds with very high purity was undertaken coupled with the investigation and characterisation of these materials using analytical methodologies (4). Without these 'gold standard' legal high calibration samples, the analytical methodologies could not have been developed.

3. References to the research

Key references to the work are 1, 2, and 4.

[1] Classification of ecstasy tablets with the application of chemometric procedures and artificial neural network algorithms, R.J.H. Waddell, N. Nic Daéid & D. Littlejohn, *Analyst,* **2004**, 129, 3, 235-240, DOI: **10.1039/b312336g**

[2] Emerging Use of Isotope Ratio Mass Spectrometry as a Tool for Discrimination of 3,4-Methylenedioxymethamphetamine by Synthetic Route, H.A.S. Buchanan, N. Nic Daéid, W. Meier-Augenstein, H.F. Kemp, W.J. Kerr, & M. Middleditch, *Anal. Chem.*, **2008**, 80, 9,

3350-3356. DOI: **10.1021/ac702559s**

[3] Characterization of Route Specific Impurities Found in Methamphetamine Synthesized by the Leuckart and Reductive Amination Methods, V. Kunalan, N. Nic Daéid, W.J. Kerr, H.A.S. Buchanan & A. McPherson, *Anal. Chem.*, **2009**, 81, 17, 7342-7348. DOI: **10.1021/ac9005588**

[4] Synthesis, full chemical characterisation and development of validated methods for the quantification of (±)-4'-methylmethcathinone (mephedrone): A new 'legal high' ,E.Y. Santali, A-K Cadogan, N. Nic Daéid, K.A. Savage & O.B. Sutcliffe, *J. Pharmaceutical and Biomedical Analysis*, **2011**, 56, 2, 246-255. DOI: **10.1016/j.jpba.2011.05.022**

[5] Rapid and semi-quantitative presumptive tests for opiate drugs, A. A. Choodum & N. Nic Daéid, *Talanta*, **2011**, 86, 284-292, DOI: **10.1016/j.talanta.2011.09.015**

[6] Investigation of the reaction impurities associated with methylamphetamine synthesised using the Nagai method, V. Kunalan, W.J. Kerr & N. Nic Daéid, *Anal. Chem.*, **2012**, 84, 13, 5744-5752. DOI: **10.1021/ac3009302**

4. Details of the impact

The overarching impact arising from the research lies in the enhanced capabilities of law enforcement agencies to deal with illicit drug production, and the influencing of policy and analytical processes to address the new legal high compounds that are emerging on the international stage with associated major societal health and wellbeing consequences. The impact is most easily broken down into three main areas.

1. New capability for law enforcement agencies by provision of new tools to identify specific manufacturing routes of illicit drugs and link this back to criminal intelligence data

Illicit drug production is a major issue affecting every country in the world with clandestine manufacturing methods and locations constantly changing and developing in their sophistication. The production of precursors for illicit drugs takes place mainly in South East Asia and specifically Malaysia. In 2011, over 1000 kg of methylamphetamine and 364,000 ecstasy tablets were seized by the Royal Malaysian Police with a combined estimated street value in excess of $105M. This indicates the scale of the problem for one specific country.

The engagement process for this research was as follows: The research published by WestCHEM on the chemical characterisation and classification of ecstasy tablets prompted the Royal Malaysian Police to fund two PhD research students to study at WestCHEM over a five-year period. This provided sustained training in core research methods within this area and the development of a research legacy to advance this field through transfer back to Malaysia. During this time, profiling of methylamphetamine prepared by 8 synthetic routes was developed using GCMS, IRMS, and ICPMS with multivariate data interpretation.

The new analytical methodologies, databases, and data analysis approaches developed at WestCHEM have now been implemented in Malaysia on a daily operational basis by the Royal Malaysian Police. The implementation of the research findings has allowed identification of precursor chemicals and the synthetic route used in the production of methylamphetamine. This has provided the Royal Malaysian Police with a new capability leading to enhanced sophistication of investigations, the development of new police intelligence, and the increased ability to secure convictions.

The majority of the impact from this research has taken place to date within Malaysia, however, there is also collaborations with the United States Drug Enforcement Agency (USDEA) in the area.

Further external engagement followed successful publications in the area of illicit drug synthesis and the Thai Government funded a postdoctoral researcher to be based at WestCHEM to investigate the development of a rapid semi-quantitative presumptive test to allow the determination of the concentration of an illicit drug present within street-seized samples. The test is based on simple colorimetric analysis subsequently recorded using a smartphone with GPS to relay information relative to the point of seizure of the materials. [Text removed for publication.]

2. Rapid identification of legal highs for use in criminal prosecutions

The emergence of legal highs as an area of significant concern has led to the increased awareness of the need for rapid and accurate identification of such compounds. One of the stumbling blocks to addressing rapidly changing legislations in this area has been the lack of 'gold standards' for each the legal high compound, which are required to facilitate robust and accurate verification and validation of analytical methodologies suitable for use in criminal court cases. The research process involved collaboration between WestCHEM and the Scottish Police Authority Forensic Sciences (SPAFS) to address this crucial issue by synthesising and characterising legal high standards which were subsequently used in verification of analytical methodologies for compound identification in an operational context. The impact of these analytical methodologies as a general cathinone screen in forensic casework in Scotland has involved the analysis of 900 samples associated with criminal and morbid toxicology cases, resulting in the detection of legal high drugs in 21 of those samples, covering 11 different 'New Psychoactive Substances' (NPS).

In recognition of the impact of this research, this new approach was nominated for a Scottish Police Authority award. One judge commented:

> '[This is ..]..*a good example of a project based on analysis of existing local data in a way which promotes a new look at a national priority area. As well as creating opportunities for closer partnership, working with health and voluntary agencies it has identified means of a more focused service provision in relation to drug misuse*.'

A second judge added:

> '*This project will be a valuable support to the new single [police] service*.'

3. New UN protocol for identification of seized materials

As a result of the WestCHEM research profile in the area of legal high drug identification, Professor Nic Daeid was invited to develop a new protocol for legal high characterisation for the United Nations Office of Drugs and Crime (UNODC). This activity further extended an on-going relationship and consultancy between Professor Nic Daeid and the UNIODC. The UNODC manuals are developed by '*scientific experts recognised for their exceptional contribution to knowledge and/or the promotion of best practice in the area of interest*' and are used by forensic science laboratories across the globe as the accepted industry standard. During the REF assessment period, the WestCHEM research published has influenced the preparation of the guidance manual, 'UNODC Recommended Methods for the Analysis of Synthetic Cathinones in Seized Materials', which is expected to be published in early 2014.

These three different areas of impact arising from the research detailed in Section 2 show the degree of reach and also the societal significance of the impact that has been achieved.

5. Sources to corroborate the impact

[1] Statement from a Chemist in the Narcotic Section, Royal Malaysian Police Forensic Science Laboratory, corroborates the operational implementation of the drug profiling methodologies within the Royal Malaysian Police Forensic Services. (section 4 point 1)

[2] Statement from the Team Manager, Toxicology, Scottish Police Authority Forensic Services, corroborates the use of analytical methods developed with Strathclyde for the analysis of legal high compounds. (Section 4 point 2).

[3] Scottish Government, Scottish Police Authority Award nominations available at http://www.scotland.gov.uk/Resource/0041/00414520.pdf (Section 4 point 2).

[4] Statement from the Chief of the Laboratory & Scientific Section, Division of Policy Analysis, UNODC, Vienna corroborates development of Legal high UNODC manual. (Section 4 point 3).