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Review On Recent Analytical Techniques Used in Forensic Sciences

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ABSTRACT

The intention of this paper was to review and discuss the some of the quantitative analytical methods used in forensic science for the analysis of trace evidences collected from the various scene incidents. The forensic scientists were depend upon the instrumental analysis of trace amounts of materials like drugs, toxicological specimens, fibers, glass, GSR, soil, etc. Differences in manufacture of chemical composition are observed and that allows considerable discrimination even with very small traces of fragments. Most on GSR, GSR analysis sometimes becomes very important to right direction of inquiry, from where the GSR is obtained and from which surfaces the GSR has produced, played an important aspect of investigations. Reviews on these techniques, which are used more extensively in forensic sciences, were reported through this paper. Based on the analytical problem facing forensic scientists, our study will summarize and use these techniques to tackle them such as chromatography, Raman spectroscopy, Atomic Absorption Spectroscopy, Inductively Coupled Plasma (ICP) techniques.

Keywords: Forensics, Chromatography, Atomic Absorption Spectroscopy, Tandem mass spectroscopy.

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INTRODUCTION

Analysis of a crime scene involves expert participation in both the physical and biological sciences, as well as in many technology and law enforcement areas. Analysis of a crime scene requires specialist expertise both in the physical and biological sciences, as well as in other fields of technology and law enforcement. Forensic scientists studies of fingerprint patterns and traces of fiber, glass, bullet and other types, evaluate medicines and poisons, investigate suspected forgeries, examine residues for potential incendiary and explosive crimes [1].

Forensic pharmacy means application of the drug sciences to legal issues like criminal cases [2]. Body fluids such as blood, seminal fluid, urine or saliva are very important objects in investigation of crimes against someone or person such as murder and rape cases [3].

This review article reflects the theory and recent developments of modern technology for the study of toxicants in biological fluids and tissues. We discuss limitations and innovations in methodology that address these limitations. To fully understand instrument performance, one has to be familiar with general analytical assay characteristics. These include the signal to noise ratio (S/N), limit of detection (LOD), Limit of Quantification (LOQ), accuracy, precision, interference, and robustness. Because of the importance of these parameters for characterizing assays and these are essential components of method validation [4].

Many analytical instruments transform a certain analyte property into an electronic or photometric signal. Several variables, such as random electronic or erroneous photon transmissions, fluctuating concentrations of inherent substances in the detector and others contribute unwanted signals that can interfere with measured target response. These aberrant signals are known as noise. The best technologies improve analyte signal or reduce noise, or both, to increase S/N. High S/N results in lower LOD and LOQ. LOD and LOQ are often defined as S/N = 3 and S/N = 10, respectively. These limits are more generally calculated in forensic toxicology by measuring serial dilutions of an analyte in the matrix of interest and choosing the lowest concentration where measurements satisfy S/N and additional criteria [5].

In this paper, we have tried to explain the available analytical instrumental techniques available for analysis of trace evidence analysis [1].

Toxicological chemistry examination using different chromatographic methods:

In almost all toxicology experimental studies, an agent, usually a single chemical, is given to an organism in known amounts. It is widely agreed that the chemical under study must be pure, or that the existence of any contaminants must be known to interpret the experimental results with validity [6].

However, it is common practice to conduct the instrumental study without verifying the compounds purity. A scheme of separation for poisons from tissues by steam distillation and differential solvent extraction is shown in Figure I

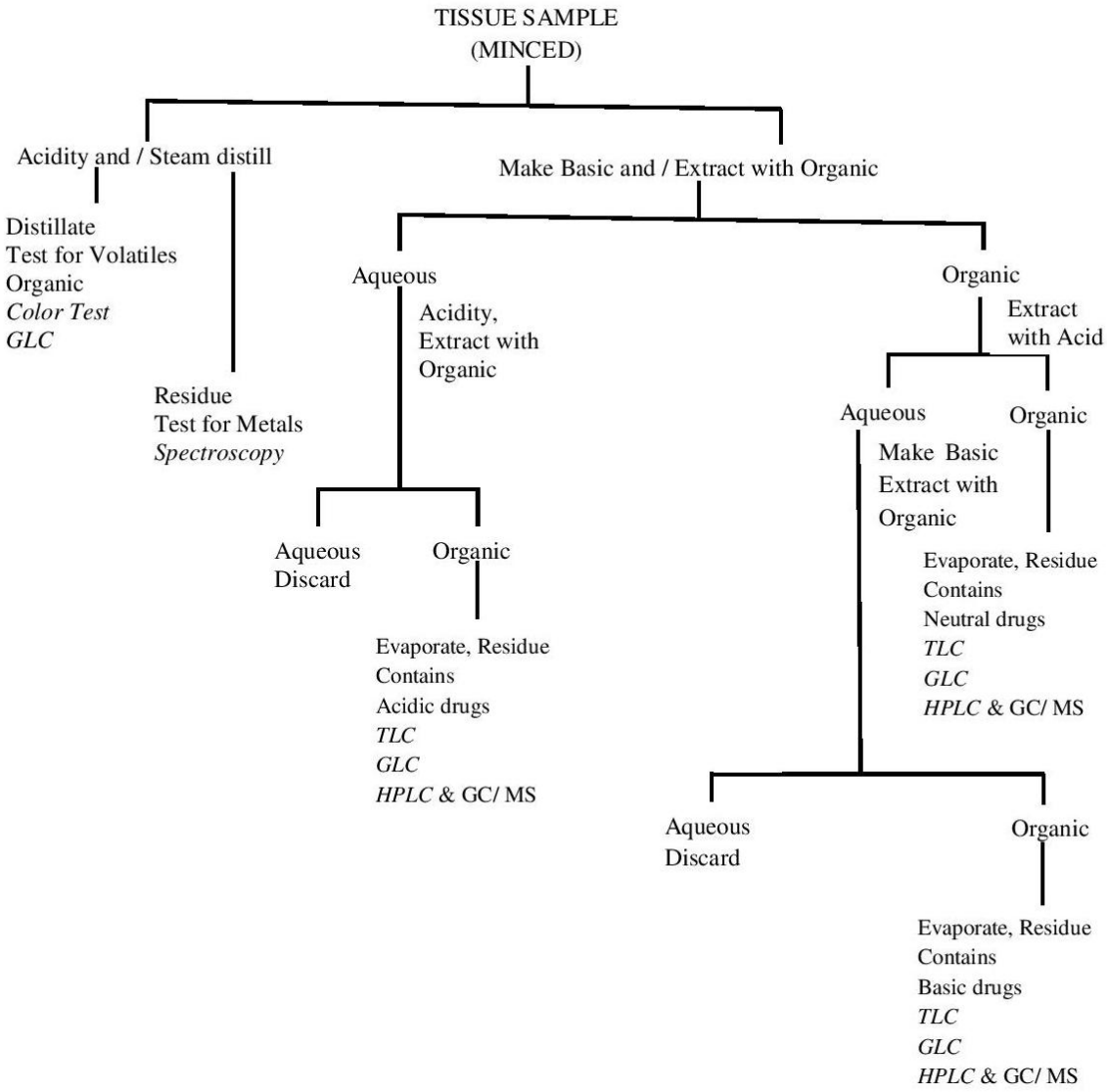

Figure I: Flow chart for Separation of Poisons from Tissues

The analytical techniques are initiated by forensic scientists have continued to enlarge in complexity and improve in reliability. Several new analytical tools have proven useful for toxicology problems in approximately all areas and the technology continue to explore open areas of research [1, 7]. The x-ray fluorescence (XRF)/ X-ray diffraction (XRD) techniques have been used in forensic science for several decades [1, 8]. Many other different analytical techniques, XRF does not affect samples so it is called as a non-destructive method.

This alone can be tremendously valuable as certain specimens involve confirmatory analysis by another group of scientists to authenticate integrity of the data. Forensic science involves the application of knowledge to law [9].

Forensic pharmacy is not an exotic field. Many issues relating to society are relevant to forensic pharmacy including the physical traces like glass fragments, fibers, soils, building material, loose powder materials etc. and also substance abuse control, impaired driving, crime, fraud, and employment testing for any type of drugs. Pharmacists may provide valuable testimony in drunk and driving cases, murder, suicide, malpractice, child abuse, personal injury and patents [2].

Possible applications of the XRF/XRD technique on different kind of forensic samples are described in Figure II.

Elemental Chemical Analysis using XRD/ XRF

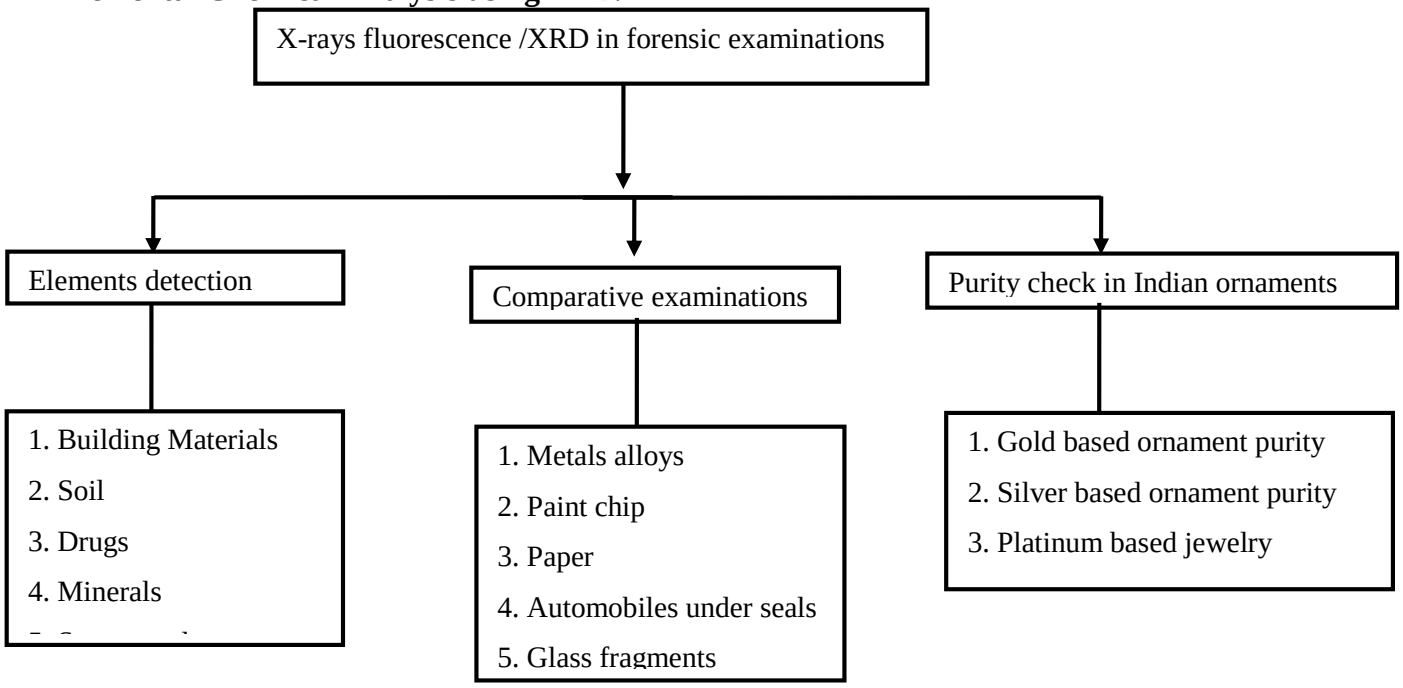

Figure II: Use of X – ray techniques in forensic sciences

Inductively coupled plasma (ICP) mass spectrometry technique

Mass spectrometry (MS) is an analytical technique that ionizes chemical compounds and detecting the ions on the basis of their mass-to-charge ratio. Inductively coupled plasma mass spectrometry (ICP-MS) is a type of mass spectrometry that can detect metals and several non-metals at concentrations as low as parts per billion on uninterfered low background isotopes [10].

Discrimination of sheet glass exposed to high temperatures when trace impurities were determined using ICP-MS was reported. Several reports on LIBS glass processing, and a comparison of LA-ICPMS, μXRF and LIBS tests for sample analysis [11]. The determination of iron in glass by laser

absorption and solution sampling comparing dynamic reaction cell-ICPMS and high resolution ICPMS was also reported [1].

Emphasis on GSR analysis

Few knowledgeable experts all over the world commence the mission of documentation of the type of bullets are taken into an account and identify the qualitative differences in chemical composition of GSR (personal communication R Keeley, London Metropolitan Laboratory, Forensic Science Service, 1997). Attempts an independent systematic approach to that investigation as methodological study of gunshot residues originating from selected type of bullets by means of SEM-EDX and uses the chemical methods for interpretation of the obtained results were obtainable by Niewoehner [12] and Broiek-Mucha et al. [13, 14]. In their major presentation was depend on quantitative analysis of out of hundred particles they are randomly taken from all of the preserved gunshot residues from different components of bullet (i.e. including the primer, case, projectile jacket etc.), whereas in the most recent two journals frequencies of incidence of primer particles of particular chemical classes are taken into an account and experimental study were performed. By knowing those both attempts results revealed the possibility of group identification of the bullets used based on GSR study.

More sensitive than SEM-EDX, analytical methods are being introduced, and all are being used to study the content of primary residues such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS)[15], provided more discriminative data. However the GSR analytical method only SEM-EDX is the more accurate, given that information on both their morphology and the key critical contents remains a reliable tool for GSR examinations [16].

Gas Chromatograph–Quadrupole Mass Spectrometer (GC–QMS) and GC– MS–MS

The GC–QMS is also called as GC–mass selective detector or GC–MS, commonly that requires the analytes are chemically extracted from blood, urine, or other matrices and, in most cases, derivatization technique is used to make them volatile and prior to introduction into the instrument [4]. The GC separates the compounds based on differences in solubility and volatility in the liquid, solid, and gaseous phases [5].

Molecules enter into the ion source sequentially, they are ionized. Electron ionization (EI) is the most common ionization technique. Molecules leaving the GC enter the QMS and are bombarded by a beam of electrons. Electrons are removed from the molecules, producing unstable positive ions (molecular ions) which break into more stable fragments.

Chemical ionization (CI) is a “soft ionization” technique utilizes a charged reagent gas (NH4 or CH4) to transfer charge to a compound. These charged species are more stable than the EI ions and

fragments are formed less extensively. Both positive and negatively charged molecules are formed. The QMS will select ions and measure their abundance from different mass-to-charge (m/z) ratios. Specific ions are isolated by creating a dynamic electromagnetic field inside the quadrupole [4]. The QMS can be configured to scan all the mass-to-charge ratios in its mass range and track specific mass-to-charge ratios.

In forensic toxicology laboratories, GC–MS–MS procedures are sufficiently more common following advances in vacuum engineering, ion sources, instrument size and operating software. GC–MS–MS procedures were improved for measuring low concentration of analytes (e.g., LSD) in blood or urine [17]. Current GC–MS–MS methods improve S / N in essential experiments with LODs of 0.1 ppb (5 pg on column) including examination of metabolites of the nerve agent and sulfur mustard in urine and metabolites in alternative matrices [18- 20].

Raman Spectroscopy Techniques

Raman spectroscopy is one technique used in forensic sciences. This method allows the measurement of inelastic light dispersion due to the molecular vibration modes when irradiated by a monochromatic source, such as a laser. The Raman technique has many benefits, such as its non-destructive nature, its rapid analytical time and the possibility of performing microscopic in situ analysis. This is a multi-purpose technique in its forensic application that covers a broad variety of samples, such as drugs of abuse, physical / trace evidence[21], fibers and inks. The analysis of textile fibers constitutes a clear example. In this field a number of studies have been carried out (e.g. Bouffard et al. [22]; Keen et al. [23]. The value of this technique in forensic analysis of fibers mainly focuses on the detection of dyes.

Atomic Absorption Spectroscopy

Hair analysis is done by Atomic Absorption Spectroscopy after sodium hydroxide and hydride generation technique. Many of the arsenic particles on the hair have also been measured in KEK-PF's BL-4A (Photon Factory at High Energy Accelerator Research Organization, a synchrotron radiation facility in Tsukuba) and found an arsenic particle on the hair. This method would allow the measurement of inelastic light dispersion due to molecular vibration modes when irradiated by a monochromatic source such as a laser. The size of the beam of synchrotron radiation along with the hair shaft was 4 or 1 mm in diameter. How many hair shafts were counted, and how many particles were found, is still not clear. It is said that arsenic particle was found on only one or two hair shaft out off hundreds of hair shafts [24,25].

LC tandem Mass Analysis

The tandem Mass spectrometer [26] is generally used an electrospray ionization source in a positive mode. The chromatograms are separated by using suitable columns. At room temperature, mobile phase Solvent A consisted of 5% acetonitrile with 0.1% formic acid and Solvent B consisted of 95% acetonitrile with 0.1% formic acid. The chromatography system is operated at gradient mode by changing the solvent ratios at different time intervals.

The urine samples are generally stored at 20^0C until analysis. Take 1mL urine sample and add 0.5mL 1.5M sodium bicarbonate buffer (pH 9.5) and 3mL ethyl acetate for liquid-liquid extraction. The samples are mixed on a suspension mixer, centrifuge for 3 minutes and collect the supernatants were decanted, dried under nitrogen gas. The residues were dissolved in 0.5mL of 5% acetonitrile with 0.1% formic acid. The mixture was vortex for 10 seconds and filtered through a 0.22µm polyvinylidenedifluoride filter into a small volume of auto sampler vial. Then, 50µL was injected into the LC-MS/MS system. All samples are prepared in this same manner [27].

CONCLUSION:

The analytical techniques are initiated by forensic experts and that have been continued to expand the complexity and improves the reliability. Many analytical techniques are used to evaluate analytical problems in nearly all fields of research and the technology continues to open areas in every field of research. Forensic examiners are continued to determine the toxic substances and drug abuses by different tools. Atomic Absorption Spectroscopy is mostly used technique to determine the metallic compounds. The problems of drug abuse, increased therapeutic potency of drug substances and widespread concern about the pollution and the safety and health of workers are the present challenges to the analyst's skills. Today investigators are uses a wide range of analytical tests and sophisticated equipment with which to study the microscopic characteristics which are collected at crime scenes.

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