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Ion mobility spectrometry evaluation of cocaine occupational exposure in forensic laboratories

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ABSTRACT

An approach, based on ion mobility spectrometry (IMS) has been developed for the control of cocaine in air of the breathing zone of operators, in laboratory surfaces and in nasal mucus of employees to evaluate cocaine exposure in a forensic laboratory. The analytical methodology has been validated in terms of accuracy, precision and limits of detection and results obtained were statistically comparable with those obtained by liquid chromatography. Cocaine concentration in laboratory air increases from 100 ± 35 ng m^{-3} of a normal day to 10,000 ng m^{-3} during the manipulation of cocaine seizures. The occupational exposure limit (OEL) for cocaine has not been established which difficult the evaluation of the health effects of continuous exposition to very small doses of cocaine. Cocaine was also found in almost all the analyzed sample surfaces and also was found in nasal mucus of the police officers that were present during the manipulation of cocaine seizures without using a face mask. In summary, cocaine concentrations could present a health hazard to the employees and therefore warrants remediation and some modifications of the manipulation operations have been proposed.

1. Introduction

Occupational safety and health can be defined as the area concerned with protecting the safety, health and welfare of people engaged in work or employment. The main goal of occupational exposure assessment programs is to eliminate contamination of the working environment in order to protect the health of workers or, at least, to keep contamination at as low a level as possible, below the exposure limit established by the competent authority or recommended by scientific bodies, by taking appropriate technical measures. The evaluation and control of the chemical exposure in the workplace are some of the major components of an effective occupational exposure assessment program.

It becomes especially relevant in the case of the pharmaceutical, agrochemical and chemical industries, where the protection of workers from the potential harmful effects of active pharmaceutical ingredients (APIs), pesticides and solvents and other chemical compounds is a significant challenge due to their potential toxicity. Unfortunate examples of the importance and necessity of adequate health and safety programs to prevent acute occupational-related illness regarding APIs [1], pesticide [2–4], textile paint components (Ardystil syndrome) [5], organic solvents [6] and heavy metals [7] exposure can be found in the literature.

In forensic laboratories, the personnel handle and, thus, are exposed to large quantities of ilicit drugs. Because of that, appropriate occupational exposure assessment programs are absolutely necessary to obtain information regarding passive exposure to illicit drugs and to propose measures to reduce the level of contamination as much as possible. However, there is only limited information on the effect of occupational exposure to illicit drugs and only a few number of reports have been published in the scientific literature [8–12]. In law enforcement settings, individuals in the immediate vicinity of seized evidence could inhale airborne cocaine dust or handling handle material contaminated with cocaine dust resulting in passive absorption [8]. Moreover, the potential for abuse drugs as cocaine [9,10] and methamphetamine [11] exposure in personnel producing dog training aids has been demonstrated. Recently, a report of the Department of Health and Human Services of the National Institute for Occupational Safety and Health (NIOSH) of the US stressed the problems associated with the passive exposure to illicit drugs of the employees during its manipulation and storage

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in forensic labs and vaults [12]. However, there is no previously published occupational exposure limit (OEL) for cocaine and, thus, it makes difficult the evaluation of the health effects of continuous exposition to very small doses of cocaine.

Procedures used to control workplace air safety frequently require the use of active or passive sampling followed by extraction and analysis by gas chromatography–mass spectrometry (GC–MS) [13] or liquid chromatography (LC) with MS detection [14] to achieve the selectivity and sensitivity required. In those methods, the time required for sample preparation and analysis typically means that results are available between one day and two weeks after sample collection. Thus, it implies that by the time a report is received, the worker may have already been exposed to excessive amounts of a hazardous compound, being completely useless the information provided.

Ion mobility spectrometry (IMS) is an analytical technique based on the gas-phase separation of ionized compounds under an electric field at ambient pressure [15]. The analytical potential of IMS, particularly as regards operational speed, atmospheric pressure operation, simplicity and sensitivity, offers viable alternatives in the determination of workplace air exposure with their own associated benefits which have not been fully exploited [16]. To our knowledge, there are only two precedents of the use of IMS as a tool for the occupational exposure prevention programs, both of them in the pharmaceutical industry [17,18].

This article reports the need to implement the occupational safety and health programs in forensic laboratories using IMS as a versatile, simple, fast and powerful tool to provide quasi real time data on drug exposure. We have used as an example a crime laboratory devoted to the analysis of seized illicit drugs in which those samples are received, sampled, analyzed and stored. The main objectives of the present study concern: (i) development of an integrated strategy for the occupational exposure assessment based on the IMS analysis of illicit drugs in air, surfaces and biological samples of employees and (ii) evaluation of the working environment conditions and suggestion of the measures of control whenever necessary.

The different testing parameters, including the concentration of illicit drugs in the personnel breathing zone [19], defined as the zone located within a ten inch radius of the worker's nose and mouth, surfaces [20] and nasal mucus of the operators [21] have demonstrated to be useful indicators to determine the potential risks of exposure of the employees and to evaluate the effectiveness of the procedural changes introduced in the laboratory and operators handling in reducing illicit drug exposure.

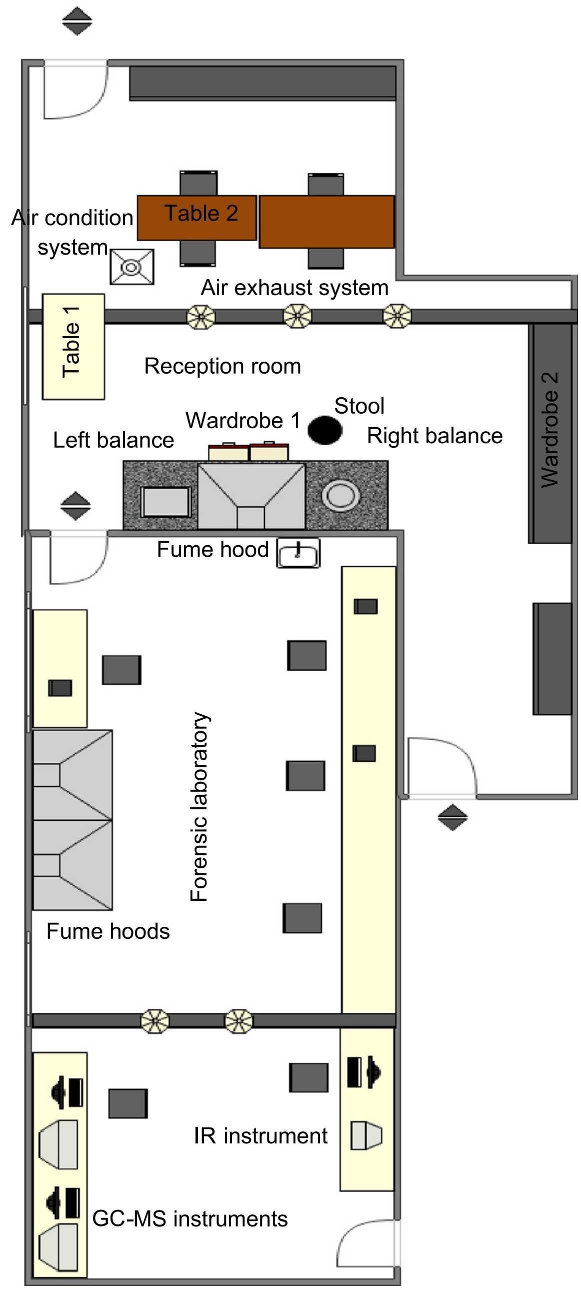

Fig. 1. Diagram of the forensic laboratory including seized simple reception room.

2. Materials and methods

2.1. Samples, reagents and standards

Illicit drug standard solutions, including cocaine hydrochloride dissolved in methanol at 1.0 mg mL^{-1} concentration level, were kindly provided by the “Ministerio de Hacienda y Administraciones Públicas” from the Spanish Government.

A calibration curve for cocaine hydrochloride, ranging from 0.02 to 100 mg L^{-1} and from 1 to 100 mg L^{-1}, was prepared by appropriate dilutions of the stock solution in isopropanol for IMS and LC analyses, respectively.

All the solvents used in this study were HPLC grade or higher. Methanol, isopropanol and acetonitrile were purchased from Scharlau Chemie S.A (Barcelona, Spain).

From September to December 2013, air, at personal breathing zone, laboratory surfaces and nasal mucus fluids were sampled in a public forensic laboratory. The laboratory diagram can be seen in Fig. 1. The laboratory itself is 42 m^2 and the reception room is 33 m^2. The reception room has two possible accesses through closed doors from either the adjacent office or a restricted corridor, while the laboratory can be accessed from the restricted corridor or the reception room. The forensic lab employees had workstations in the office area. An exhaust system placed in the reception area and also in the laboratory is continuously working, at a flow rate of approximately 10 times per hour, to remove contaminated air.

2.2. Air sampling

Air samples were collected inside the reception room, the laboratory and the two vaults by aspiration through polytetrafluoroethylene (PTFE) membranes of 4.62 cm diameter, 40 μm filter thickness and 2 μm pore size and a polypropylene (PP) supporting ring media obtained from Whatman Inc. (Florham Park, NJ, USA). The filters, specially manufactured for US EPA PM