

Drug profiling: a new scientific contribution to law enforcement operations in Viet Nam

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ABSTRACT

Since 1995 heroin sample comparisons have been carried out in Viet Nam to establish links between wholesalers and retailers. To that end, the physical and chemical characteristics of samples are analysed: their colour, the packaging material, including fingerprints, diacetylmorphine (heroin) content and the composition of some main alkaloids.

At the beginning of 2002, having acquired expertise on impurity profiling and with the support of new instruments, the Institute of Forensic Sciences of Viet Nam introduced the routine impurity profiling of seized heroin and methamphetamine and later undertook to explain that process to national law enforcement bodies.

Since then, 375 heroin and 29 methamphetamine samples have been analysed for major and minor impurities. Substances detected in the analysis of illicit heroin include diacetylmorphine, morphine, codeine, O⁶-monoacetylmorphine and acetylcodeine as well as adulterants such as paracetamol and caffeine. Since methamphetamine impurity profiling began, 29 samples have so far been analysed, and some samples have been grouped through the application of cluster analysis.

In the case of heroin, impurity profiling has established a link between two major trafficking groups suspected of obtaining heroin from the same source of production. Analysis has also revealed a link between one wholesaler and several retailers in one region. In addition, impurity profiling provides new information on the preparation and production of some methamphetamine and fake Ecstasy tablets.

Keywords: forensic science; heroin; methamphetamine; gas chromatography (GC); gas chromatography/mass spectrometry (GC/MS); linking samples; methods of production

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Introduction

Worldwide, the impurity profiling of drugs such as heroin and methamphetamine has a long history [1-7]. In Viet Nam, from 1993 until 2002, the Institute of Forensic Science had only one gas chromatograph (GC) for drug analysis.

In Viet Nam, heroin sample comparison is done to answer the questions of law enforcement bodies, for example, whether there is a link between a wholesaler and specific retailers in a given region. Before 2002, heroin sample comparisons were based simply on the sample's physical characteristics; colour (typically yellow, brown, pale white or white), the characteristics of the paper or plastic bag used as packaging, fingerprints on the packaging material, and the qualitative and quantitative analysis of diacetylmorphine content and the main alkaloidal impurities, such as O⁶-monoacetylmorphine (O6MAM) and acetylcodeine.

The Institute incorporated impurity profiling into its work at the end of 2002. At that time, it had received sophisticated instrumentation, including a gas chromatograph (GC), a gas chromatograph-mass spectrometer (GC-MS), a Fourier Transform infrared (FT-IR) spectrometer, a high-performance liquid chromatography mass spectrometer (HPLC-MS) and an inductively coupled plasma mass spectrometer (ICP-MS).

Impurity profiling analysis began with heroin and methamphetamine samples alone. Going beyond the process used for heroin sample comparison prior to 2002, which consisted of determining physical characteristics such as colour, logos (imprint), hardness, weight and fingerprints on the packaging material, the new method included the analysis of chemical characteristics of the packaging material, such as paper, cellophane and polyethylene bags, using FT-IR. Since 2004, the Institute has analysed some impurities of heroin samples, including adulterants and diluents. Further, in 2006 and 2007, minor compounds, by-products and traces of solvents in heroin samples will be analysed with the help of GC-MS, headspace-GC and HPLC.

This article presents the first results of the impurity profiling analysis of heroin and methamphetamine samples using GC and GC-MS. Those results have provided a great deal of valuable information for law enforcement authorities. Some operational findings are discussed.

Impurity profiling of heroin

Heroin is the drug most frequently encountered in Viet Nam, accounting for 60-70 per cent of all seized samples of drugs. Heroin is a semi-synthetic product derived from morphine, which, in turn, is extracted from the opium poppy, *Papaver somniferum* L. Differences in cultivation and manufacturing procedures produce the different concentrations of opium alkaloids present in the heroin samples. Those processing by-products, as well as adulterants added, can provide information on origin and processing, thus enabling analysts to establish links between groups trafficking in illicit heroin. All these parameters constitute a profile to be used in comparative analysis.

Analytical aspects

The present article is based on the analysis of 375 heroin samples selected from single-item and multiple-item seizures, in other words, seizures of one bag or multiple bags. Prior to analysis, all samples were dissolved in methanol at a concentration of 1 mg/ml to determine the quantity of heroin, acetylcodeine, O6MAM, caffeine, paracetamol and phenobarbital, and at a concentration of 10 mg/ml to determine the quantity of codeine, morphine, papaverine and noscapine. N-Octacosane (C₂₈H₅₈) is used as the internal standard.

Instrumentation: Agilent 6890N and Thermo-Finnigan GC-MS

Column: Ultra II fused silica capillary column, 5% phenyl GC 95% dimethyl polysiloxane, crosslinked, 25 m x 0.2 mm x 0.33 μm

Injector: 280° C (splitless, with purge flow: 1.2 min)

Carrier gas: nitrogen at flow rate of 1.0 ml/min

Temperature programme: 160° C at a rate of 8° C/min to 250° C, then at 10° C/min to 300° C, 8-min hold

Flame ionization detector:

Hydrogen flow: 35 ml/min

Air flow: 400 ml/min

Make-up flow (nitrogen): 30 ml/min

Temperature: 300° C

Mass spectrometer:

70 eV

50-650 m/z

Ion source temperature: 250° C

Transfer-line temperature: 280° C

Results and discussion

The first step of heroin sample characterization is performed by means of visual inspection. The 375 selected heroin samples can be classified in four colour groups: white, pale white, brown and yellow.

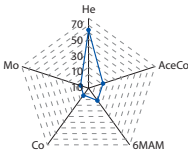
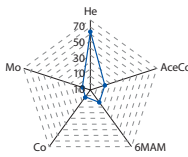
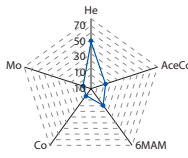
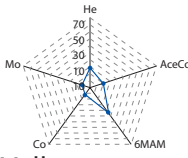
After visual inspection, the next step is the qualitative and quantitative analysis of diacetylmorphine, of major and minor impurities such as morphine, codeine, acetylcodeine, O⁶-monoacetylmorphine, noscapine and papaverine, and of adulterants such as paracetamol, caffeine and phenobarbital.

Street samples obtained in Viet Nam often contain adulterants such as chloramphenicol, vitamin C, ephedrine, aspirin, paracetamol, caffeine, sulfonamide and diluents such as calcium carbonate, glucose and starch, which have been added by drug vendors. Table 1 shows the types of heroin found among the 375 samples investigated.

Table 1. Heroin colour types and corresponding adulterants

Colour of heroin sample	Frequency of occurrence in samples		Year of occurrence
	Samples (number)	Proportion (percentage)	
White	337	89.9	1995-2005
Pale white	23	6.1	1995-2005
Brown	13	3.5	1996-2003
Yellow	2	0.5	1995 and 2002

Table 2. Average content of heroin and alkaloid impurities, by colour type (Percentage)

Colour type of heroin sample ^a	Heroin		Acetylcodeine	
	Average concentration	Range	Average concentration	Range
 White	68.4	60-89	13.2	—
 Pale white	61.4	50-70	12.4	—
 Brown	46.6	20-67	11.0	—
 Yellow	17.8	6.6-29	9.1	4.5-13.6

^aHe = heroin

AceCo = acetylcodeine

6MAM = O⁶-monoacetylmorphine

Co = codeine

Mo = morphine

^bNot detected in 19.3 per cent of white heroin samples.^cNot detected in 73.6 per cent of white heroin samples.^dNot detected in 53.9 per cent of brown heroin samples.^eNot detected in yellow heroin samples.

<i>Adulterant</i>					
<i>Paracetamol</i>		<i>Caffeine</i>		<i>Phenobarbital</i>	
<i>Samples (number)</i>	<i>Proportion (percentage)</i>	<i>Samples (number)</i>	<i>Proportion (percentage)</i>	<i>Samples (number)</i>	<i>Proportion (percentage)</i>
3	0.9	25	7.4	1	0.3
3	1.3	—	—	—	—
6	36.1	1	0.8	—	—
—	—	—	—	—	—

<i>O⁶-monoacetylmorphine</i>		<i>Codeine</i>		<i>Morphine</i>	
<i>Average concentration</i>	<i>Range</i>	<i>Average concentration</i>	<i>Range</i>	<i>Average concentration</i>	<i>Range</i>
4.5	—	0.02 ^b	—	0.30 ^c	—
10.4	—	0.08	—	0.27	—
17.9	—	0.19	—	0.5 ^d	—
32.5	28-37	0.21	0.2-0.22	— ^e	— ^e

As can be seen in table 1, the number of adulterated heroin samples is small: 39 of 375 samples. The most common adulterants are caffeine and paracetamol, which are easy to obtain. A single sample contained phenobarbital. Adulterants were found in only three heroin colour types: white, pale white and brown.

The colour of the heroin samples is a product of the quality of the processing methods used. White and pale white heroin samples are the most common colour types found in Viet Nam, accounting for 96 per cent of seized heroin. Brown heroin samples were seized in Viet Nam between 1996 and 2003, but no such seizures have been reported since then. Yellow heroin was discovered once in 1995. It surfaced again in 2002, although in small amounts.

In addition to the analysis of colour and adulterants, the 375 heroin samples were analysed for their diacetylmorphine (heroin) content and for selected alkaloid impurities. Heroin samples seized in Viet Nam typically have a high concentration of diacetylmorphine and very low concentrations of morphine and codeine. That may be the result of skilled production processes that use good quality morphine as starting material.

Low morphine levels were detected in the heroin samples analysed. Table 2 shows that morphine levels in white and pale white heroin samples were almost the same—roughly half the average amount present in brown heroin. Thus, the colour of the samples may serve as a rough indicator of the quality of the heroin, given that the concentration of diacetylmorphine is high in white heroin samples and lower in brown and yellow heroin samples.

It should also be noted that morphine was present in only 26.4 per cent of white heroin samples and in 46.1 per cent of yellow heroin samples. Codeine was found to be present in 80.7 per cent of all white heroin samples.

Noscapine and papaverine were not detected in the raw heroin samples analysed using the GC method. They might be found with the help of capillary electrophoresis (CE), or HPLC, and there are plans to investigate heroin samples using those techniques in the future. However, it is also possible that those substances were not detected because the heroin samples were produced from morphine extracted from opium from the region containing very low noscapine and papaverine levels.

In one case in 1996, an analysis of brown heroin samples revealed a high average acetylcodeine content of approximately 20 per cent. That unusual finding (compared with typical acetylcodeine levels of approximately 10 per cent, as seen in table 2 above) was communicated to Vietnamese law enforcement officials. A small illicit laboratory producing heroin from terpene codeine cough tablets was subsequently dismantled in 1996. On the other hand, other analytical results of that same year could not be fully used in law enforcement operations at the time. For example, some samples of pale white heroin seized in 1996 showed an unusual average diacetylmorphine content, and some white heroin samples were characterized by the presence of unknown, red impurities, which made those samples visibly different from other white heroin samples. Only later, in 2005, with the statements of offenders belonging to a large dismantled network responsible for trafficking 1,000 kg of heroin over the

previous years, it was confirmed that the larger amounts of white and pale white heroin were imported and that the smaller amounts, typically of brown heroin, were produced in Viet Nam.

Table 2 also shows that, of the four types of heroin samples found in Viet Nam, yellow heroin has the lowest heroin content, a high acetylcodeine content and the highest O6MAM content. Those alkaloid levels translate into relatively high acetylcodeine:heroin and O6MAM:heroin ratios, a fact which suggests that another, distinct production/preparation method for yellow heroin might exist or that those samples are particularly prone to hydrolysis.

It is observed that, during sample storage heroin concentration decreases as O6MAM concentration increases, with the result that the total concentration of the two alkaloids remains constant. Consequently, the ratio of acetylcodeine:heroin + O6MAM) changes very little during the storage of heroin samples. The acetylcodeine concentration also remains stable.* Provided that short-term storage conditions are acceptable, thus preventing degradation, the ratios of acetylcodeine:heroin and of acetylcodeine:O6MAM can be used to determine whether two samples come from the same source.

Figure I illustrates the relationships between samples from three heroin cases investigated in Viet Nam. To establish links between samples, scatter diagrams were prepared using the acetylcodeine:heroin ratio as the vertical axis and the ratio acetylcodeine:6-MAM as the horizontal axis.

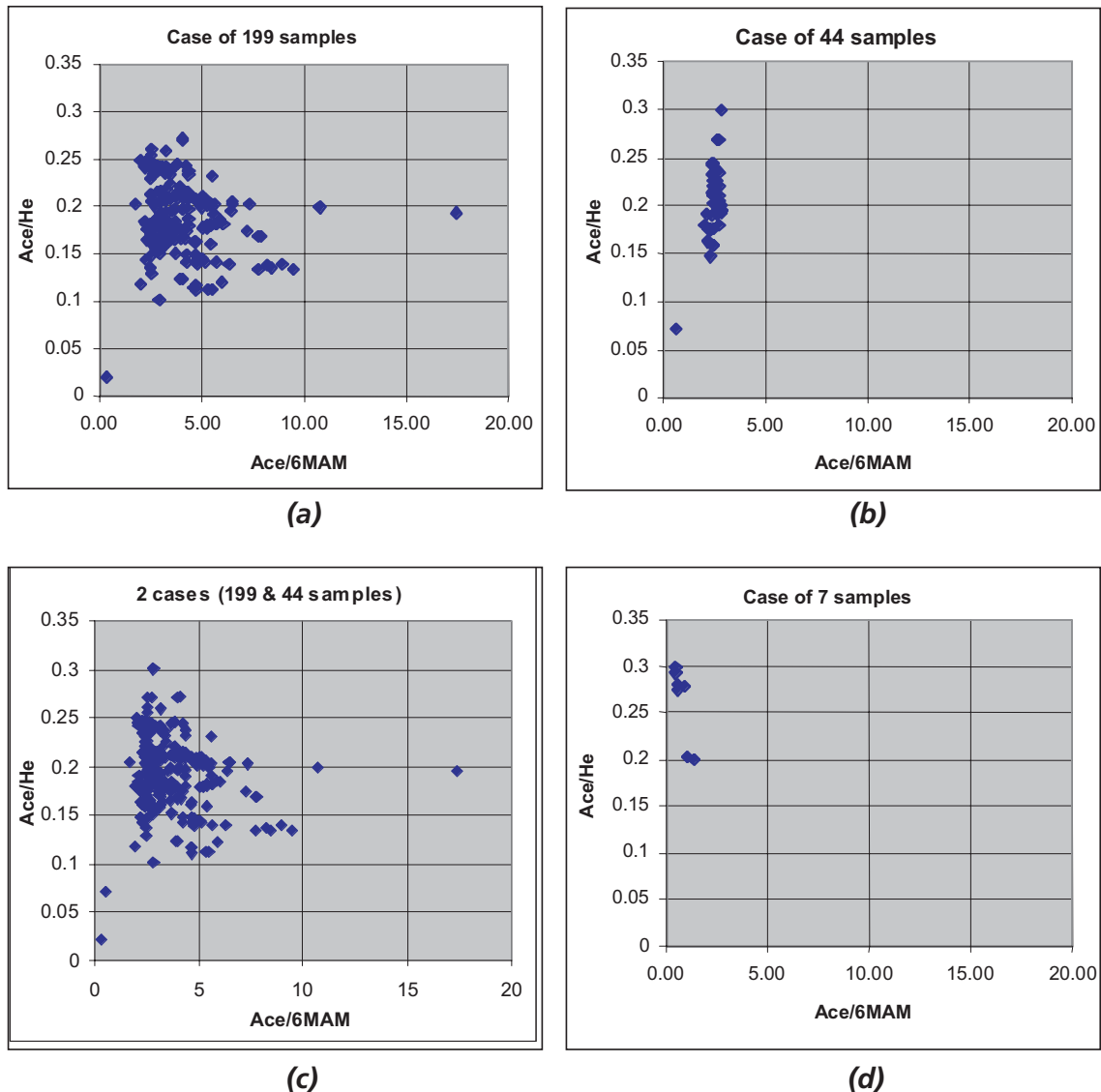
Case 1 involved the analysis of 199 heroin samples taken from 199 separate bags seized in a single operation. Those bags had been found hidden in several cartons in two different cars. Figure I (a) shows that most of the 197 heroin samples form one large group. As can be seen, two samples are clearly different from the other 197 samples and from each other. In figure I (a) sample 1 is located close to the point of origin. And sample 2 is located close to the coordinates 17.5, 0.2. Sample 1 is characterized by a low acetylcodeine content of 1.7 per cent, which suggests that it may have been produced from good quality morphine. Sample 2 exhibits a low, 0.7 per cent O6MAM content, which suggests that it may have been produced under good reaction conditions, resulting in a stable product.

Case 2 involved the analysis of 44 heroin bags taken from a car that had been brought from the western border to the centre of Viet Nam. Analysis indicated that 41 of the 44 bags form a single group (see figure I (b)).

Analysing samples seized from different trafficking groups enables us to establish links between those groups. Figure I (c) combines the results of the samples from case 1 and case 2. It is shown that the samples can be classified in three groups. The largest group comprises samples from the larger groups of the two cases, that is 197 of 199 samples from case 1 and 41 of 44 bags from case 2. The second group comprises one sample of the 44-bags case and one

*Because the codeine concentration was at the detection limit of the technique, the ratio of codeine:acetylcodeine is not a useful indicator to determine the origin of a sample. In the future, heroin samples will be derivatized in order to quantify codeine and morphine, or they will be analysed by other methods such as CE or HPLC.

Figure I. Comparison of three heroin cases (199, 44 and 7 bags of seized heroin, based on two alkaloid ratios)



sample from the 199-bags case (the two points located close to the origin of the axes). And the third group comprises a single sample of the 199-bags case, located at the coordinates 17.5, 0.2.

It is important to note that there are both adulterated and non-adulterated heroin samples in the main group of the 41 of 44 heroin bags. The fact that those samples form one group based on their acetylcodeine:heroin and acetylcodeine:O6MAM ratios suggests that the heroin seized in both cases was produced by the same production process and that adulteration occurred later along the trafficking chain, during distribution.

In the case involving 199 bags, the wholesaler appears to have added caffeine and paracetamol to some samples in order to increase bulk weight. Despite that post-processing alteration to increase weight, impurity profiling analysis made it possible to determine that the adulterated heroin samples came from the same source as those not containing adulterants. Law enforcement

authorities were able to link the two cases with the help of that forensic information.

Finally, the final scatter diagram in figure I (d) shows the analytical results of case 3, which involves seven heroin samples from a single case. The samples were seized at five locations from three individuals. Three samples were found in the house and kitchen of woman A. One sample was found in the garden of her neighbour B, and another in an abandoned car near the house of neighbour B. Finally, two samples were found in the house of offender C.

Analysis confirmed that six of the seven samples contained the same concentrations of heroin and caffeine, while one of the samples seized in the house of offender C did not contain any adulterants. The ratios of key alkaloids of all seven samples was similar, which suggests that all samples came from a single source. The existence of a chemical link between the samples led to the suspicion that there might also be a link between individuals A, B and C, although all three offenders denied any such relation existed. When the results of that analysis were combined with evidence from law enforcement officials, it was concluded that C sold drugs to B, and B sold drugs to A.

Figure II. Some logos of samples of heroin seized in Viet Nam



"globe and lion"



"one ruby with crown"



"dragon"



"999/AAA"



"rose flower/AAA"

The print most frequently encountered on packaging material of seized heroin is the “globe and lion” logo (see figure II), which is also found in other Asian countries. The “one ruby with crown” logo was encountered for the first time in Viet Nam in the 199-bag case of 2003. Heroin cakes with other logos, such as the “AAA”, “999” and “rose flower” logos, are usually trafficked in standard weights of 360 grams, but occasionally small cakes of 60 grams are encountered. It is typical of heroin trafficking in Viet Nam that most offenders carry only one cake at a time. That may be a result of the 2001 narcotic drug law, which established 100 grams of product, regardless of purity, as the threshold for capital punishment. However, the courts can adjust punishment in accordance with the diacetylmorphine content of the seized drugs.

Impurity profiling of methamphetamine

From 2000 to 2004, seizures of amphetamine-type stimulants (ATS) tablets in Viet Nam increased steadily: 17,000 tablets were seized in 2000, 43,160 in 2001, 44,428 in 2002, 27,218 in 2003 and 61,000 in 2004. Most were methamphetamine tablets. ATS accounts for approximately 20 per cent of all seized drugs. The amount of ATS seized in Viet Nam is expected to increase further in the future, reflecting a worldwide trend.

Recently, an increasing variety of logos has been observed on tablets sold as Ecstasy—with the same weight and size as real Ecstasy tablets—on the illicit markets in Viet Nam, especially in discotheques. Analysis has shown that some of those tablets did not contain methylenedioxyamphetamine (MDMA), methylenedioxyamphetamine (MDA) or other Ecstasy-type substances but only methamphetamine. In response, our laboratory introduced the impurity profiling of ATS in 2002, extending its range of analytical tools beyond qualitative and quantitative analyses, which characterized the laboratory’s work on methamphetamine prior to 2002. The impurity profiling of that drug now makes it possible to establish links between samples, determine whether new types of crystalline methamphetamine have appeared on the market, give the courts evidence on chemical links and determine whether there are new production and preparation processes for methamphetamine tablets.

Analytical aspects

Prior to analysis, tablets are ground into powder. One hundred milligrams of the powder are dissolved in 1 ml of 0.1M phosphate buffer. The solution is made basic with 0.25 ml of 10 per cent Na_2CO_3 solution, and 0.4 ml of ethylacetate containing an internal standard ($\text{C}_{30}\text{H}_{62}$) are added. The solution is shaken vigorously for 5 minutes, centrifuged, and the organic layer is transferred to an insert of a microvial; 1 μl of the solution is injected into the GC.

Instrumentation 1: Thermo-Finnigan GC-MS

Column: Rtx1-ms (100% dimethylpolysiloxane, crosslinked, 30 m x 0.25 mm x 0.25 μm)

Injector temperature: 275° C; mode: splitless

Carrier gas: Helium, constant flow at 1.0 ml/min

Temperature programme: 100° C, hold for 1 min, at 10° C/min to 270° C, 20 min hold

Transfer line 275° C; ion source: 200° C

MS mode: full-scan 50-650 m/z

Instrumentation 2: Agilent 6890N GC

Column: Ultra II: 5% phenyl 95% dimethylpolysiloxane, crosslinked, 25 m x 0.2 mm x 0.33 μm

Injector and detector temperature: 280° C

Carrier gas: nitrogen at flow rate of 1 ml/min; splitless

Temperature programme: 50° C, hold for 1 min, at 10° C/min to 300° C, 9 min hold

Results and discussion

In 1995, an illicit methamphetamine laboratory in Ho Chi Minh City operated by a person who was not a national of Viet Nam was dismantled. Authorities seized 234 kg of crystalline methamphetamine that had been packed in plastic green tea bags one kilogram in weight ready for export. Ten years later, in 2005, crystalline methamphetamine was seized once again. The question of law enforcement authorities was whether there was a link between the two seizures of crystalline methamphetamine, in particular whether they were manufactured using the same synthesis route.

Figure III. Chromatogram of crystalline methamphetamine seized in 1995 (1=1,2-dimethyl-3-phenylaziridine; 2=methamphetamine; 3=ephedrine; 4=unknown; 5="naphthalene"; IS=internal standard)

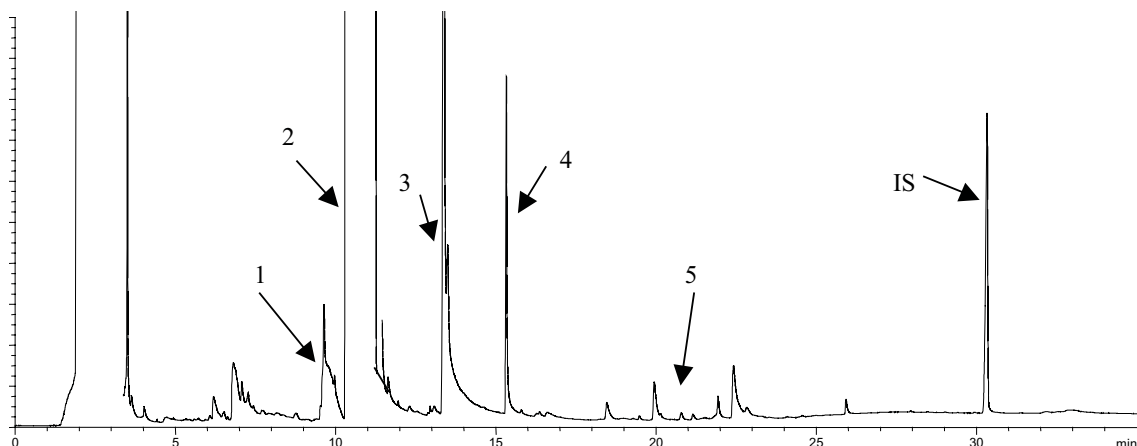
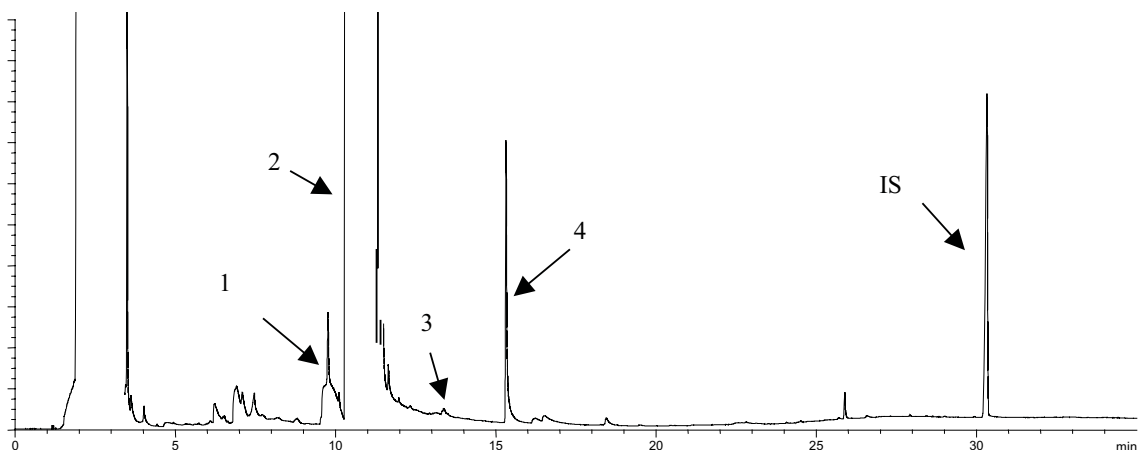


Figure IV. Chromatogram of crystalline methamphetamine seized in 2005 (1=1,2-dimethyl-3-phenylaziridine; 2=methamphetamine; 3=ephedrine; 4=unknown; IS=internal standard)



As can be seen from figures III and IV, there are significant differences in the impurity profiles of the two methamphetamine samples, which suggests that the methamphetamine seized in 2005 had a production process different from that seized in 1995. The main difference between the two chromatograms is the presence of peak No. 3 (at $R_t=13.5$ min.) in the impurity profile of the sample seized in 1995 (figure III). That peak, which was identified to be ephedrine, is absent in the profile of the sample sized in 2005 (figure IV). Because of the crystalline nature of the two samples, it is unlikely that ephedrine was added as a cutting agent. That suggests that the two samples were produced using different production processes. That finding contradicted the view of law enforcement authorities that there was only one method of methamphetamine production. However, the presence of traces of ephedrine in both samples suggests that both batches of crystalline methamphetamine were synthesized using that precursor.

Unlike the crystalline methamphetamine discussed in the foregoing case, most methamphetamine found in Viet Nam is in tablet form. "Red tablets", as methamphetamine tablets are commonly called in Viet Nam because of their red colour, have been imported into the country since 2000 and have become popular.










Tablets with the "WY" logo found in Viet Nam resemble those from the Golden Triangle; they have the same logo (see figure V), the same size (0.6 x 0.25 cm), the same weight (80-90 mg) and the same colour (such as red, orange and green [8]). The tablets have a 10-24 per cent methamphetamine content and contain adulterants such as caffeine, ethylvanillin and ketamine.

Figure V. Some types of the "WY" logo of methamphetamine tablets



In May and June 2005, Ecstasy tablets were seized in more than 20 discotheques in the country's two biggest cities, Hanoi and Ho Chi Minh City. The tablets physically resembled real Ecstasy tablets with the same weight, nearly 0.25 and 0.34 g, and the same size, 0.8 x 0.5 cm. However, analysis of the tablets showed that they were very different from real Ecstasy, in both qualitative and quantitative terms. Some tablets contained MDMA, some contained methamphetamine and some contained a combination of both. Ketamine, which in Viet Nam is controlled by Government decree No. 133 of 6 November 2003, was also detected in most tablets, and was sometimes the main active component. Paracetamol and caffeine were frequently present. Table 3 shows selected results of the analysis of the seized tablets being sold as Ecstasy.

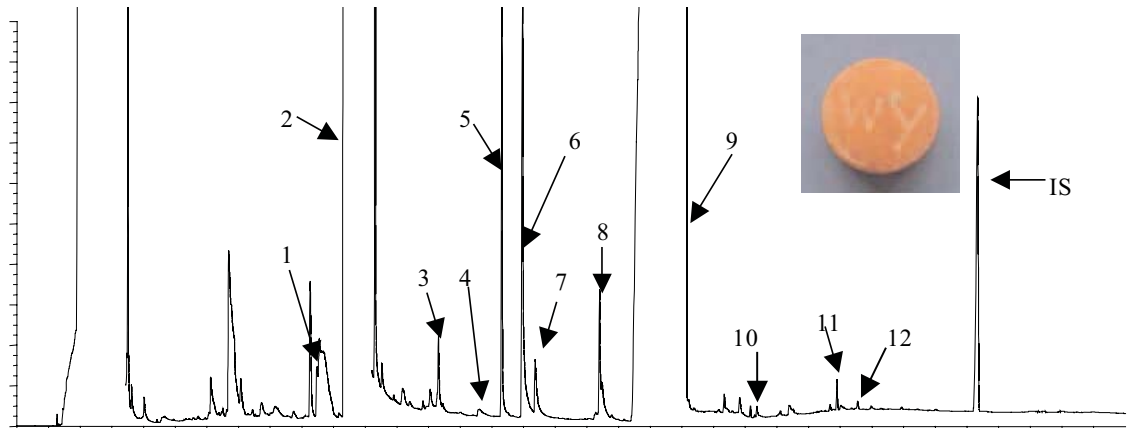
Table 3. Physical characteristics and chemical composition of different types of tablets sold as Ecstasy

Tablet	Size (cm)	Weight (g)	Methamphetamine content (percentage)	MDMA ^a content (percentage)	Adulterants
	0.8 x 0.5	0.358	0.52	0	Paracetamol, caffeine and ketamine
	0.9 x 0.5	0.325	0.62	0	Paracetamol, caffeine and ketamine
	0.9 x 0.4	0.320	0.87	0	Paracetamol, caffeine and ketamine
	0.8 x 0.4	0.342	33.18	0	Ketamine
		0.283	0.03	21.15	Ketamine
	0.7 x 0.4	0.299	0.05	25.18	Ketamine
	0.7 x 0.4	0.263	1.68	66.86	Ketamine
	0.8 x 0.4	0.365	0	36.69	Ketamine
	0.6 x 0.5	0.191	0	81.96	Ketamine

^a3,4-Methylenedioxyamphetamine.

Figure VI shows the impurity profiles of two traditional “WY” logo methamphetamine tablets—orange and green—and a fake Ecstasy tablet carrying a spider logo. Other logos seen on fake Ecstasy tablets include the “E” (euro), “leaf”, “ox head”, “crocodile”, “butterfly” and “XO” logos. A variety can be seen in figure VII.

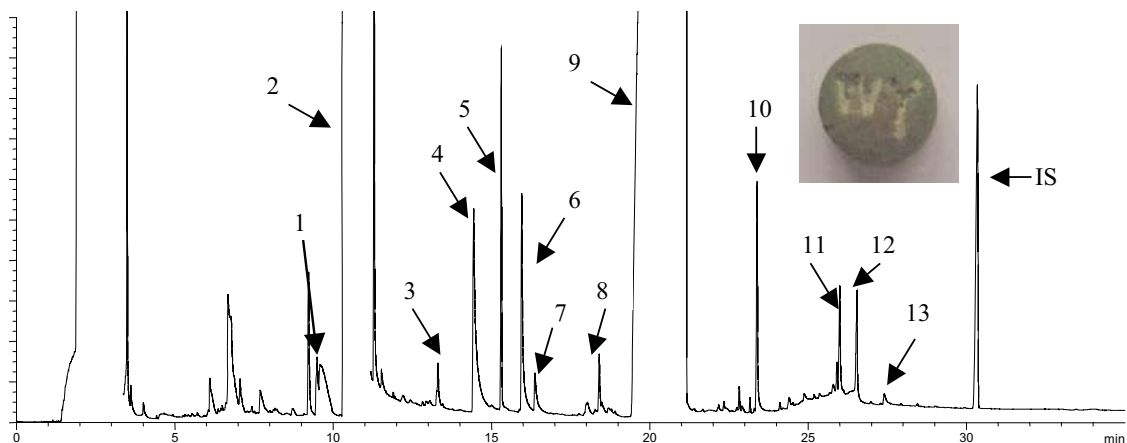
Figure VI. Impurity profiles of two traditional methamphetamine tablets carrying the “WY” logo



Note:

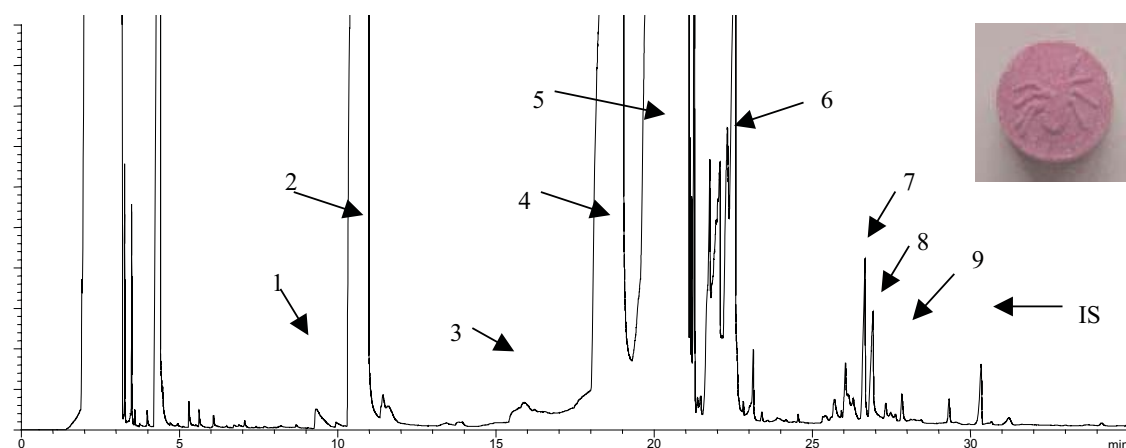
- | | |
|-------------------------------------|--|
| 1. 1,2-Dimethyl-3-phenylaziridine | 8. Acetyephedrine |
| 2. Methamphetamine | 9. Caffeine |
| 3. Ephedrine | 10. Unknown-2 |
| 4. Ethylvanillin | 11. Unknown-3 |
| 5. Unknown-1 | 12. O ⁶ -Monoacetylmorphine |
| 6. <i>N</i> -Formyl methamphetamine | IS Internal standard |
| 7. Acetylmethamphetamine | |

Figure VIa. Impurity profiles of two traditional methamphetamine tablets carrying the “WY” logo



Note:

- | | |
|-------------------------------------|--|
| 1. 1,2-Dimethyl-3-phenylaziridine | 8. Acetyephedrine |
| 2. Methamphetamine | 9. Caffeine |
| 3. Ephedrine | 10. Unknown-2 |
| 4. Ethylvanillin | 11. Unknown-3 |
| 5. Unknown-1 | 12. O ⁶ -Monoacetylmorphine |
| 6. <i>N</i> -Formyl methamphetamine | 13. Heroin |
| 7. Acetylmethamphetamine | IS Internal standard |

Figure VII. Impurity profile of fake pink Ecstasy tablet with a spider logo

Note:

1. 1,2-Dimethyl-3-phenylaziridine
2. Methamphetamine
3. Methylenedioxyamphetamine
4. Caffeine
5. Ketamine
6. Phenobarbital
7. Acetylcodeine
8. O⁶-Monoacetylmorphine
9. Heroin
- IS Internal standard

Figure VIII. Logos of fake Ecstasy tablets seized in 2005

Fake Ecstasy tablets containing sassafras oil, a pre-precursor of MDMA, and adulterants such as diazepam and other substances of the benzodiazepine group have also been encountered. The profile analysis of those tablets point to the existence of illicit sites that pressed the fake Ecstasy tablets that have appeared in recent times. In fact, law enforcement bodies have eradicated an illicit site containing a tablet press and a variety of punches.

Conclusion

Impurity profiling in the strict sense was not done in Viet Nam before 2002. Since then, with the help of the Japan International Cooperation Agency (JICA) and the United Nations Office on Drugs and Crime, the forensic chemists of the Institute of Forensic Sciences have acquired a great deal of knowledge in the field.

In the case of heroin, combating the results of physical characteristics and impurity profiling, as done in table 2, can provide information about the sources of heroin that may subsequently help law enforcement agencies stop the

supply of heroin imported into Viet Nam. Moreover, because there are potential domestic sources of raw materials for the manufacture of illicit heroin, impurity profiling can help identify those starting materials and provide valuable information for suitable regulatory control measures. Such potential domestic sources include small-scale illicit opium production, medicinal morphine available for legitimate use against cancer and codeine, which is available in low concentrations in cough medicine from pharmacies.

The impurity profiling of ATS can provide law enforcement authorities with information to determine how many different production processes are being used to produce seized methamphetamine tablets with the "WY" logo. The profiling of two seizures of crystalline methamphetamine revealed that although both were manufactured from the same precursor, ephedrine, different chemicals must have been used in their respective production processes. Analysis of new forms of both real and fake Ecstasy tablets reveals the subtle and devious skills of the manufacturers. They are able not only to make great profits but also to make things more difficult for law enforcement authorities and forensic teams. The findings on fake Ecstasy tablets also demonstrate the value of profiling analysis in monitoring actual drug availability, as opposed to perceived or reported availability based on the physical appearance or presentation and/or marketing of drug samples on illicit markets.

In order to make full use of the potential of drug characterization and impurity profiling analyses, law enforcement authorities must be trained to understand the necessity and the usefulness of impurity profiling and to combine investigative and forensic information. Stopping big trafficking groups may be one of the main duties of law enforcement agencies in the future. Impurity profiling gives law enforcement authorities supplementary information for the detection of heroin and methamphetamine trafficking and production.

Building adequate databases is critical to impurity profiling. In addition to the work on heroin and methamphetamine, law enforcement authorities will have to provide the Institute of Forensic Sciences with sufficient MDMA samples so that it can create a database on the impurity profiling of that drug too. Hopefully, the impurity profiling of major drugs such as heroin and methamphetamine—and MDMA by 2007—will become routine work in drug law enforcement laboratories.

References

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