行政院所屬各機關因公出國人員出國報告書

（出國類別：參加會議）

赴美國達拉斯參加
「第五十六屆美國刑事科學年會」報告

服務機關：法務部法醫研究所

出國人　職　　稱：助理研究員

　　姓　　名：殷瑞敏

出國地點：美國德州達拉斯

出國時間：民國九十三年二月十三日至
　　民國九十三年二月二十一日

報告日期：民國九十三年四月三十日

系統識別號 C09301061

行政院及所屬各機關公務出國報告提要

出國報告名稱：赴美國達拉斯參加「第五十六屆美國刑事科學年會」報告

頁數：16　　含附件：否

出國計畫主辦機關/聯絡人/電話

法務部法醫研究所/高瑞梅/27372967

出國人員姓名/服務機關/單位/職稱/電話

殷瑞敏/法務部法醫研究所/毒物化學組/助理研究員/27372967

出國類別：其他

出國期間：民國九十三年二月十三日至民國九十三年二月二十一日

出國地點：美國德州達拉斯

報告日期：民國九十三年四月三十日

關鍵詞：美國刑事科學年會、論文發表

內容摘要：

二OO四年第五十六屆美國刑事科學年會，於九十三年二月十五日至民國九十三年二月二十日在美國德州達拉斯市盛大舉行。會議是採取分組、分項方式進行。為藉由論文發表提昇本所國際地位，並藉此機會觀摩其他先進國家在刑事鑑識科學領域之研究成果，並促進國際學術交流。本所於九十三年度內編列預算計畫派員參加第五十六屆美國刑事科學年會並發表論文。經由本屆會議投稿，獲評審委員團審核通過准予本屆年會中公開發表，而得以成行。本所於會中，發表有關法醫毒物分析之論文一篇：「甲基安非他命及安非他命在指甲及毛髮中分佈情形」(林棟樑、殷瑞敏、劉秀娟)

會議期間由本所顧問法務部調查局第六處柳煌處長事先安排，而得以參觀德州達拉斯醫學中心之法醫科學研究所實驗室及美國達拉斯浸信會大學法務系參訪。為因應司法偵審品質提昇之訴求，並提高鑑定結果之公信力，各國鑑識實驗室均以通過認證為努力目標，此次參觀從受訪單位中瞭解，實驗室認證之重點包括人員素質與訓練、工作標準化、門禁管理、證物儲存、實驗場所規格等。礙於本所人力、財力、物力及實驗室空間配置皆缺乏，僅能就現有狀況先循序漸進改善。建議多參加此類國際會議一方面可增廣見聞，了解全世界鑑識科學發展的趨勢與進程，再者本所派員參加此類國際會議亦可促進學術交流，提昇本所國際聲譽。

赴美國達拉斯參加「第五十六屆美國刑事科學年會」報告

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摘　　要

二OO四年第五十六屆美國刑事科學年會，於九十三年二月十五日至民國九十三年二月二十日在美國德州達拉斯市盛大舉行。會議是採取分組、分項方式進行。為藉由論文發表提昇本所國際地位，並藉此機會觀摩其他先進國家在刑事鑑識科學領域之研究成果，並促進國際學術交流。本所於九十三年度內編列預算計畫派員參加第五十六屆美國刑事科學年會並發表論文。經由本屆會議投稿，獲評審委員團審核通過准予本屆年會中公開發表，而得以成行。本所於會中，發表有關法醫毒物分析之論文一篇：
「甲基安非他命及安非他命在指甲及毛髮中分佈情形」
(林棟樑、殷瑞敏、劉秀娟)
會議期間由本所顧問法務部調查局第六處柳煌處長事先安排，而得以參觀德州達拉斯醫學中心之法醫科學研究所實驗室及美國達拉斯浸信會大學法務系參訪。為因應司法偵審品質提昇之訴求，並提高鑑定結果之公信力，各國鑑識實驗室均以通過認證為努力目標，此次參觀從受訪單位中瞭解，實驗室認證之重點包括人員素質與訓練、工作標準化、門禁管理、證物儲存、實驗場所規格等。礙於本所人力、財力、物力及實驗室空間配置皆缺乏，僅能就現有狀況先循序漸進改善。建議多參加此類國際會議一方面可增廣見聞，了解全世界鑑識科學發展的趨勢與進程，再者本所派員參加此類國際會議亦可促進學術交流，提昇本所國際聲譽。

壹、出國目的：

為藉由論文發表提昇本所國際地位，並藉此機會觀摩其他先進國家在刑事鑑識科學領域之研究成果，並促進國際學術交流。本所於九十三年度內編列預算計畫派員參加第五十六屆美國刑事科學年會並發表論文。經由本屆會議投稿，獲評審委員團審核通過准予本屆年會中公開發表，而得以成行。會中由本所顧問法務部調查局第六處柳煌處長事先安排，而得以參觀德州達拉斯醫學中心之法醫科學研究所實驗室及美國達拉斯浸信會大學法務系參訪。

本次出席會議，同行的尚有法務部調查局第六處蒲長恩科長、李富國調查員、鄭家賢調查員、陳孟宜調查員、孟令敏調查員，旅居美國本所顧問李昌鈺博士、台灣警界於美博士研究員李承龍先生等亦出席本次會議。

本所於會中，發表有關法醫毒物分析之論文一篇：「甲基安非他命及安非他命在指甲及毛髮中分佈情形」(林棟樑、殷瑞敏、劉秀娟)

本所於八十七年成立以來，每年均編有此項經費預算，若法務部長官能持續支持鼓勵下，本所將能繼續對外發表論文與參與國際會議，此乃是法醫工作研究發展最大的成果，對本所法醫科學學術地位之提昇，頗有助益。此次會議希望使本所在法醫鑑識方面的努力與成果廣為人知，也藉此機會促進本所與各國法醫鑑識科學界的知名學者、教授在法醫鑑識技術之交流，並汲取法醫鑑識新科技與方法，以充實本所未來研究發展實力。

特別感謝本所王崇儀所長及毒物化學組林棟樑組長之支持及指導，才能有此次機會觀摩國外法醫鑑識之發展。除觀摩法醫鑑識新科技與方法外，亦擬選擇可供學習液相層析質譜儀等先進鑑識技術之刑事鑑識實驗室，未來或可派員出國學習相關鑑定技術。

貳、會議過程：

赴美國達拉斯參加「第五十六屆美國刑事科學年會」行程

日期	時　間	行　程　內　容
2/13 (Fri)	12:10	搭乘國泰航空公司班機自中正國際機場至東京成田機場，轉機至美國達拉斯。
2/14 (Sat)	08:30	第五十六屆美國刑事科學年會之相關會議流程開始進行。
2/15 (Sun)		參加「第五十六屆美國刑事科學年會」
	13:00	大會報到
2/16 (Mon)	08:00	技術講習會(WORKSHOP)及特別演講
2/17 (Tue)	08:00	參訪美國達拉斯浸信會大學
	13:00	技術講習會(WORKSHOP)
	18:00	歡迎晚會
2/18 (Wed)	08:00	參訪美國德州達拉斯醫學中心之法醫鑑識科學中心實驗室
	13:00	技術講習會(WORKSHOP)、壁報論文及論文發表
2/19 (Thu)	08:00	技術講習會(WORKSHOP)、壁報論文及論文發表
2/20 (Fri)	08:00	由美國達拉斯搭機至日本轉機
2/21 (Sat)	18:40	抵達桃園中正國際機場

參、參加會議內容

一、92.2.15-16 赴會場認識環境及辦理註冊等相關事宜(參附錄一)，利用時間參觀與大會同時進行的科學器材儀器及書籍展覽，蒐集最新儀器及各式實驗室相關資料。

二、92.2.18 張貼壁報論文，今年本所發表在毒物化學類計有一篇(附件一)；期間並與前來閱覽之與會學者詳細討論(參附錄一)，並與其他毒物化學壁報論文區作者們廣泛交換意見，了解最新研究情形(參附錄二)。

三、92.2.19 參觀調查局張貼之壁報論文 (參附錄一)，今年調查局投稿內容十分多元化，使與會學者對調查局 DNA 鑑定之發展情形、測謊技術及問題文書鑑定技術印象深刻。

四、92.2.20 張貼發表之論文為一般類一篇，作者為調查局李復國，期間並與前來閱覽之與會學者廣泛討論。刑事科學年會期間，美國各著名儀器廠商及刑事鑑識書籍廠商，利用會場展覽及販售有關毒物分析、DNA 檢驗、法醫病理等刑事鑑識相關書籍及儀器。(參附錄一)。

肆、參訪學校

92.2.17 經調查局調查班八期學長，目前已移民至美國達拉斯市擔任達拉斯浸信會大學司法警務系（Criminal Justice）系主任孔希教授引領，參訪達拉斯浸信會大學，期間獲該校國際學生部主任羅貝卡女士熱烈接待，並與該校副校長瑞克教授晤面，會後應孔教授邀請，於司法警務系教室張貼發表論文，由蒲長恩科長向司法警務系

學生進行為期一小時的演講課程，內容包含化學檢驗、文書鑑定、物理鑑定、法醫 DNA 鑑定等專業科技，及特殊案例介紹，講演內容豐富充實，與會學生反應熱烈 (參附錄二)。課後經孔教授安排與國際學生部主任羅貝卡女士及該校台灣留學生進行餐敘，席間互動愉快，留學生們對到訪人員到訪備感親切與光榮（參附錄二）。

伍、參觀實驗室

92.2.18 赴達拉斯市法醫鑑識科學中心參訪，由死因調查科副科長查理士先生親自接待，帶領參觀並交換意見(參附錄二)。參訪紀錄如下：

1、該中心全名為 DALLAS COUNTY INSTITUTE OF FORENSIC SCIENCES，負責德州約三分之一區域的死因解剖及刑事證物鑑定。

2、該中心每年約受理 15,000 件案件以上，其中約三分之一為死因解剖案件，三分之一為微量證物案件，餘為槍彈、工具痕跡及毒化分析等案件，証物之收發均使用電腦管理系統追蹤，並設有頗具規模儲藏室妥善保管所有證物。

3、該中心包含四個獨立實驗室區，第一區為大體解剖室，編制病理醫師十二名，每日解剖屍體約十五至二十具，其中約百分之七十的死因為槍傷致死，解剖一具屍體收費美金一千五百元。

4、第二區為槍彈及工具痕跡實驗室，大部分案件為彈道比對、槍支樣品及彈道資料建檔，該實驗室運用 IBIS 彈痕電腦建檔比對系統，可以快速比對出涉案槍械並建檔供未來比對用，實驗室另配備有 EDAX X 光金屬元素比對系統，可以快速自動定位掃描，

五、毒物化學類之壁報論文閱讀心得擇要紀錄 3：「以 ELISA 偵測非人類之靈長類尿中 Ketamine」，Ketamine 近年來被有心人士利用當做約會強暴丸，此 Kit 為 Neogen 公司提供。此報告除以 ELISA Kit 測尿中 Ketamine 亦以 NCI-GC-MS 分析尿中 Ketamine 及 Norketamine，並比較兩者結果。此研究發現猴子在服用 Ketamine 後，一隻約四天其尿液仍可偵測到，有二隻約七天可偵測到，另一隻至十一天，最長於注射後十六天仍可偵測到 Ketamine 及其代謝物。

乙、參訪實驗室部分心得感想

一、達拉斯市法醫鑑識科學中心，負責德州約三分之一區域的死因解剖及刑事證物鑑定，每年約受理一萬五千件案件以上，其中主要鑑定項目為死因鑑定，含屍體解剖、微量證物、槍彈比對等鑑定，實驗室的案件數多，業務繁重，編制人員尚稱不足，且空間配置較為擁擠，惟該實驗室擁有多項先進之儀器配備，如 IBIS 彈痕電腦建檔比對系統；EDAX X 光金屬元素比對系統等。

二、達拉斯市法醫鑑識科學中心所受理的案件之鑑定項目均詳細分項定價，如解剖一具屍體收費美金一千五百元；微量證物之前處理項目收費美金四十六元；DNA STR CODIS 9 型項目收費美金三百一十五元；毒物化學分析亦為單項計費。本所似可仿效此一收費做法，讓委驗單位及上級了解本所鑑定各項實驗所需之耗材與人事成本，進而支持本所儀器設備之維護與更新所需

之耗材與人事成本，進而支持本所儀器設備之維護與更新所需之預算審核。

三、為因應司法偵審品質提昇之訴求，並提高鑑定結果之公信力，各國鑑識實驗室均以通過認證為努力目標，惟直接向國外認證機構首次申請認證之經費即高達三萬美金，恐於現在政府財政十分困難狀況下，不易辦理，因此國內目前由已成立之中華民國鑑識科學會所設立之刑事鑑識實驗室認證規劃小組，規劃推動擔任認證機構，可接受各實驗室申請認證，較符經濟效益。

四、經參考目前蒐集到的文獻並從受訪單位中瞭解，實驗室認證之重點包括人員素質與訓練、工作標準化、門禁管理、證物儲存、實驗場所規格等。礙於本所人力、財力、物力及實驗室空間配置皆缺乏，僅能就現有狀況先循序漸進改善。除積極實施實驗室工作標準化作業流程，並應明確規定其儀器校正、維護方法及頻率。另應強化實驗室安全，本所實驗室之安全設備應計畫性增購相關配備，除能符合法規規定，亦能確保工作人員及實驗室之安全。工作人員亦應積極參與相關刑事鑑識訓練研討會及實驗室認證相關研討會，以提昇專業知識及技能，以因應本所未來實驗室品質認證之需要。

丙、建議：

一、目前全世界鑑識科學年會有許多種類，較重大者包含三年一度之世界刑事科學年會(2005 年於香港舉行)、三年一度之歐洲刑

年會(2005 年於美國加州紐奧良舉行)等，參加此類國際會議一方面可增廣見聞，了解全世界鑑識科學發展的趨勢與進程，再者本所派員參加此類國際會議亦可促進學術交流，提昇本所國際聲譽，因此針對此類國際會議宜預先規劃時程與預算，盡量派員參加，不宜缺席。

二、為求提昇本所鑑識科技水準及維持本所科技鑑定之公信力，各項科技鑑定的研究發展必須持續進行，因此本所宜持續精神或物質鼓勵研究發展具有成效者，以大力推動研發工作。

三、人員專業訓練方面，由於法醫科技日新月異，犯罪案件與日俱增，為汲取國外相關專業知識和技能，除參加國際會議外，宜安排人員赴國外短期進修，培養人才以強化本所鑑識能力，建立國際交流管道。

which quantitatively measures alcohol concentrations from 0 to 150 mg/dL. We evaluated the QED® A-150 Saliva Alcohol Test Device for the determination of alcohol in urine. We followed the manufacturer's procedure, except that the cotton tip of the swab was dipped into urine so that the cotton swab was saturated with urine. Samples were analyzed on the same day by Gas Chromatography (GC) with flame ionization detector (FID) on a glass column, 1.82 m x 2 mm ID glass column, 60/80 Carbopack B/ 5% Carbowax 20M (Supelco, Bellefonte, PA, 16823). N-propanol (NP) is used as internal standard (IS). Urine samples, which were spiked with ethanol at 20, 40 and 80 mg/dl gave the following average results. Within-run precision by QED® at the 3 concentrations (n=12) was 7.3% with a 128 +/- 31% recovery; between-run precision averaged 11% with 131 +/- 29% recovery. For comparison the average within-run precision by GC at the 3 concentrations (n=12) was 2.9% with a 104 +/- 5% recovery; between-run precision averaged 4% with 103 +/- 3% recovery. Urine samples that were analyzed on the same day by QED® and GC gave the following results. The concentration of samples ranged from 0 to 383 mg/dl of ethanol with a mean of 117.35 and standard deviation (+/-) of 79.01 by GC mean= 117.35 +/- 79.01, n=31) and a mean of 100.09 and standard deviation (+/-) of 65.75 by QED® (mean= 100.09 +/- 65.75, n=31). Least squares analysis of urine alcohols by GC (x) in comparison to QED® (y) gave a slope (m) of 0.929, y-intercept (b) of -1.028 and correlation coefficient (r) of 0.99 (y = 0.929x - 1.028, r= 0.99) with a standard error of estimate Syx of 14.95. Recovery studies indicate that QED® overestimates urine alcohols at low concentrations. No false positive results were reported by QED®. Interference studies indicate that n-propanol will cross react 60% and isopropanol 20% with the QED alcohol method. We conclude that the QED® saliva method can be used for the determination (identification and quantitation) of alcohol in urine. Although QED does not have the sensitivity, selectivity and precision or accuracy of GC, it will provide qualitative and quantitative results more rapidly than GC, less than 3 minutes.

Urine Alcohol, Gas Chromatography, QED®

K4 Analysis of Amphetamines in Nail Clippings Collected From Female Prisoners

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This presentation will demonstrate the usefulness of fingernails as an analytical specimen for confirming amphetamine use and the relationship of evidence of amphetamines in hair and nail specimens

With respect to the use of fingernail as an analytical specimen, fewer studies have been directed to amphetamines than other commonly abused drugs, such as opiates or cocaine. In this study, paired fingernail and hair specimens were collected from 43 consenting female prisoners who have admitted the use of amphetamines and/or opiates. These specimens were quantitatively analyzed for amphetamine, methamphetamine, methylenedioxyamphetamine, and methylenedioxymethamphetamine. Methamphetamine and amphetamine concentration ranges, and methamphetamine/amphetamine ratios found in the 21 amphetamines-containing specimens were 0.46-58.17 ng/mg, <0.20-5.42 ng/mg, and 4.06-14.01, respectively. Six paired hair specimens from these 21 sets were selected and cut into 1.5-cm sections. The first 5 sections (from the root) were analyzed. Analytical data are shown in Table 1.

Table 1. Amphetamines in fingernail and hair

Sample No.	Fingernail (ng/mg)				Hair (ng/mg)		
	Methamph.	Amph.	Methamph./ Amph.		Methamph.	Amph.	Methamph./ Amph.
3 (A-008)	13.96	2.73	5.11	S-1[a]	16.78	4.32	3.88
				S-5[a]	58.78	12.83	4.58
5 (A-013)	12.43	1.70	7.31	S-1	18.95	2.27	8.35
				S-5	38.29	3.59	10.67
8 (A-024)	58.17	5.42	10.73	S-1	134.1	24.37	5.50
				S-5	80.55	10.42	7.73
11 (A-027)	3.94	0.97	4.06	S-1	7.03	1.76	3.99
				S-5	30.23	5.89	5.13
13 (A-030)	43.63	3.38	12.91	S-1	71.81	11.59	6.20
				S-5	9.24	1.73	5.34
19 (A-041)	11.70	1.42	8.24	S-1	20.95	3.84	5.46
				S-5	45.25	6.44	7.03

[a] S-1, S-5: The first and the 5th sections of the 5 sections analyzed.

It is interesting to note that results obtained from hair sectional analysis follow definite trends. Specifically, the concentrations of methamphetamine and amphetamine in samples 3, 5, 11, and 19 increase continuously, while the same analytes' concentrations in samples 8 and 13 decrease continuously. Nail clippings will be continuously colleted on biweekly intervals. Whether the analytes' concentrations in nail specimens will follow the same trends observed for hair will be investigated.

Nail, Amphetamines, Hair

K5 Validation of Volatile Analysis Using Dual Column Capillary GC

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The authors will present data obtained during the validation of a dual column capillary gas chromatography (GC) procedure. The assay, which is routinely used by the New Mexico Department of Health for evidential ethanol testing and postmortem investigation, was validated in terms of precision, accuracy, matrix effects, carryover, linearity, limit of detection and limit of quantitation. A comparison of quantitative ethanol concentrations using postmortem and antemortem casework using both capillary columns (Restek BAC1 and BAC2), together with a comparison of capillary and packed GC columns is also described.

A targeted analysis is performed for methanol, ethanol, acetone and isopropanol using an Agilent HP 6890 GC equipped with a flame ionization detector (FID). Methanol, ethanol, acetone and isopropanol are identified based upon characteristic retention times relative to the two internal standards, n-propanol and t-butanol.

The limit of detection (LOD) in blood was 0.001 g/dL for all analytes tested. The limit of quantitation (LOQ) for ethanol, isopropanol and acetone was 0.005 g/dL and 0.010 g/dL for methanol. Precision using whole blood was evaluated by replicate analysis of in-house controls (n=8). Intraassay CVs for ethanol, methanol, acetone and isopropanol were 1.1, 1.1, 1.0 and 1.1% at 0.474 g/dL, 1.2, 0.9, 1.5 and 0.8% at 0.158 g/dL, 1.7, 1.6, 2.4 and 1.2% at 0.079 g/dL and 4.4, 3.5, 1.9 and 3.4% at 0.019 g/dL respectively. Intraassay CVs using a commercial whole blood control (BioRad) were in the range 2.2 - 3.1% (n=8). Accuracy was determined using internal and external controls. Accuracy using in-house blood controls was 99-103% in the concentration range tested (0.039 – 0.379 g/dL). Accuracy using aqueous external controls (Cerilliant) was 96-102% and commercial whole blood controls (Utak Laboratories, BioRad) were within the acceptable limits defined by the

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Disposition Characteristics of Methamphetamine and Amphetamine in Nail Clippings and Hair Sections

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ABSTRACT

Fingernail clippings collected from 97 consenting females, who have admitted the use of amphetamines and/or opiates and are currently under treatment, were quantitatively analyzed for the presence of methamphetamine and amphetamine. Sixty-two subjects were found positive for methamphetamine/amphetamine. Paired fingernail-hair specimens were collected from 6 of these subjects for an 12-week period and analyzed to determine: (a) The duration of detectability and disposition characteristics of amphetamines in fingernails; (b) Whether data derived from the analysis of fingernail clippings and hair sections are reflective of drug use patterns; and (c) Whether there is a relationship between the analytical data derived from the paired fingernail and hair specimens.

Major findings of this study include: (a) Methamphetamine was found in the fingernails from 62 subjects collected in Week 0. The distribution of methamphetamine concentrations (ng/mg) in these samples are: range, 0.46–61.50; mean, 9.96, and standard deviation: 13.33; corresponding data for amphetamine are <0.20–5.42, 0.93, and 1.01, respectively. (b) Sectional analysis of hair samples collected from 6 subjects in Week 0 indicate methamphetamine concentrations peak at different distance from the root for different individuals. (c) Methamphetamine/amphetamine concentrations in fingernails are general lower than the first 1.5-cm section of hair samples collected at the same time from the same individual. (d) Amphetamine/methamphetamine ratios in fingernail clippings and hair samples are comparable. (e) The methamphetamine/amphetamine concentration decrease patterns for the fingernail clippings and the first 1.5-cm hair sections of samples collected at Weeks 0, 4, 8, and 12 are similar.

INTRODUCTION / BACKGROUND

- There have been a very substantial number of studies addressing the analysis of hair for the detection of abused drugs (e.g., *see* [1]), while much fewer reports have been devoted to the study of nail as the specimen for the same purpose.
- With respect to the use of nail as an analytical specimen, studies directed to the study of amphetamines [2–4] have not been as thorough as those addressing other commonly abused drugs, such as cocaine [5–8], opiates [6–9], cannabis [10], and methadone [11]. (*See* **Table 1** for summary of these studies.) Although limited in number, these studies have, however, demonstrated that nails can be used for detecting drug exposure.
- In this study, fingernail clippings were collected from 97 consenting females who have admitted the use of amphetamines and/or opiates and are currently under treatment. These specimens were quantitatively analyzed for the presence of methamphetamine and amphetamine.
- Fingernail clippings from 62 subjects were found positive for methamphetamine/ amphetamine. Paired fingernail-hair specimens were collected from 6 of these subjects for an 8-week period and analyzed to examine:

    - The duration of detectability and disposition characteristics of amphetamines in fingernails;
    - Whether data derived from the analysis of fingernail clippings and hair sections can be reflective of drug use patterns; and
    - Whether there is a relationship between the analytical data derived from the paired fingernail and hair specimens.

EXPERIMENTAL DESIGN AND RESULTS

Control/Blank and Specimen

- Control/Blank: Nail clippings collected from four laboratory personnel (on a monthly basis) are used for growth rate determination and as analytical controls/blanks.
- Test specimen: The following specimen sets were collected from 97 consenting female drug users who are currently under treatment:

    - Set A: Fingernail clippings from 97 subjects — 62 were found to be positive for methamphetamine and amphetamine
    - Set B: Series of fingernail clippings from 8 (?) subjects — Among the 62 subjects positive for amphetamines, fingernail clippings were continuously collected (bi-weekly for an 8-week period) from 8 (?) subjects with higher concentrations of amphetamines
    - Set C: Series of paired hair-fingernail clippings from 6 subjects — Among the 8 subjects with higher initial concentrations of amphetamines, paired hair specimens were collected from 6 subjects on weeks 0, 4, and 8.

Sample Preparation (Figure 1)

- Wash: Methanol
- Digestion: 2-N NaOH (80 °C)
- Extraction: Ethyl acetate
- Derivatization: Heptafluorobutyric anhydride (HFB)

Instrumentation, Standards/Reagents, and GC-MS Analysis (Figure 1)

- Instrumentation: HP-6890N Series II GC / HP-5973N MSD with HP 1MS (30-m, 0,25-mm ID, 0.25-μm film thickness)
- Internal standard: Amphetamine-d8, methamphetamine-d8 (all from Cerilliant: Austin, TX)
- GC-MS Analysis of amphetamine, methamphetamine and their deuterated analogs (all as HFB-derivatives)
    - Full-scan mass spectra (**Figure 2**)
    - Quantitation ions
        - Amphetamine/amphetamine-d8, (as HFB-derivatives): *m/z* 240/243
        - Methamphetamine/methamphetamine-d8, (as HFB-derivatives): *m/z* 254/261

RESULTS AND DISCUSSION

Nail Growth Rate — Based on Specimens Collected from 4 Laboratory Personnel

- Individual finger data are shown in **Table 2.**
- Mean values:
    - Mean 10-finger growth rate (length of "free edge") per month: 0.278±0.025, 0.222±0.041, 0.285±0.020, 0.295±0.018 cm
    - Mean 10-finger "nail plate" length: 1.140±0.126, 1.275±0.162, 1.060±0.135, 1.045±0.093 cm
    - "Nail plate" length/"free edge" length (1 month): 4.10, 5.74, 3.72, 3.54 (mean: 4.28±1.00; approximate range: 3.00 – 6.00), i.e., it takes 3–6 months for the matrix part of the nail to become "free edge".
- These fingernail growth rate data are used along with the rate of hair growth (0.25 cm/week) [12] for the correlation of data derived from the paired hair-fingernail specimens (*see* discussion in a later section).

Evaluation of Specimen Pre-Treatment Procedures

- Washing: The most desirable washing procedure would allow for complete removal of external contamination, while keeping those derived from internal disposition intact. The primary concern of the washing procedure adapted for this study is to ensure that imperfect

characteristics (incomplete removal of external contamination or partial removal of internal disposition) do not affect or distort analytical data to the extent that may cause the misinterpretation of these findings.

- Analyte recovery: The most desirable procedure would allow for 100% extraction of the analytes of interest from the specimen matrix, without causing any decomposition. Again, recovery data are evaluated to ensure that imperfect characteristics do not affect or distort analytical data to the extent that may cause the misinterpretation of these findings.
- Findings of the adapted procedures

    - Data derived from hair sectional analysis (*see* discussion in a later section) indicate that the adapted washing procedure did not distort drug disposition patterns in hair.
    - Without standard nail samples of know concentrations, it is not known whether the adapted digestion/extraction procedure can recover the analytes completely; however, recovery data derived from blank nail samples, that are spiked with known amounts of the analytes, indicate 90.4±2.7% and 92.5±0.8% recoveries of amphetamine and methamphetamine, respectively.

Evaluation of Assay Parameters — Linearity, Precision, Accuracy, and Limits of Detection and Quantitation

- Assay *linearity, precision*, and *accuracy* have been thoroughly studied using the same approach as reported earlier for urine samples [13] and briefly described as follows:

    - Four replicates of standards were prepared at five analyte concentration levels (2.0, 5.0, 10.0, 20.0, and 40.0 ng/mg) by spiking appropriate amounts of analyte stock solutions into test tubes containing 25 mg drug-free fingernail.
    - Four sets of these standards were analyzed three time each day for three days.
    - One set was used as the calibration standards to derive the analytes' concentrations in the remaining three sets.

    - Exemplar calibration data are plotted in **Figure 3**.
    - Precision and accuracy data are shown in **Tables 3** and **4**.

- Standards for the evaluation of assay's *limits of detection* and *quantitation* were prepared similarly with the following specifics:

    - Concentrations of four sets of standards were: 4.0, 2.0, 1.0, 0.5, 0.4, 0.25, 0.2, 0.1, 0.05, 0.02 ng/mg.
    - One set was used as the calibrators to derive the analytes' concentrations in the other three sets.
    - Resulting data shown in **Table 5** indicate the limits of quantitation and detection for amphetamine and methamphetamine are better than 0.2 ng/mg.

Analytical Findings

- Methamphetamine and amphetamine profiles derived from sectional analysis of hair
  - Analytical data derived from *sectional analysis* of hair samples collected in *Week 0* are shown in **Table 6**:
    - Analyte concentrations for subjects A-008, A-013, A-027, and A-041 peak at approximately 5–7 cm from the root (*See* an exemplar profile shown in the upper portion of **Figure 4**).
    - Analyte concentrations for subjects A-024 and A-030 peak at approximately 2 and 1 cm from the root, respectively (*See* an exemplar profile shown in the lower portion of Figure 4).
  - Analytical data derived from the *first sectional* of hair samples collected in *Weeks 0, 4, 8, and 12* are shown in **Table 7**. Two examples (Subjects A-030 and A-041) are shown in the left side of the upper portion of **Figure 5**.
- Concentrations of methamphetamine and amphetamine in fingernail:
  - Analytical data derived from the initial clippings (Week 0) of the 62 subjects are shown in **Table 8**:
    - Methamphetamine concentration (ng/mg): Range: 0.46–61.50; mean: 9.96; standard deviation: 13.33.
    - Amphetamine concentration (ng/mg): Range: <0.20–5.42; mean: 0.93; standard deviation: 1.01.
  - Analytical data derived from the fingernail clippings collected in Weeks 0, 4, 8, and 12 are shown in **Table 7**:
    - Methamphetamine was detectable in the fingernail clippings collected in Week 8 in subjects A-008, A-013, A-041 and A-073
    - For the other four subjects, methamphetamine was not detectable in the fingernail clippings collected in Week 8.
    - Two examples (Subjects A-030 and A-041) are shown in Figure 5.
- Comparison of analyte concentrations in fingernail clippings and hair samples
  - Amphetamine/methamphetamine concentrations in fingernail appear to be lower than the first section of the hair sample collected at the same time.
  - Amphetamine/methamphetamine concentration ratios in nail and hair are compatible (*see* data shown in Tables 7 and 8).
  - Comparison of methamphetamine/amphetamine concentrations in the *initial* and *later fingernail clippings* and the first sections of hair samples collected at the same time as the nail clippings (Table 7 and Figure 5)

- The left-hand portions of Figure 5 show similar decrease pattern.
- Considering that hairs are cut into 1.5-cm sections with each section equivalent to approximately a 3–7 week of growth period, the analyte concentration decrease patterns observed for later fingernail and hair collections (shown in Figure 5) are very similar.

Summary and Conclusion

- With a significant number of fingernail samples analyzed and the comparison of the resulting data with the data derived from corresponding hair samples, this study has further confirm that fingernails can be used for testing methamphetamine exposure.
- Methamphetamine/amphetamine concentrations in hair appear to be higher than that found in fingernail.
- If blood capillary in nail matrix is the sole source of drug disposition in nail, drugs would be expected to distribute (longitude) in the nail plate similar to the way drugs are distributed in the whole length of the hair. Comparisons of the analytical data from the fingernail clippings collected in Weeks 0, 4, 8, and 12 with the first section of hair samples collected at the same time along with the sectional analysis of hair samples collected at Week 0 do not confirm this expectation. This may suggest that drugs are transferred to nail plate through nail bed.

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Figure Legends

Figure 1. Scheme for sample preparation.

Figure 2. Full-scan mass spectra of the analytes and their deuterated internal standards (all as HFB-derivatives).

Figure 3. Exemplar calibration data.

Figure 4. Exemplar sectional analysis profile of hair collected in Week 0.

Figure 5. Exemplar nail and the first section of hair samples collected in Weeks 0, 4, 8, and 12.

Table 1. Literature information related to the use of nails as the specimen for the detection of abused drugs

Drug analyzed	Sampling characteristics and Analytical approach	Major finding	Ref.
AM, MA		Mean MA: 4.75 ng/mg	1984 [2]
MA, AM, *p*-OH-MA	Antemortem (n = 20);	MA in nail/hair: 0.4–642/0.6–15.8 ng/mg; AM in nail/hair: 0.3–23.2/0.5–0.9 ng/mg	1989 [3]
AM, MDA, MDMA	Fingernail scrapping (n = 1); ^{2}H-IS GC-MS	Slightly higher concn in nail than hair (AM: 12.0 vs. 10.2 ng/mg)	1995 [4]
Cocaine	Postmortem fingernail & toenail clipping (n = 17 & 15, respectively); ^{2}H-IS GC-MS	Generate higher positive rate than blood and urine; Mainly cocaine/BZ (in 2–10/1 ratio)	1998 [5]
Cocaine, opiate	Antemortem fingernail scrapping (n = 8); ^{2}H-IS GC-MS	Higher concn in hair than nail; Significant dose-response relationship for hair, but not for nail; Washing procedure removes more drugs from nail (scrapping) than hair	2000 [6]
Cocaine, opiate	Postmortem toenail clipping (n = 46); ^{2}H-IS GC-MS	Cocaine (n = 20)/BZ (n = 21): 0.20–140/0.30–315 ng/mg; Mean morphine and 6-MAM (n = 3) are 0.37 and 0.89 ng/mg	1998 [7]
Cocaine, opiate	Postmortem finger & toenail clipping; GC-MS	Higher concn in finger than toenail; Cocaine (n = 15)/BZ (n = 21)/EME (n = 14)/norcocaine (n = 12)/coca-ethylene (n = 2): 1.2–414/1.4–170/0.19–27.0/0.11–32.7/0.08–2.93	2002 [8]
Opiate	Antemortem fingernail clipping user (n = 26) RIA; HPLC	Mean & range of morphine: 0.167, 0.06–4.69 ng/mg	2000 [9]
Cannabis	Antemortem fingernail clipping; RIA, ^{2}H-IS GC-MS	Mean & range of THC (n = 14) & THC-COOH (n = 3): 1.44, <0.1–6.97; 0.1–29.7 ng/mg	1999 [10]
Methadone	Antemortem fingernail clipping (n = 30); EIA, ^{2}H-IS GC-MS	Mean & range of methadone (n = 30): 0.05–363 ng/mg	2000 [11]

Table 2. One month nail growth rate of four laboratory staff

Subject	L5	L4	L3	L2	L1	R1	R2	R3	R4	R5	Mean±S.D.	Nail bed/ Free edge
1 Free edge	0.25	0.30	0.30	0.30	0.25	0.25	0.30	0.28	0.30	0.25	0.28±0.03	
Nail bed	0.9	1.1	1.2	1.2	1.3	1.3	1.1	1.2	1.1	1.0	1.14±0.13	4.10
2 Free edge	0.20	0.20	0.20	0.30	0.21	0.21	0.20	0.20	0.30	0.20	0.22±0.04	
Nail bed	1.0	1.2	1.3	1.4	1.5	1.5	1.25	1.3	1.2	1.1	1.28±0.16	5.74
3 Free edge	0.28	0.30	0.25	0.30	0.29	0.30	0.30	0.25	0.30	0.28	0.29±0.02	
Nail bed	0.8	0.9	1.1	1.1	1.2	1.2	1.1	1.15	1.0	1.0	1.06±0.14	3.72
4 Free edge	0.25	0.30	0.30	0.30	0.30	0.28	0.30	0.32	0.30	0.30	0.30±0.02	
Nail bed	0.95	1.0	1.0	1.0	1.1	1.25	1.1	1.1	1.0	0.95	1.05±0.09	3.54

Table 3. Recovery and intra- and inter-day precision — Amphetamine

Concn (ng/mg)	Replicate	Recovery [a]	Precision [a]	
			Intra-day	Inter-day
2.0	3	91.08; 2.08; 2.28	2.08; 0.14; 6.73	2.10; 0.03; 1.43
5.0	3	86.61; 7.05; 8.14	4.94; 0.12; 2.43	4.91; 0.04; 0.81
10.0	3	93.96; 18.4; 19.6	10.16; 0.12; 1.18	9.96; 0.17; 1.71
20.0	3	89.25; 12.0; 13.4	21.05; 0.16; 0.76	20.29; 0.68; 3.35
40.0	3	91.29; 5.04; 5.52	39.50; 0.44; 1.11	40.21; 0.74; 1.84

[a] Mean; standard deviation; relative standard deviation (in %).

Table 4. Recovery and intra- and inter-day precision — Methamphetamine

Concn (ng/mg)	Replicate	Recovery [a]	Precision [a]	
			Intra-day	Inter-day
2.0	3	93.70; 9.29; 9.91	2.04; 0.13; 6.37	2.07; 0.11; 5.31
5.0	3	92.45; 5.04; 5.45	4.92; 0.11; 2.24	4.92; 0.03; 0.61
10.0	3	92.33; 5.12; 5.55	10.30; 0.11; 1.07	10.30; 0.28; 2.72
20.0	3	92.77; 9.51; 10.3	21.33; 0.26; 1.22	20.73; 0.81; 3.91
40.0	3	91.39; 5.23; 5.72	39.35; 0.35; 1.40	40.62; 1.60; 3.94

[a] Mean; standard deviation; relative standard deviation (in %).

Table 5. Evaluation of the limits of detection and quantitation on the analysis of amphetamine and methamphetamine in nail matrix

Standard		Amphetamine		Methamphetamine	
Concn (ng/mg)	*n*	Mean±S.D.	% Deviation	Mean±S.D.	% Deviation
0.02	3	ND	—	ND	—
0.05	3	ND	—	ND	—
0.10	3	0.105±0.007	+5.00	ND	—
0.20	3	0.195±0.050	-2.50	0.190±0.028	-5.00
0.40	3	0.415±0.134	+3.75	0.405±0.021	+1.25
0.50	3	0.500±0.028	+0.00	0.510±0.057	+2.00
1.00	3	0.960±0.169	-4.00	0.985±0.134	-1.50
2.00	3	1.990±0.125	-0.50	2.010±0.240	+0.05
4.00	3	3.720±0.141	-7.00	3.865±0.134	- 3.38

[a] ND: Not detectable.

Table 6. Amphetamine and methamphetamine concentrations in the first 10 1.5-cm sections of hair samples collected in Week 0

		H_{S-1}	H_{S-2}	H_{S-3}	H_{S-4}	H_{S-5}	H_{S-6}	H_{S-7}	H_{S-8}	H_{S-9}	H_{S-10}
A-008	Amphetamine	4.32	9.29	10.38	12.67	12.83	8.73	6.23	4.99	5.88	4.65
	Methamphetamine	16.78	41.81	45.76	57.78	58.78	40.75	27.99	21.95	26.73	21.10
	Am/Metham (in %)	25.7	22.2	22.68	21.93	21.83	21.4	22.3	22.8	22.0	22.0
A-013	Amphetamine	2.27	2.25	2.46	3.16	3.59	2.57	2.41	2.55	2.55	2.32
	Methamphetamine	18.95	21.18	24.36	32.17	38.29	24.57	22.01	24.10	23.20	18.38
	Am/Metham (in %)	12.0	10.6	10.1	9.82	9.38	10.5	11.0	10.6	11.0	12.6
A-024	Amphetamine	24.37	26.36	21.12	16.10	10.42	5.77	4.78	3.36	2.67	2.33
	Methamphetamine	134.09	152.92	129.01	110.75	80.55	47.88	38.95	23.57	17.86	15.19
	Am/Metham (in %)	18.17	17.24	16.37	14.54	12.94	12.1	9.98	14.3	15.0	15.3
A-027	Amphetamine	1.76	3.22	4.53	6.26	5.89	3.79	3.13	2.24	2.06	2.02
	Methamphetamine	7.03	14.95	23.46	30.61	30.23	16.77	13.12	8.11	7.27	6.80
	Am/Metham (in %)	25.0	21.5	19.3	20.5	19.5	22.6	23.9	27.6	28.3	29.7
A-030	Amphetamine	11.59	7.13	4.83	2.29	1.73	1.67	1.52	1.51	1.34	1.34
	Methamphetamine	71.81	48.16	31.00	13.03	9.24	6.32	5.32	5.15	3.83	3.62
	Am/Metham (in %)	16.14	14.8	15.6	17.6	18.7	26.4	28.6	29.3	35.0	37.0
A-041	Amphetamine	3.84	6.06	7.98	9.15	6.44	5.18	5.58	3.49	2.76	2.38
	Methamphetamine	20.95	34.62	48.45	59.66	45.25	39.73	32.52	27.39	22.28	19.54
	Am/Metham (in %)	18.3	17.5	16.5	15.3	14.2	13.0	17.2	12.7	12.4	12.2

Table 7. Amphetamine and methamphetamine concentrations in fingernail clippings and hair (first 1.5-cm section) collected in Weeks 0, 4, 8, and 12

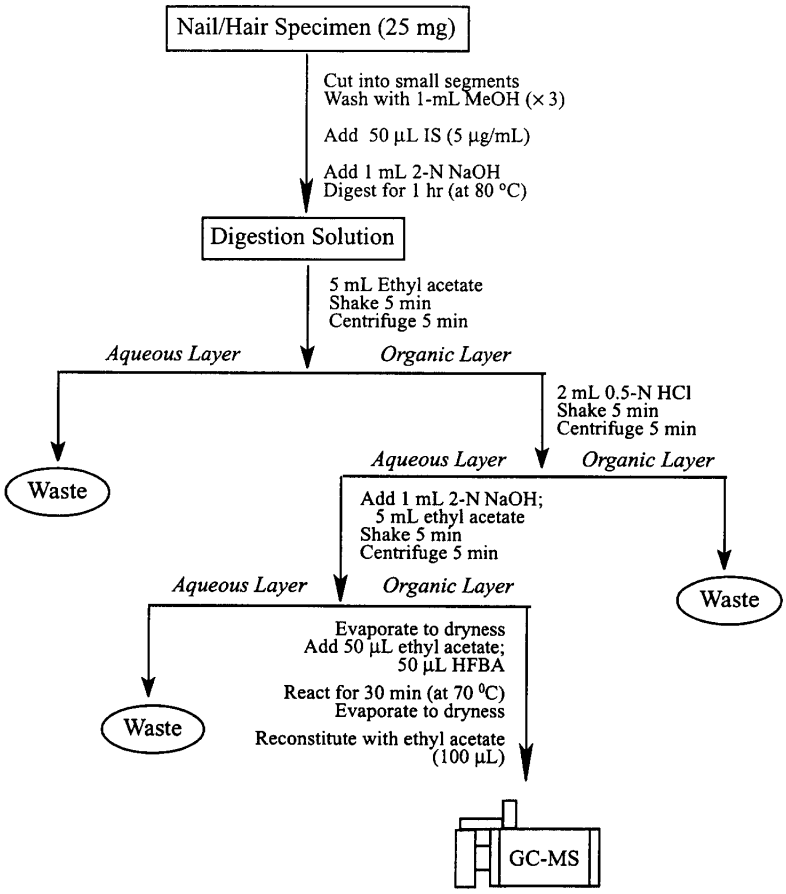
Subject		Week 0		Week 4		Week 8		Week 12	
		Nail	$Hair_{S-1}$	Nail	$Hair_{S-1}$	Nail	$Hair_{S-1}$	Nail	$Hair_{S-1}$
A-008	Amphetamine	2.73	4.32	1.10	0.82	1.12	0.61	ND[a]	ND
	Methamphetamine	13.96	16.78	3.63	2.07	2.01	1.05	ND	0.67
	Am/Metham (in %)	19.6	25.7	30.3	39.61	55.7	58.1	NA[a]	NA
A-013	Amphetamine	1.70	2.27	0.30	0.62	ND	ND	ND	ND
	Methamphetamine	12.43	18.95	2.00	2.03	2.11	ND	ND	ND
	Am/Metham (in %)	13.7	12.0	15.0	30.54	NA	NA	NA	NA
A-024	Amphetamine	5.42	24.37	0.30	0.92	ND	ND	ND	ND
	Methamphetamine	58.17	134.09	1.90	3.78	ND	0.63	ND	ND
	Am/Metham (in %)	9.32	18.17	15.8	24.34	NA	NA	NA	NA
A-027	Amphetamine	0.97	1.76	0.20	ND	ND	ND	ND	ND
	Methamphetamine	3.94	7.03	0.50	0.88	ND	0.62	ND	ND
	Am/Metham (in %)	24.6	25.0	40.0	NA	NA	NA	NA	NA
A-030	Amphetamine	3.38	11.59	0.40	1.42	ND	0.60	ND	ND
	Methamphetamine	43.63	71.81	3.00	5.93	ND	1.32	ND	0.94
	Am/Metham (in %)	7.8	16.14	13.3	24.0	NA	45.5	NA	NA
A-041	Amphetamine	1.42	3.84	1.14	0.89	ND	ND	ND	ND
	Methamphetamine	11.70	20.95	2.18	3.02	1.32	3.81	ND	ND
	Am/Metham (in %)	12.1	18.3	52.3	29.5	NA	NA	NA	NA
A-055	Amphetamine	0.91	—[a]	0.20	—	ND	—	ND	—
	Methamphetamine	21.58	—	0.30	—	ND	—	ND	—
	Am/Metham (in %)	4.22	—	66.7	—	NA	—	NA	—
A-073	Amphetamine	1.44	—	1.19	—	ND	—	ND	—
	Methamphetamine	15.38	—	3.25	—	2.30	—	ND	—
	Am/Metham (in %)	9.36	—	36.6	—	NA	—	NA	—

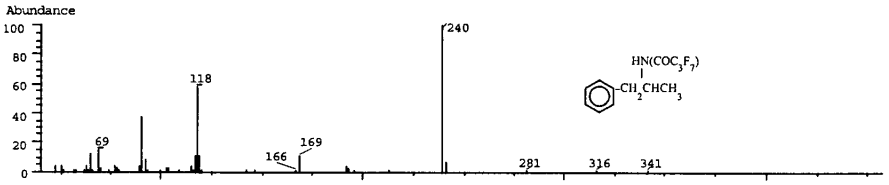
[a] ND: Not detected (limit of detection 0.2 ng/mg); NA: Not applicable; —: Not tested.

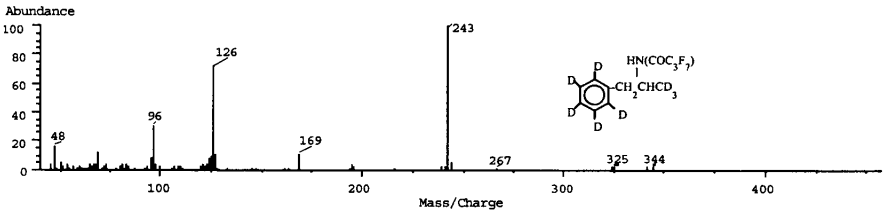
Table 8. Amphetamine (AM) and methamphetamine (MA) concentrations in the fingernails of 62 females under treatment

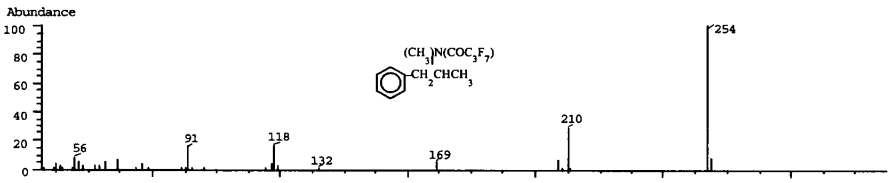
Subject	AM	MA	AM/MA (%)	Subject	AM	MA	AM/MA (%)
1	ND[a]	1.01	NA[a]	32	0.56	8.56	6.54
2	ND	4.17	NA	33	2.10	36.46	5.76
3	2.73	13.96	19.6	34	0.26	1.13	23.0
4	1.35	7.73	17.5	35	0.35	2.42	14.5
5	1.70	12.43	13.7	36	0.17	0.57	29.8
6	0.94	7.82	12.0	37	0.64	5.78	11.1
7	0.73	6.27	11.6	38	0.19	0.63	30.2
8	5.42	58.17	9.32	39	1.12	16.95	6.61
9	0.63	6.43	9.80	40	0.40	5.21	7.68
10	1.03	12.96	7.95	41	1.21	8.22	14.7
11	0.97	3.94	24.6	42	1.44	15.38	9.36
12	1.16	16.25	7.14	43	1.35	14.62	9.23
13	3.38	43.63	7.75	44	1.47	12.13	12.1
14	0.44	4.32	10.2	45	0.96	15.30	6.27
15	0.65	3.75	17.3	46	ND	1.46	NA
16	ND	1.69	NA	47	1.10	7.48	14.7
17	0.36	3.31	10.9	48	2.59	61.50	4.21
18	0.17	1.35	12.6	49	ND	2.06	NA
19	1.42	11.70	12.1	50	2.43	20.92	11.6
20	ND	0.46	NA	51	ND	2.67	NA
21	0.28	2.77	10.1	52	ND	1.69	NA
22	0.31	2.14	14.5	53	ND	1.23	NA
23	0.38	3.50	10.9	54	ND	1.44	NA
24	0.39	2.78	14.0	55	ND	1.28	NA
25	0.23	1.04	22.1	56	ND	1.11	NA
26	0.31	1.22	25.4	57	2.28	23.28	9.79
27	1.04	4.72	22.0	58	1.23	5.75	21.4
28	0.34	6.11	5.56	59	1.67	10.62	15.7
29	0.21	1.65	12.7	60	1.02	1.68	60.7
30	0.91	21.58	4.22	61	2.90	46.70	6.21
31	0.39	4.66	8.37	62	1.24	9.79	12.7
Range					ND–5.42	0.46–61.50	
Mean± S.D.					0.93±1.01	9.96±13.33	

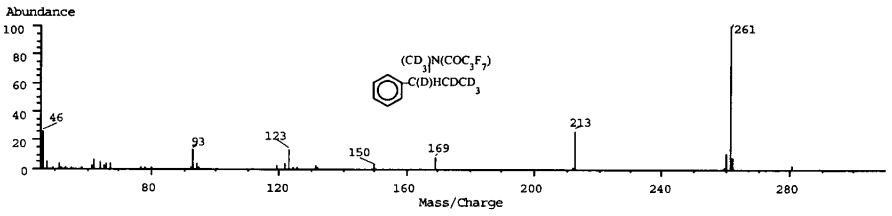
[a] ND: Not detected (limit of detection 0.2 ng/mg); NA: Not applicable.

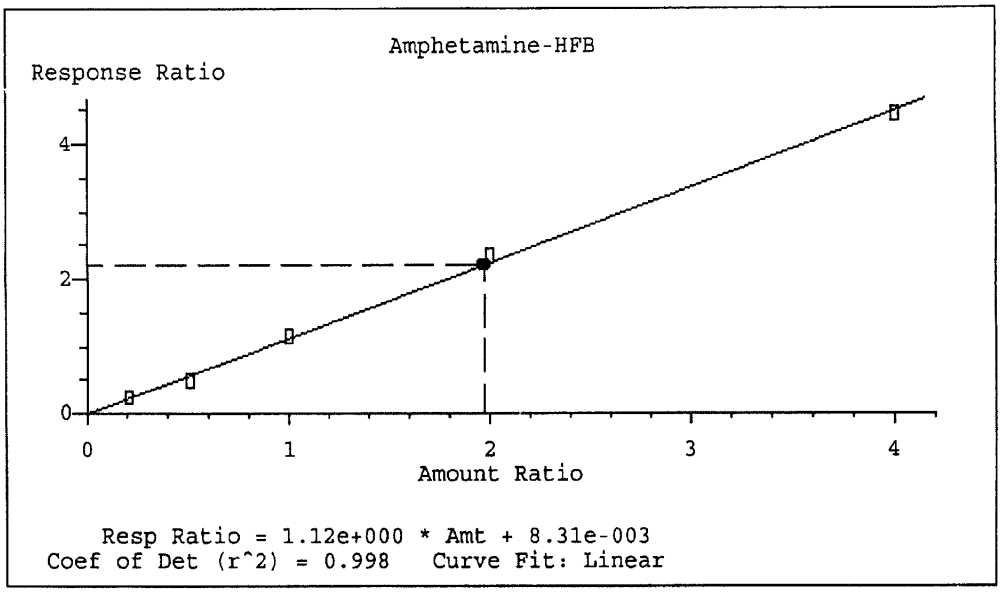

Nail/Hair Specimen (25 mg)
Cut into small segments
Wash with 1-mL MeOH (× 3)
Add 50 µL IS (5 µg/mL)
Add 1 mL 2-N NaOH
Digest for 1 hr (at 80 °C)
Digestion Solution
5 mL Ethyl acetate
Shake 5 min
Centrifuge 5 min
Aqueous Layer
Organic Layer
2 mL 0.5-N HCl
Shake 5 min
Centrifuge 5 min
Waste
Aqueous Layer
Organic Layer
Add 1 mL 2-N NaOH;
5 mL ethyl acetate
Shake 5 min
Centrifuge 5 min
Waste
Aqueous Layer
Organic Layer
Evaporate to dryness
Add 50 µL ethyl acetate;
50 µL HFBA
React for 30 min (at 70 °C)
Evaporate to dryness
Reconstitute with ethyl acetate
(100 µL)
Waste
GC-MS

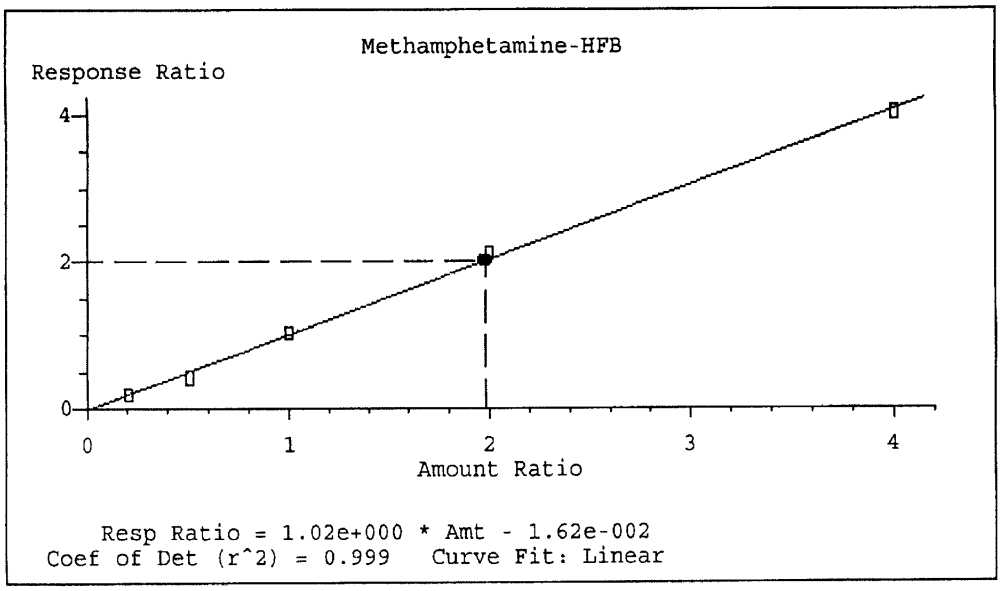

Abundance
100
80
60
40
20
0
240
118
69
169
166
281
316
341
HN(COC3F7)
CH2CHCH3

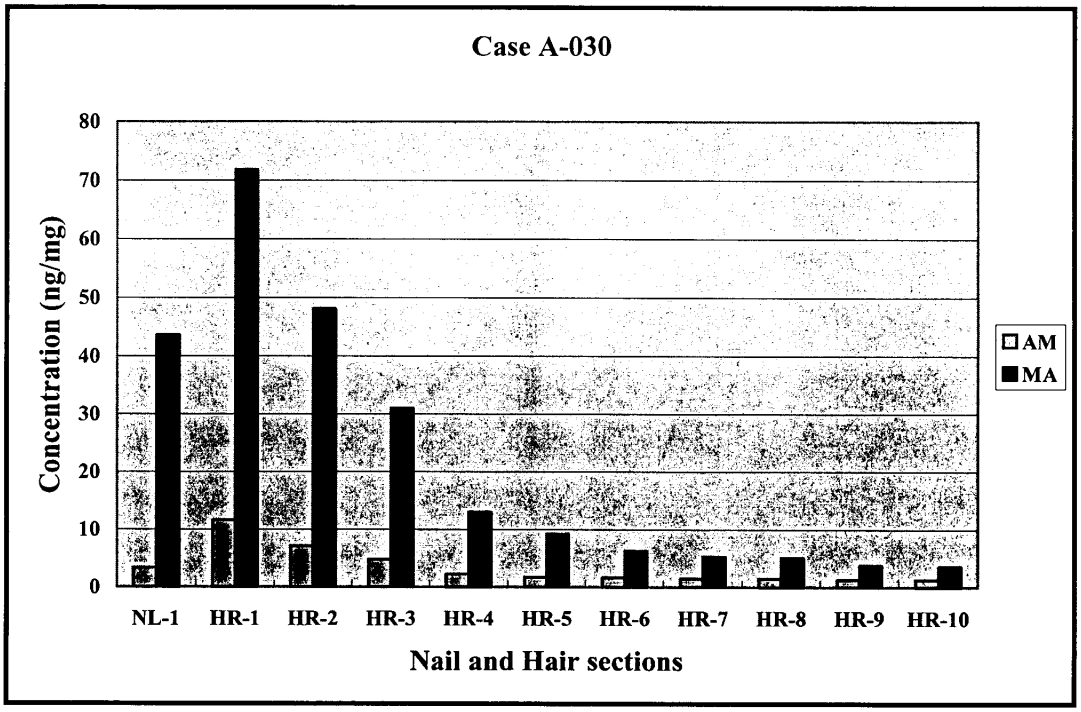

Abundance
100
80
60
40
20
0
243
126
96
48
169
267
325
344
D
HN(COC3F7)
CH2CHCD3
100
200
300
400
Mass/Charge

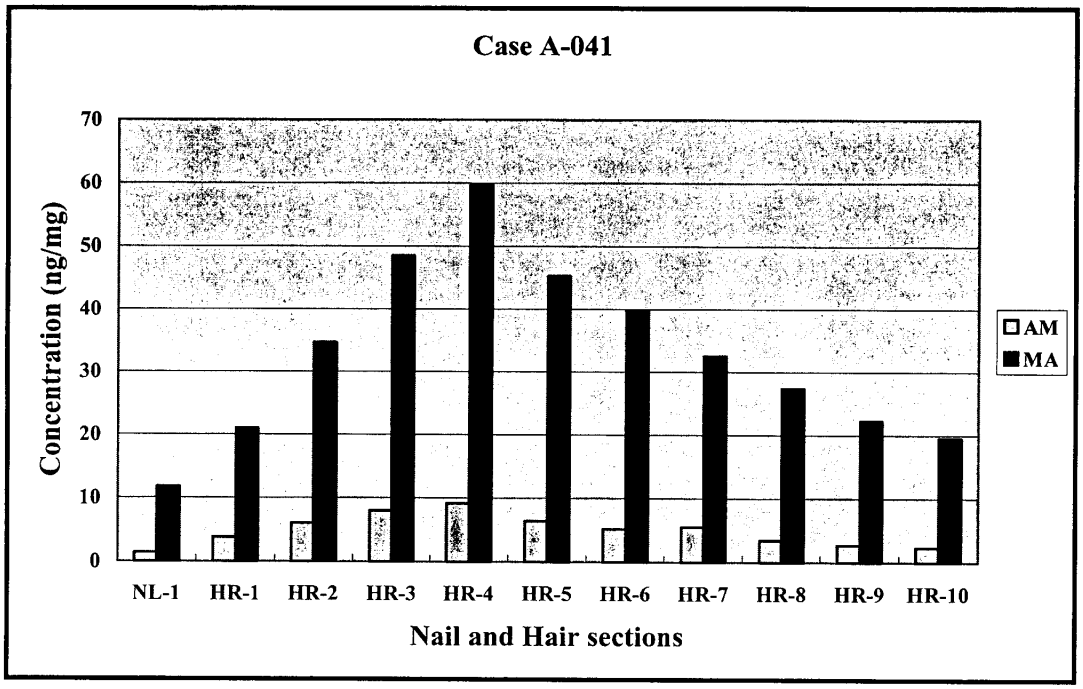

Abundance
100
80
60
40
20
0
254
(CH3)N(COC3F7)
CH2CHCH3
210
91
118
56
132
169

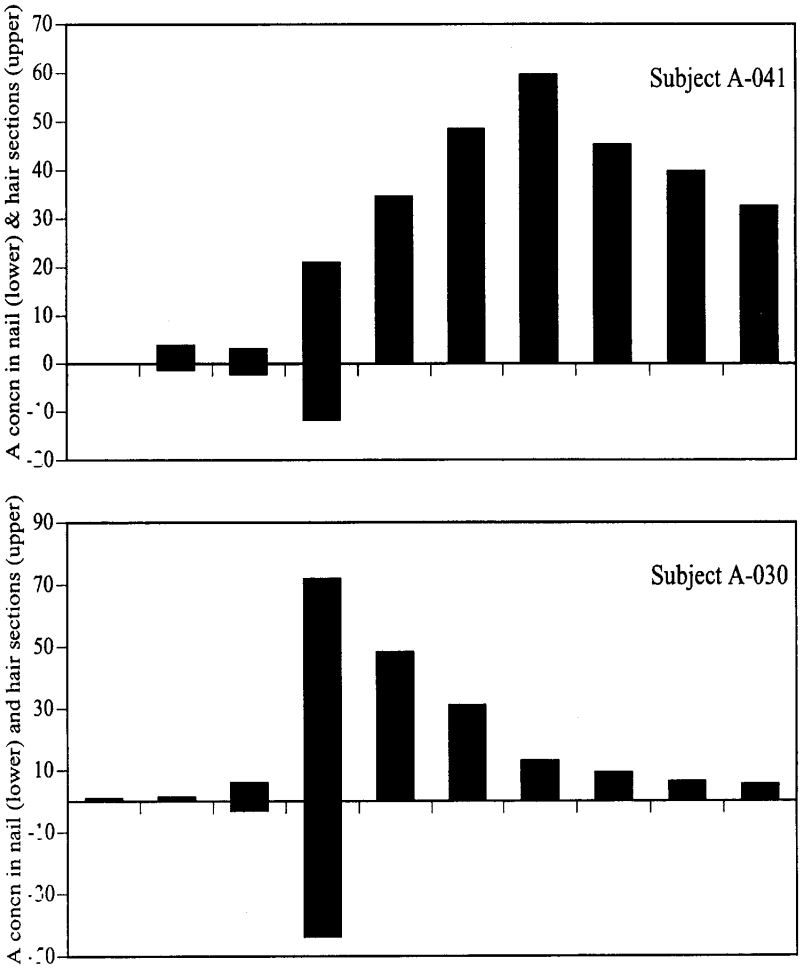

Abundance
100
80
60
40
20
0
261
(CD3)N(COC3F7)
C(D)HCDCD3
213
46
93
123
150
169
80
120
160
200
240
280
Mass/Charge


Amphetamine-HFB
Response Ratio
4
2
0
0
1
2
3
4
Amount Ratio
Resp Ratio = 1.12e+000 * Amt + 8.31e-003
Coef of Det (r^2) = 0.998 Curve Fit: Linear


Methamphetamine-HFB
Response Ratio
4
2
0
0
1
2
3
4
Amount Ratio
Resp Ratio = 1.02e+000 * Amt - 1.62e-002
Coef of Det (r^2) = 0.999 Curve Fit: Linear


Case A-030
Concentration (ng/mg)
80
70
60
50
40
30
20
10
0
NL-1
HR-1
HR-2
HR-3
HR-4
HR-5
HR-6
HR-7
HR-8
HR-9
HR-10
Nail and Hair sections
AM
MA


Case A-041
Concentration (ng/mg)
70
60
50
40
30
20
10
0
NL-1
HR-1
HR-2
HR-3
HR-4
HR-5
HR-6
HR-7
HR-8
HR-9
HR-10
Nail and Hair sections
AM
MA


A concn in nail (lower) & hair sections (upper)
70
60
50
40
30
20
10
0
Subject A-041
A concn in nail (lower) and hair sections (upper)
90
70
50
30
10
Subject A-030