Value of paint transfer and damage examinations in the forensic investigation of boat collisions

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Key information sought in a boat collision investigation includes: path and direction of boats, speed, impact angle, impact site, and evasive actions. Boat collision and road traffic collision investigations are similar in application of dynamics, Newton's Laws and kinetic energy, and in examining damages, contact evidence, and navigation lights. Unlike road accidents, boat collisions do not leave skidmarks and scars on roads. Road vehicles usually follow clearly marked lanes and directions and come to rest on the ground after collision, unlike boats in open seas. The positions and orientations of boats when investigated can differ markedly from those immediately after engagement. Finding collision debris is more difficult in boat collisions — debris could sink to a murky seabed or disperse and float away from the impact site. Like road vehicles, boats may suffer full impact or partial impact collisions. A displacement hull may cause a slamming (full impact) or a sideswipe, depending whether impact occurred at or away from the impacted boat's point of rotation. A high-speed boat with a planing hull may ramp up onto a low-profile boat, pushing it down into water. The nature and extent of damages depend on relative sizes, boat design, construction, strength of the structural framework, hard parts, and shell plating materials. 3-D movements such as rotation (yaw), pitching, and rolling are easier and more pronounced on water. Flooding due to the entry of water can critically affect buoyancy, centre of gravity and stability, and may capsize and sink the swamped boat. The analysis of damages on the gunwale, bow, deck, and hull, complemented by identification of paint transfers (chips, smears and rub-off), can reveal contacting surfaces and the directionality of the colliding vessels. Contact damage and induced damage include: holes, dents, imprints, bending, collapse, protrusions, fractures, abrasion, scrapes (scoring), and scuffmarks. Damages in the boat and injuries to occupants may indicate occupant kinematics. If undisturbed, the positions of the throttle, levers, gauges and switches, propellers and rudder provide a critical snapshot at collision. GPS equipment and voyage data recorders provide critical information, but unfortunately are usually found only on larger and more sophisticated vessels or military and law enforcement boats. Toxicological analysis indicates whether the boat operator was under influence of medication, alcohol or drugs. Eyewitness accounts must be carefully evaluated against physical evidence. Case studies will be used to illustrate the value of damage and paint evidence in boat collision investigations.

doi:10.1016/j.scijus.2009.11.052

Evidential value of a cigarette butt and some blue denim fibres under the fingernails of the victim of a homicide

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A case report will be presented demonstrating the evidential value of common denim fibres which usually have very low evidential value. However, in this particular case the fibres played an important role. The victim, Martti K. was a 78-year-old healthy but mentally retarded man living alone isolated in his hut. Some teenage boys used to visit him and they tried to irritate him, but Martti was friendly and harmless and it was not easy to argue with him. Martti never left his home and never let anybody enter his hut. Once or twice a week, a postman used to bring food and cigarettes to Martti. One day, the postman couldn't find Martti in the courtyard and found Martti lying dead on the floor. Lot of work over two years was done by the police and the forensic laboratory to solve the case. After two years a man was arrested in a means-of-payment offence. His DNA sample was added to the DNA register. There was a hit and this man could be connected to the crime scene. What about the other two persons who had been together with this man during this period of time?

doi:10.1016/j.scijus.2009.11.053

The Ipswich serial killings

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In December 2006, the naked bodies of five young women were discovered in various locations on the outskirts of the town of Ipswich in England. Two of these women were recovered from a river after immersion for a number of weeks, whilst the remaining three had been deposited in woodland and exposed to a combination of heavy rainfall and wind. Despite the adverse conditions to which the bodies of these women had been exposed, DNA evidence was recovered from the three women deposited on land and combinations of fibre collectives common to all of the victims were identified in debris recovered from their bodies. Sources for these fibre collectives were identified within the home environment of a suspect, Steve Wright, who had been identified through the DNA evidence. The trial in February 2008 attracted media attention from all over the world and the scientific evidence in this case was to prove absolutely crucial in the subsequent conviction of Wright on all five counts of murder. This presentation outlines the case management and crucial interpretational issues involved in this case.

doi:10.1016/j.scijus.2009.11.054

Analytical Science

Development of an IRMS technology for tracing gamma-hydroxybutyric acid (GHB)

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γ-Hydroxybutyric acid (GHB) is a drug of abuse controlled under the legislation addressing psychotropic substances. According to recent studies, recreative use of this drug and to a lesser extent GHB-facilitated sexual assaults (‘date rape’) are an emerging trend. Hence the seriousness of the situation; its chemical precursors, γ-butyrolactone (GBL) and 1,4-butanediol (1,4-BD), suffer from a lack of interest by law authorities. Indeed, there are no legal restrictions or sanctions regarding the use and trade of GBL and 1,4-BD, despite being almost readily available to purchase as commercial cleaning solvent. Furthermore, GHB can be easily synthesised from these precursors and direct oral consumption of these substances results in a rapid conversion to GHB in the body. In intoxication cases, more particularly in date rape cases, the judicial and law enforcement entities first ask to investigate the presence of GHB or analogues in a suspected drink or biological sample (urine). Then the potential link between this evidence and a source (drug stock solution seized at the suspect's place) has to be assessed. Although GHB or analogues may be detected in a beverage by conventional analytical methods, the origin of the drug is difficult to ascertain. In the present project, we developed a procedure to trace the origin of GHB and its chemical precursors GBL and 1,4-BD by Isotope Ratio Mass Spectrometry (IRMS). For that purpose, a database of the carbon isotope ratio of GHB and analogues was created in order to develop statistical models for predicting the membership of a specimen to a relevant source. Furthermore, the conservation of the carbon isotope ratio between a precursor and its GHB end-product will be evaluated as well. This aspect is of major importance and could be extended to precursors profiling on an international level to develop refined geographical strategies to control them. GHB, GBL, and 1,4-BD samples were obtained from different police departments in Switzerland, from internet retailers of various countries and several regular chemicals suppliers. Significant differences in the carbon isotopic ratio (δ^{13}C-values ranging from −23.1‰ to −46‰) were found between all GBL samples. Accordingly, this method demonstrates a high potential to distinguish between GBL, GHB, or 1,4-BD samples of various sources.

doi:10.1016/j.scijus.2009.11.055

Optimisation of the separation of amphetamine-type stimulants using artificial neural networks for applications on lab-on-a-chip technology

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There is a technology gap for ‘in-field’ detection methods that are capable of separating complex mixtures of precursor chemicals and active ingredients of amphetamine-type stimulants (ATS). The Agilent Bioanalyzer 2100 is a commercial lab-on-a-chip (LOC) device designed to separate and analyse DNA and RNA. Modification of the routine operational procedures and buffers facilitates the analysis of compounds that the instrument was not originally designed for. The limiting factor is the method of detection, which is restricted to laser-induced fluorescence. Fluorescein isothiocyanate (FITC)-derivatized ATS were chosen for method optimization on conventional capillary electrophoresis (CE). The initial parameters altered for optimization were pH, sodium dodecyl sulfate (SDS) concentration, and the amount and identity of organic modifier added to the buffer. Preliminary results indicated that SDS did not provide the sufficient resolving power to separate amphetamine compounds under the extremely fast analysis times encountered in chip-based separations. Consequently, focus was shifted to separation models using cyclodextrins, chiral selectors that have a high resolving power. Artificial neural networks were used to simplify the optimization process and to limit the number of experiments needed to reach a ‘global’ optimum. The model generated with the lowest training error was a multilayer perception network which was used to predict the electrophoretic mobilities of the target compounds over a predetermined pH and surfactant concentration range. The optimized method was then applied to controlled ATS, such as methamphetamine and MDMA, with collaboration from the Queensland Health, Forensic, and Scientific Services (QHFSS) for separation by LOC. This research demonstrated fast analysis of both amines and amino acids by microchip electrophoresis. The speed and sensitivity demonstrated that the device has potential for in-field detection of amphetamine and related compounds.

doi:10.1016/j.scijus.2009.11.056

Comparative analysis of ephedrine and pseudoephedrine by using stable isotope ratio mass spectrometry (IRMS)

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The isotope ratios of methamphetamine depend on both the precursor and the synthetic pathway. Ephedrine and pseudoephedrine are the commonly used precursors. The determination of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ isotope ratios was reported some years ago [1], but for $^{2}H/^{1}H$ and $^{18}O/^{16}O$ isotope ratios only a little data is available [2]. This article discusses the potential and limitations of using isotope ratio mass spectrometry for comparison purposes of ephedrine and pseudoephedrine. On the one hand, the variation of the isotope ratios of samples from one known source was determined for intra-batch and inter-batch samples. Additionally seized samples of unknown sources were compared to these values.

40 samples of pseudoephedrine from one source and 34 seized ephedrine samples were available. $^{13}C/^{12}C$, $^{15}N/^{14}N$, $^{2}H/^{1}H$, and $^{18}O/^{16}O$ isotope ratios were determined using elemental analyser (EA) and high temperature conversion elemental analyser (TC/EA) coupled to an isotope ratio mass spectrometer (IRMS). The isotope ratios are expressed in delta notation relative to primary international standards (e.g., V-PDB, Vienna Pee Dee Belemnite). Intra-batch samples of pseudoephedrine were undistinguishable concerning all four determined parameters, whilst significant differences between batches could be identified. The determination of stable isotopes enhances the possibilities of precursor characterisation, e.g., determining natural, semi-synthetic, or synthetic sources as well as sample comparison, including linking of seized samples and detection of possible trading ways. The results show that IRMS provides a high potential in differentiating precursors for the clandestine production of ATS and identifying their sources.

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doi:10.1016/j.scijus.2009.11.057

An investigation into the power of IRMS to discriminate batches of MDMA by synthetic route

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Drug profiling, or the ability to link batches of illicit drugs to a common source or synthetic route, has long been a goal of law-enforcement agencies. Recently, research has been focused on the applicability of isotope ratio mass spectrometry (IRMS) for this task. In the first study, 18 MDMA samples were synthesised in-house from the same batch of starting ketone by three commonly used reductive aminations (Al/Hg amalgam, $NaBH_4$, and Pt/H_2), and the resulting MDMA HCl was analysed by isotope ratio mass spectrometry (IRMS) for carbon, nitrogen, hydrogen, and oxygen isotope ratios. Accurate discrimination of the samples by synthetic route was demonstrated using δ^{2}H values on their own or in combination with δ^{13}C, δ^{15}N, and/or δ^{18}O. In the second study, a factorial design experiment was undertaken in which 32 MDMA HCl samples were synthesised by the most commonly used route (Pt/H_2) in order to investigate the effect on the isotope profile of altering five of the reaction conditions (quantity of methylamine, quantity of PMK, stirring time allowed for imine formation, amount of catalyst, and time allowed for hydrogenation).