



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 4, April 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

# Forensic Chemistry-A Modern Scope Today

Dr. Anil Kumar

Dept. of Chemistry, D.A.V. [P.G.] College, Dehradun, India

**ABSTRACT:** Forensic chemistry is the application of chemistry and its subfield, forensic toxicology, in a legal setting. A forensic chemist can assist in the identification of unknown materials found at a crime scene.<sup>[1]</sup> Specialists in this field have a wide array of methods and instruments to help identify unknown substances. These include high-performance liquid chromatography, gas chromatography-mass spectrometry, atomic absorption spectroscopy, Fourier transform infrared spectroscopy, and thin layer chromatography. The range of different methods is important due to the destructive nature of some instruments and the number of possible unknown substances that can be found at a scene. Forensic chemists prefer using nondestructive methods first, to preserve evidence and to determine which destructive methods will produce the best results.

**KEYWORDS-**forensic,chemistry,scope,crime,toxicology,instruments,methods

## I. INTRODUCTION

Along with other forensic specialists, forensic chemists commonly testify in court as expert witnesses regarding their findings. Forensic chemists follow a set of standards that have been proposed by various agencies and governing bodies, including the Scientific Working Group on the Analysis of Seized Drugs. In addition to the standard operating procedures proposed by the group, specific agencies have their own standards regarding the quality assurance and quality control of their results and their instruments. To ensure the accuracy of what they are reporting, forensic chemists routinely check and verify that their instruments are working correctly and are still able to detect and measure various quantities of different substances.

### Role in investigations



Chemists were able to identify the explosive ANFO at the scene of the Oklahoma City bombing.<sup>[2]</sup>

Forensic chemists' analysis can provide leads for investigators, and they can confirm or refute their suspicions. The identification of the various substances found at the scene can tell investigators what to look for during their search. During fire investigations, forensic chemists can determine if an accelerant such as gasoline or kerosene was used; if so, this suggests that the fire was intentionally set.<sup>[3]</sup> Forensic chemists can also narrow down the suspect list to people who would have access to the substance used in a crime. For example, in explosive investigations, the identification of RDX or C-4 would indicate a military connection as those substances are military grade explosives.<sup>[4]</sup> On the other hand, the identification of TNT would create a wider suspect list, since it is used by demolition companies as well as in the military.<sup>[4]</sup> During poisoning investigations, the detection of specific poisons can give detectives an idea of what to

look for when they are interviewing potential suspects.<sup>[5]</sup> For example, an investigation that involves ricin would tell investigators to look for ricin's precursors, the seeds of the castor oil plant.<sup>[6]</sup>

Forensic chemists also help to confirm or refute investigators' suspicions in drug or alcohol cases. The instruments used by forensic chemists can detect minute quantities, and accurate measurement can be important in crimes such as driving under the influence as there are specific blood alcohol content cutoffs where penalties begin or increase.<sup>[7]</sup> In suspected overdose cases, the quantity of the drug found in the person's system can confirm or rule out overdose as the cause of death.<sup>[8]</sup>

## History

### Early history



A bottle of strychnine extract was once easily obtainable in apothecaries.<sup>[9]</sup>

Throughout history, a variety of poisons have been used to commit murder, including arsenic, nightshade, hemlock, strychnine, and curare.<sup>[10]</sup> Until the early 19th century, there were no methods to accurately determine if a particular chemical was present, and poisoners were rarely punished for their crimes.<sup>[11]</sup> In 1836, one of the first major contributions to forensic chemistry was introduced by British chemist James Marsh. He created the Marsh test for arsenic detection, which was subsequently used successfully in a murder trial.<sup>[12]</sup> It was also during this time that forensic toxicology began to be recognized as a distinct field. Mathieu Orfila, the "father of toxicology", made great advancements to the field during the early 19th century.<sup>[13]</sup> A pioneer in the development of forensic microscopy, Orfila contributed to the advancement of this method for the detection of blood and semen.<sup>[13]</sup> Orfila was also the first chemist to successfully classify different chemicals into categories such as corrosives, narcotics, and astringents.<sup>[11]</sup>

The next advancement in the detection of poisons came in 1850 when a valid method for detecting vegetable alkaloids in human tissue was created by chemist Jean Stas.<sup>[14]</sup> Stas's method was quickly adopted and used successfully in court to convict Count Hippolyte Visart de Bocarmé of murdering his brother-in-law by nicotine poisoning.<sup>[14]</sup> Stas was able to successfully isolate the alkaloid from the organs of the victim. Stas's protocol was subsequently altered to incorporate tests for caffeine, quinine, morphine, strychnine, atropine, and opium.<sup>[15]</sup>

The wide range of instrumentation for forensic chemical analysis also began to be developed during this time period. The early 19th century saw the invention of the spectroscope by Joseph von Fraunhofer.<sup>[16]</sup> In 1859, chemist Robert Bunsen and physicist Gustav Kirchhoff expanded on Fraunhofer's invention.<sup>[17]</sup> Their experiments with spectroscopy showed that specific substances created a unique spectrum when exposed to specific wavelengths of light. Using spectroscopy, the two scientists were able to identify substances based on their spectrum, providing a method of identification for unknown materials.<sup>[17]</sup> In 1906 botanist Mikhail Tsvet invented paper chromatography, an early predecessor to thin layer chromatography, and used it to separate and examine the plant proteins that make up chlorophyll.<sup>[15]</sup> The ability to separate mixtures into their individual components allows forensic chemists to examine the parts of an unknown material against a database of known products. By matching the retention factors for the separated components with known values, materials can be identified.<sup>[18]</sup>

### Modernization





A GC-MS unit with doors open. The gas chromatograph is on the right and the mass spectrometer is on the left.

Modern forensic chemists rely on numerous instruments to identify unknown materials found at a crime scene. The 20th century saw many advancements in technology that allowed chemists to detect smaller amounts of material more accurately. The first major advancement in this century came during the 1930s with the invention of a spectrometer that could measure the signal produced with infrared (IR) light. Early IR spectrometers used a monochromator and could only measure light absorption in a very narrow wavelength band. It was not until the coupling of an interferometer with an IR spectrometer in 1949 by Peter Fellgett that the complete infrared spectrum could be measured at once.<sup>[19];202</sup> Fellgett also used the Fourier transform, a mathematical method that can break down a signal into its individual frequencies, to make sense of the enormous amount of data received from the complete infrared analysis of a material.<sup>[19]</sup> Since then, Fourier transform infrared spectroscopy (FTIR) instruments have become critical in the forensic analysis of unknown material because they are nondestructive and extremely quick to use. Spectroscopy was further advanced in 1955 with the invention of the modern atomic absorption (AA) spectrophotometer by Alan Walsh.<sup>[20]</sup> AA analysis can detect specific elements that make up a sample along with their concentrations, allowing for the easy detection of heavy metals such as arsenic and cadmium.<sup>[21]</sup>

Advancements in the field of chromatography arrived in 1953 with the invention of the gas chromatograph by Anthony T. James and Archer John Porter Martin, allowing for the separation of volatile liquid mixtures with components which have similar boiling points. Nonvolatile liquid mixtures could be separated with liquid chromatography, but substances with similar retention times could not be resolved until the invention of high-performance liquid chromatography (HPLC) by Csaba Horváth in 1970. Modern HPLC instruments are capable of detecting and resolving substances whose concentrations are as low as parts per trillion.<sup>[22]</sup>

One of the most important advancements in forensic chemistry came in 1955 with the invention of gas chromatography-mass spectrometry (GC-MS) by Fred McLafferty and Roland Gohlke.<sup>[23][24]</sup> The coupling of a gas chromatograph with a mass spectrometer allowed for the identification of a wide range of substances.<sup>[24]</sup> GC-MS analysis is widely considered the "gold standard" for forensic analysis due to its sensitivity and versatility along with its ability to quantify the amount of substance present.<sup>[25]</sup> The increase in the sensitivity of instrumentation has advanced to the point that minute impurities within compounds can be detected potentially allowing investigators to trace chemicals to a specific batch and lot from a manufacturer.<sup>[5]</sup>

## Methods

Forensic chemists rely on a multitude of instruments to identify unknown substances found at a scene.<sup>[26]</sup> Different methods can be used to determine the identity of the same substance, and it is up to the examiner to determine which method will produce the best results. Factors that forensic chemists might consider when performing an examination are the length of time a specific instrument will take to examine a substance and the destructive nature of that instrument. They prefer using nondestructive methods first, to preserve the evidence for further examination.<sup>[27]</sup> Nondestructive techniques can also be used to narrow down the possibilities, making it more likely that the correct method will be used the first time when a destructive method is used.<sup>[27]</sup>

## Spectroscopy

The two main standalone spectroscopy techniques for forensic chemistry are FTIR and AA spectroscopy. FTIR is a nondestructive process that uses infrared light to identify a substance. The attenuated total reflectance sampling technique eliminates the need for substances to be prepared before analysis.<sup>[28]</sup> The combination of nondestructiveness and zero preparation makes ATR FTIR analysis a quick and easy first step in the analysis of unknown substances. To facilitate the positive identification of the substance, FTIR instruments are loaded with databases that can be searched for known spectra that match the unknown's spectra. FTIR analysis of mixtures, while not impossible, presents specific difficulties due to the cumulative nature of the response. When analyzing an unknown that contains more than one substance, the resulting spectra will be a combination of the individual spectra of each component.<sup>[29]</sup> While common

mixtures have known spectra on file, novel mixtures can be difficult to resolve, making FTIR an unacceptable means of identification. However, the instrument can be used to determine the general chemical structures present, allowing forensic chemists to determine the best method for analysis with other instruments. For example, a methoxy group will result in a peak between 3,030 and 2,950 wavenumbers ( $\text{cm}^{-1}$ ).<sup>[30]</sup>

Atomic absorption spectroscopy (AAS) is a destructive technique that is able to determine the elements that make up the analyzed sample. AAS performs this analysis by subjecting the sample to an extremely high heat source, breaking the atomic bonds of the substance, leaving free atoms. Radiation in the form of light is then passed through the sample forcing the atoms to jump to a higher energy state.<sup>[31]:2</sup> Forensic chemists can test for each element by using a corresponding wavelength of light that forces that element's atoms to a higher energy state during the analysis.<sup>[31]:256</sup> For this reason, and due to the destructive nature of this method, AAS is generally used as a confirmatory technique after preliminary tests have indicated the presence of a specific element in the sample. The concentration of the element in the sample is proportional to the amount of light absorbed when compared to a blank sample.<sup>[32]</sup> AAS is useful in cases of suspected heavy metal poisoning such as with arsenic, lead, mercury, and cadmium. The concentration of the substance in the sample can indicate whether heavy metals were the cause of death.<sup>[33]</sup>

## II. DISCUSSION

### Chromatography

Spectroscopy techniques are useful when the sample being tested is pure, or a very common mixture. When an unknown mixture is being analyzed it must be broken down into its individual parts. Chromatography techniques can be used to break apart mixtures into their components allowing for each part to be analyzed separately.

Thin layer chromatography (TLC) is a quick alternative to more complex chromatography methods. TLC can be used to analyze inks and dyes by extracting the individual components.<sup>[18]</sup> This can be used to investigate notes or fibers left at the scene since each company's product is slightly different and those differences can be seen with TLC. The only limiting factor with TLC analysis is the necessity for the components to be soluble in whatever solution is used to carry the components up the analysis plate.<sup>[18]</sup> This solution is called the mobile phase.<sup>[18]</sup> The forensic chemist can compare unknowns with known standards by looking at the distance each component travelled.<sup>[18]</sup> This distance, when compared to the starting point, is known as the retention factor ( $R_f$ ) for each extracted component.<sup>[18]</sup> If each  $R_f$  value matches a known sample, that is an indication of the unknown's identity.<sup>[18]</sup>

High-performance liquid chromatography (HPLC) can be used to extract individual components from a mixture dissolved in a solution. HPLC is used for nonvolatile mixtures that would not be suitable for gas chromatography.<sup>[34]</sup> This is useful in drug analysis where the pharmaceutical is a combination drug since the components would separate, or elute, at different times allowing for the verification of each component.<sup>[35]</sup> The eluates from the HPLC column are then fed into various detectors that produce a peak on a graph relative to its concentration as it elutes off the column. The most common type of detector is an ultraviolet-visible spectrometer as the most common item of interest tested with HPLC, pharmaceuticals, have UV absorbance.<sup>[36]</sup>

Gas chromatography (GC) performs the same function as liquid chromatography, but it is used for volatile mixtures. In forensic chemistry, the most common GC instruments use mass spectrometry as their detector.<sup>[1]</sup> GC-MS can be used in investigations of arson, poisoning, and explosions to determine exactly what was used. In theory, GC-MS instruments can detect substances whose concentrations are in the femtogram ( $10^{-15}$ ) range.<sup>[37]</sup> However, in practice, due to signal-to-noise ratios and other limiting factors, such as the age of the individual parts of the instrument, the practical detection limit for GC-MS is in the picogram ( $10^{-12}$ ) range.<sup>[38]</sup> GC-MS is also capable of quantifying the substances it detects; chemists can use this information to determine the effect the substance would have on an individual. GC-MS instruments need around 1,000 times more of the substance to quantify the amount than they need simply to detect it; the limit of quantification is typically in the nanogram ( $10^{-9}$ ) range.<sup>[38]</sup>

### Forensic toxicology

Forensic toxicology is the study of the pharmacodynamics, or what a substance does to the body, and pharmacokinetics, or what the body does to the substance. To accurately determine the effect a particular drug has on the human body, forensic toxicologists must be aware of various levels of drug tolerance that an individual can build up as well as the therapeutic index for various pharmaceuticals. Toxicologists are tasked with determining whether any toxin found in a body was the cause of or contributed to an incident, or whether it was at too low a level to have had an effect.<sup>[39]</sup> While the determination of the specific toxin can be time-consuming due to the number of different

substances that can cause injury or death, certain clues can narrow down the possibilities. For example, carbon monoxide poisoning would result in bright red blood while death from hydrogen sulfide poisoning would cause the brain to have a green hue.<sup>[40][41]</sup>

Toxicologists are also aware of the different metabolites that a specific drug could break down into inside the body. For example, a toxicologist can confirm that a person took heroin by the presence in a sample of 6-monoacetylmorphine, which only comes from the breakdown of heroin.<sup>[42]</sup> The constant creation of new drugs, both legal and illicit, forces toxicologists to keep themselves apprised of new research and methods to test for these novel substances. The stream of new formulations means that a negative test result does not necessarily rule out drugs. To avoid detection, illicit drug manufacturers frequently change the chemicals' structure slightly. These compounds are often not detected by routine toxicology tests and can be masked by the presence of a known compound in the same sample.<sup>[43]</sup> As new compounds are discovered, known spectra are determined and entered into the databases that can be downloaded and used as reference standards.<sup>[44]</sup> Laboratories also tend to keep in-house databases for the substances they find locally.<sup>[44]</sup>

### Standards

SWGDRUG analysis categories		
Category A	Category B	Category C
Infrared spectroscopy Mass spectrometry Nuclear magnetic resonance spectroscopy Raman spectroscopy X-ray diffractometry	Capillary electrophoresis Gas chromatography Ion-mobility spectrometry Liquid chromatography Microcrystalline tests Pharmaceutical identifiers Thin-layer chromatography Cannabis only: Macroscopic and microscopic examination	Color tests Fluorescence spectroscopy Immunoassay Melting point analysis Ultraviolet spectroscopy

Guidelines have been set up by various governing bodies regarding the standards that are followed by practicing forensic scientists. For forensic chemists, the international Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) presents recommendations for the quality assurance and quality control of tested materials.<sup>[45]</sup> In the identification of unknown samples, protocols have been grouped into three categories based on the probability for false positives. Instruments and protocols in category A are considered the best for uniquely identifying an unknown material, followed by categories B and then C. To ensure the accuracy of identifications SWGDRUG recommends that multiple tests using different instruments be performed on each sample, and that one category A technique and at least one other technique be used. If a category A technique is not available, or the forensic chemist decides not to use one, SWGDRUG recommends that at least three techniques be used, two of which must be from category B.<sup>[45]:14-15</sup> Combination instruments, such as GC-MS, are considered two separate tests as long as the results are compared to known values individually. For example, the GC elution times would be compared to known values along with the MS spectra. If both of those match a known substance, no further tests are needed.<sup>[45]:16</sup>

Standards and controls are necessary in the quality control of the various instruments used to test samples. Due to the nature of their work in the legal system, chemists must ensure that their instruments are working accurately. To do this, known controls are tested consecutively with unknown samples.<sup>[46]</sup> By comparing the readouts of the controls with their known profiles the instrument can be confirmed to have been working properly at the time the unknowns were tested. Standards are also used to determine the instrument's limit of detection and limit of quantification for various common substances.<sup>[47]</sup> Calculated quantities must be above the limit of detection to be confirmed as present and above the limit of quantification to be quantified.<sup>[47]</sup> If the value is below the limit the value is not considered reliable.<sup>[47]</sup>

### Testimony

The standardized procedures for testimony by forensic chemists are provided by the various agencies that employ the scientists as well as SWGDRUG. Forensic chemists are ethically bound to present testimony in a neutral manner and to be open to reconsidering their statements if new information is found.<sup>[45]:3</sup> Chemists should also limit their testimony to areas they have been qualified in regardless of questions during direct or cross-examination.<sup>[45]:27</sup>

Individuals called to testify must be able to relay scientific information and processes in a manner that lay individuals can understand.<sup>[48]</sup> By being qualified as an expert, chemists are allowed to give their opinions on the evidence as opposed to just stating the facts. This can lead to competing opinions from experts hired by the opposing side.<sup>[48]</sup> Ethical guidelines for forensic chemists require that testimony be given in an objective manner, regardless of what side the expert is testifying for.<sup>[49]</sup> Forensic experts that are called to testify are expected to work with the lawyer who issued the summons and to assist in their understanding of the material they will be asking questions about.<sup>[49]</sup>

#### Education

Forensic chemistry positions require a bachelor's degree or similar in a natural or physical science, as well as laboratory experience in general, organic, and analytical chemistry. Once in the position, individuals are trained in protocols performed at that specific lab until they are proven competent to perform all experiments without supervision. Practicing chemists in the field are expected to complete continuing education to maintain their proficiency.<sup>[45]: 4-6</sup>

### III. RESULTS

Forensic toxicology is the use of toxicology and disciplines such as analytical chemistry, pharmacology and clinical chemistry to aid medical or legal investigation of death, poisoning, and drug use.<sup>[1]</sup> The primary concern for forensic toxicology is not the legal outcome of the toxicological investigation or the technology utilized, but rather the obtention and interpretation of results. A toxicological analysis can be done to various kinds of samples. A forensic toxicologist must consider the context of an investigation, in particular any physical symptoms recorded, and any evidence collected at a crime scene that may narrow the search, such as pill bottles, powders, trace residue, and any available chemicals. Provided with this information and samples with which to work, the forensic toxicologist must determine which toxic substances<sup>[2]</sup> are present, in what concentrations, and the probable effect of those chemicals on the person.<sup>[3]</sup>

In the United States, forensic toxicology can be separated into 3 disciplines: Postmortem toxicology, human performance toxicology, and forensic drug testing (FDT).<sup>[4]</sup> Postmortem toxicology includes the analysis of biological specimens taken from an autopsy to identify the effect of drugs, alcohol, and poisons. A wide range of biological specimens may be analyzed including blood, urine, gastric contents, oral fluids, hair, tissues, and more. The forensic toxicologist works with pathologists, medical examiners, and coroners to help determine the cause and manner of death. In human performance toxicology, a dose-response relationship between a drug(s) present in the body and the effects on the body are examined. This field of forensic toxicology is responsible for building and implementing laws such as driving under the influence of alcohol or drugs. Lastly, forensic drug testing (FDT) is the detection of drug use among individuals in the workplace, sport doping, drug-related probation, and new job applicant screenings.<sup>[3]</sup>

Determining the substance ingested is often complicated by the body's natural processes (see ADME), as it is rare for a chemical to remain in its original form once in the body. For example: heroin is almost immediately metabolised into another substance and further to morphine, making detailed investigation into factors such as injection marks and chemical purity necessary to confirm diagnosis.<sup>[5]</sup> The substance may also have been diluted by its dispersal through the body; while a pill or other regulated dose of a drug may have grams or milligrams of the active constituent, an individual sample under investigation may only contain micrograms or nanograms.

#### How certain substances affect your body

---

##### Alcohol

Alcohol enters your central nervous system through the blood stream through the lining within your stomach and your small intestine. Once it is in your blood stream, it passes through your blood brain barrier via blood circulation. The alcohol absorbed will reduce your reflexes, interfere with nerve impulses, prolong muscle responses, and affect other parts of your body as well.<sup>[6]</sup>

##### Marijuana

Marijuana, like alcohol, is also absorbed into the blood stream and passed through the blood brain barrier. However, the THC that is released from marijuana attaches to the CB-1 cannabinoid receptors which causes all of the effects experienced. These effects include, but are not limited to, mood changes, altered perception of time, and increased sensitivity.<sup>[7]</sup>

##### Cocaine

Cocaine is a stimulant unlike Marijuana or Alcohol. As soon as cocaine enters the bloodstream it reaches the brain in minutes. Dopamine levels are increased intensely and the effects can last up to about 30 minutes. The most common

way to use cocaine is by snorting it through the nose but other methods could be by smoking it in a crystal rock form. But because dopamine levels are increased at such a rate this leads to an even worse comedown leading to needing a higher dose to get the same effect as the time before if taken again. This is how some addictions begin. Some effects when taken are an increase of energy and happiness, paranoia, rapid heart rate, anxiety, etc...<sup>[8]</sup>

## Examples

---

### Drugs In Body

#### Urine

A urine sample is urine that has come from the bladder and can be provided or taken post-mortem. Urine is less likely to be infected with viruses such as HIV or Hepatitis B than blood samples.<sup>[9]</sup> Many drugs have a higher concentration and can remain for much longer in urine than blood. Collection of urine samples can be taken in a non-invasive way which does not require professionals for collection. Urine is used for qualitative analysis as it cannot give any indication of impairment due to the fact that drug presence in urine only indicates prior exposure.<sup>[10]</sup> Different drugs can also stay in your urine for different amounts of time. For example, alcohol will stay within your urine for 7–12 hours, cocaine metabolites will stay for 2–4 days, and morphine will stay for 48–74 hours. One drug that will stay in your urine for a varying amount of time (dependent on the usage and frequency) is marijuana. For a single use, it will stay for 3 days, moderate use (4 times per week) will stay for 5–7 days, daily use of the drug will cause it to stay for 10–15 days, and a long-term heavy smoker will have it stay within their urine for less than 30 days.<sup>[11]</sup>

#### Blood

A blood sample of approximately 10 ml (0.35 imp fl oz; 0.34 US fl oz) is usually sufficient to screen and confirm most common toxic substances. A blood sample provides the toxicologist with a profile of the substance that the subject was influenced by at the time of collection; for this reason, it is the sample of choice for measuring blood alcohol content in drunk driving cases.<sup>[12]</sup>

#### Hair

Hair is capable of recording medium to long-term or high dosage substance abuse. Chemicals in the bloodstream may be transferred to the growing hair and stored in the follicle, providing a rough timeline of drug intake events. Head hair grows at rate of approximately 1 to 1.5 cm a month, and so cross sections from different sections of the follicle can give estimates as to when a substance was ingested. Testing for drugs in hair is not standard throughout the population. The darker and coarser the hair the more drug that will be found in the hair. If two people consumed the same amount of drugs, the person with the darker and coarser hair will have more drug in their hair than the lighter haired person when tested. This raises issues of possible racial bias in substance tests with hair samples.<sup>[13]</sup> Hair samples are analyzed using enzyme-linked immunosorbent assay (ELISA). In ELISA, an antigen must be immobilized to a solid surface and then complexed with an antibody that is linked to an enzyme.<sup>[7]</sup>

#### Bone Marrow

Bone marrow can be used for testing but that depends on the quality and availability of the bones. So far there is no proof that says that certain bones are better than others when it comes to testing. Extracting bone marrow from larger bones is easier than smaller bones.<sup>[14]</sup> Forensic toxicologists use bone marrow to find what type of poisons used. These poisons can include cocaine or ethanol.<sup>[15]</sup>

#### Other

Other bodily fluids and organs may provide samples, particularly samples collected during an autopsy. A common autopsy sample is the gastric contents of the deceased, which can be useful for detecting undigested pills or liquids that were ingested prior to death. In highly decomposed bodies, traditional samples may no longer be available. The vitreous humour from the eye may be used, as the fibrous layer of the eyeball and the eye socket of the skull protects the sample from trauma and adulteration. Other common organs used for toxicology are the brain, liver, and spleen.<sup>[12]</sup>

## Detection and classification

---

Detection of drugs and pharmaceuticals in biological samples is usually done by an initial screening and then a confirmation of the compound(s), which may include a quantitation of the compound(s). The screening and confirmation are usually, but not necessarily, done with different analytical methods. Every analytical method used in



forensic toxicology should be carefully tested by performing a validation of the method to ensure correct and indisputable results at all times. The choice of method for testing is highly dependent on what kind of substance one expects to find and the material on which the testing is performed.<sup>[16]</sup> Customarily, a classification scheme is utilized that places poisons in categories such as: corrosive agents, gases and volatile agents, metallic poisons, non-volatile organic agents, and miscellaneous.<sup>[3]</sup>

#### Immunoassays

Immunoassays requires you to draw blood and use the antibodies to find a reaction with substances such as drugs. The substances must be specific. It is the most common drug screening technique. Using the targeted drug the test will tell you if it is positive or negative to that drug. There can be 4 results when taking the test. Those results can be a true-positive, a false-negative, a false-positive, and a true-negative.<sup>[14]</sup>

#### Gas chromatography-mass spectrometry

Gas chromatography-mass spectrometry (GC-MS) is a widely used analytical technique for the detection of volatile compounds. Ionization techniques most frequently used in forensic toxicology include electron ionization (EI) or chemical ionization (CI), with EI being preferred in forensic analysis due to its detailed mass spectra and its large library of spectra. However, chemical ionization can provide greater sensitivity for certain compounds that have high electron affinity functional groups.<sup>[17]</sup>

#### Liquid chromatography-mass spectrometry

Liquid chromatography-mass spectrometry (LC-MS) has the capability to analyze compounds that are polar and less volatile. Derivatization is not required for these analytes as it would be in GC-MS, which simplifies sample preparation. As an alternative to immunoassay screening which generally requires confirmation with another technique, LC-MS offers greater selectivity and sensitivity. This subsequently reduces the possibility of a false negative result that has been recorded in immunoassay drug screening with synthetic cathinones and cannabinoids.<sup>[18]</sup> A disadvantage of LC-MS on comparison to other analytical techniques such as GC-MS, is the high instrumentation cost. However, recent advances in LC-MS have led to higher resolution and sensitivity which assists in the evaluation of spectra to identify forensic analytes.<sup>[19]</sup>

#### Detection of metals

The compounds suspected of containing a metal are traditionally analyzed by the destruction of the organic matrix by chemical or thermal oxidation. This leaves the metal to be identified and quantified in the inorganic residue, and it can be detected using such methods as the Reinsch test, emission spectroscopy or X-ray diffraction. Unfortunately, while this identifies the metals present it removes the original compound, and so hinders efforts to determine what may have been ingested. The toxic effects of various metallic compounds can vary considerably.<sup>[12]</sup>

### IV. CONCLUSIONS

Forensic science, also known as criminalistics,<sup>[1]</sup> is the application of science to criminal and civil laws. During criminal investigation in particular, it is governed by the legal standards of admissible evidence and criminal procedure. It is a broad field utilizing numerous practices such as the analysis of DNA, fingerprints, bloodstain patterns, firearms, ballistics, and toxicology.

Forensic scientists collect, preserve, and analyze scientific evidence during the course of an investigation. While some forensic scientists travel to the scene of the crime to collect the evidence themselves, others occupy a laboratory role, performing analysis on objects brought to them by other individuals.<sup>[2]</sup> Still others are involved in analysis of financial, banking, or other numerical data for use in financial crime investigation, and can be employed as consultants from private firms, academia, or as government employees.<sup>[3]</sup>

In addition to their laboratory role, forensic scientists testify as expert witnesses in both criminal and civil cases and can work for either the prosecution or the defense. While any field could technically be forensic, certain sections have developed over time to encompass the majority of forensically related cases.<sup>[4]</sup>

#### Etymology

The term forensic stems from the Latin word, *forēnsis* (3rd declension, adjective), meaning "of a forum, place of assembly".<sup>[5]</sup> The history of the term originates in Roman times, when a criminal charge meant presenting the case before a group of public individuals in the forum. Both the person accused of the crime and the accuser would give

speeches based on their sides of the story. The case would be decided in favor of the individual with the best argument and delivery. This origin is the source of the two modern usages of the word forensic—as a form of legal evidence; and as a category of public presentation.<sup>[6]</sup>

In modern use, the term forensics is often used in place of "forensic science."

The word "science", is derived from the Latin word for 'knowledge' and is today closely tied to the scientific method, a systematic way of acquiring knowledge. Taken together, forensic science means the use of scientific methods and processes for crime solving.

## REFERENCES

1. "A Simplified Guide to Forensic Drug Chemistry" (PDF). National Forensic Science Technology Center. Archived from the original (PDF) on March 21, 2016. Retrieved September 24, 2015.
2. ^ Browne, Malcolm W. (April 21, 1995). "Terror in Oklahoma: the Science; Experts Search for Debris to Link Bomb to a Suspect". The New York Times. Retrieved October 28, 2015.
3. ^ Stern, Wal (November 1995). "Modern Methods of Accelerant Analysis". Southeast Asia Fire and Security. Retrieved October 28, 2015 – via T.C. Forensic.
4. ^ a b "Common Explosives". The National Counterterrorism Center. Archived from the original on January 13, 2016. Retrieved October 28, 2015.
5. ^ a b Halford, Bethany (February 6, 2012). "Tracing a Threat". Chemical & Engineering News. 90 (6): 10–15. doi:10.1021/cen-09006-cover. Retrieved December 6, 2016.
6. ^ Goldstein, Joseph (June 7, 2013). "Woman from Texas is Charged in Ricin Case". The New York Times. Retrieved December 6, 2016.
7. ^ "Legal BAC Limits Data by Country". World Health Organization. Retrieved October 30, 2015.
8. ^ "Toxicology Screen". The New York Times. Retrieved December 5, 2016.
9. ^ Wetherell, Donald G. (2016). *Wildlife, Land, and People: a Century of Change in Prairie Canada*. McGill-Queen's Press. ISBN 9780773599895 – via Google Books.
10. ^ Cellania, Miss (November 3, 2009). "5 Classic Poisons and the People who Used Them". Mental Floss. Retrieved September 24, 2015.
11. ^ a b Pizzi, Richard A. (September 2004). "Pointing to Poison" (PDF). *Today's Chemist at Work*: 43–45. Retrieved September 24, 2015.
12. ^ Watson, Stephanie (June 9, 2008). "How Forensic Lab Techniques Work". How Stuff Works. Retrieved September 24, 2015.
13. ^ a b "Mathieu Joseph Bonaventure Orfila (1787–1853)". National Library of Medicine. June 5, 2014. Retrieved September 24, 2015.
14. ^ a b Wennig, Robert (April 2009). "Back to the Roots of Modern Analytical Toxicology: Jean Servais Stas and the Bocarmé Murder Case" (PDF). *Drug Testing and Analysis*. 1 (4): 153–155. doi:10.1002/dta.32. PMID 20355192.
15. ^ a b "Technologies". National Library of Medicine. June 5, 2014. Retrieved September 25, 2015.
16. ^ "Fraunhofer, Joseph von". The Encyclopedia Americana. Vol. 12. The Encyclopedia American Corporation. 1919. p. 28.
17. ^ a b "Spectroscopy and the Birth of Astrophysics". American Institute of Physics. Center for History of Physics. Archived from the original on September 7, 2015. Retrieved September 25, 2015.
18. ^ a b c d e f g Carlyle, Felicity (2011-07-26). "TLC the Forensic Way". theGIST. Glasgow Insight Into Science & Technology. Archived from the original on July 30, 2016. Retrieved October 10, 2015.
19. ^ a b Derrick, Michele R.; Stulik, Dusan; Landry, James M. "Infrared Spectroscopy in Conservation Science" (PDF). The Getty Conservation Institute. Retrieved September 26, 2015.
20. ^ Willis, J B (1993). "The Birth of the Atomic Absorption Spectrometer and its Early Applications in Clinical Chemistry" (PDF). *Clinical Chemistry*. 39 (1): 155–160. doi:10.1093/clinchem/39.1.155. PMID 8419043. Retrieved October 6, 2015.
21. ^ Willis, J B (May 1962). "Determination of Lead and Other Heavy Metals in Urine by Atomic Absorption Spectroscopy". *Analytical Chemistry*. 34 (6): 614–617. doi:10.1021/ac60186a008.

22. ^ Forbes, Patricia, ed. (2015). Monitoring of Air Pollutants: Sampling, Sample Preparation and Analytical Techniques. Comprehensive Analytical Chemistry. Vol. 70. Elsevier. p. 274. ISBN 9780444635532 – via Google Books.
23. ^ Jones, Mark. "Gas Chromatography-Mass Spectrometry". American Chemical Society. Retrieved 19 Nov 2019.
24. ^ a b Gohlke, Roland S.; McLafferty, Fred W. (May 1993). "Early Gas Chromatography/Mass Spectrometry". Journal of the American Society for Mass Spectrometry. 4 (5): 367–371. doi:10.1016/1044-0305(93)85001-e. PMID 24234933.
25. ^ Kapur, BM (1993). "Drug-testing Methods and Clinical Interpretations of Test Results". Bulletin on Narcotics. 45 (2): 115–154. PMID 7920539. Retrieved September 27, 2015.
26. ^ Gaensslen, R.E.; Kubic, Thomas A.; Desio, Peter J.; Lee, Henry C. (December 1985). "Instrumentation and Analytical Methodology in Forensic Science". Journal of Chemical Education. 62 (12): 1058–1060. Bibcode:1985JChEd..62.1058G. doi:10.1021/ed062p1058.
27. ^ a b "Quality Assurance Guide for the Forensic Analysis of Ignitable Liquids". Forensic Science Communications. 8 (2). April 2006. Archived from the original on May 29, 2016. Retrieved September 24, 2015.
28. ^ Angelos, Sanford; Garry, Mike (August 5, 2011). "Seized Drug Analysis Using FT-IR and Mixture Searching For More Effective Identification". Forensic Magazine. Advantage Business Media. Retrieved October 6, 2015.
29. ^ Izzia, Federico; Nunn, Simon; Bradley, Michael (August 1, 2008). "Analysis of Mixtures by FT-IR: Spatial and Spectral Separation of Complex Samples". Spectroscopy Online. Special Issues-08-01-2008. Retrieved October 6, 2015.
30. ^ Socrates, George (2004). Infrared and Raman Characteristic Group Frequencies: Tables and Charts (Third ed.). John Wiley & Sons. p. 55. ISBN 9780470093078 – via Google Books.
31. ^ a b Cantele, John Edward, ed. (1986). Atomic Absorption Spectrometry. Techniques and Instrumentation in Analytical Chemistry. Vol. 5. Elsevier. ISBN 9780444420152 – via Google Books.
32. ^ Schiller, Matt. "Atomic Absorption Spectroscopy (AAS)". Easy Chem. Retrieved October 7, 2015.
33. ^ Baldwin, Dianne R; Marshall, William J (1999). "Heavy Metal Poisoning and its Laboratory Investigation". Annals of Clinical Biochemistry. 36 (3): 267–300. CiteSeerX 10.1.1.528.7546. doi:10.1177/000456329903600301. PMID 10376071. S2CID 26671861.
34. ^ Picó, Yolanda, ed. (2012). Chemical Analysis of Food: Techniques and Applications. Elsevier. p. 501. ISBN 9780123848628 – via Google Books.
35. ^ Nikolin, B; Imamović, B; Medanhodžić-Vuk, S; Sober, M (May 2004). "High Performance Liquid Chromatography in Pharmaceutical Analyses". Bosnian Journal of Basic Medical Sciences. 4 (2): 5–9. doi:10.17305/bjbms.2004.3405. PMC 7250120. PMID 15629016.
36. ^ Dong, Michael W. (2016). Modern HPLC for Practicing Scientists. John Wiley & Sons. ISBN 9780471727897 – via Google Books.
37. ^ Fialkov, Alexander; Steiner, Urs; Lehotay, Steven; Amirav, Aviv (January 15, 2007). "Sensitivity and Noise in GC-MS: Achieving Low Limits of Detection for Difficult Analytes". International Journal of Mass Spectrometry. 260 (1): 31–48. Bibcode:2007IJMSp.260...31F. doi:10.1016/j.ijms.2006.07.002.
38. ^ a b Smith, Michael L.; Vorce, Shawn P.; Holler, Justin M.; Shimomura, Eric; Magluilo, Joe; Jacobs, Aaron J.; Huestis, Marilyn A. (June 2007). "Modern Instrumental Methods in Forensic Toxicology". Journal of Analytical Toxicology. 31 (5): 237–253. doi:10.1093/jat/31.5.237. PMC 2745311. PMID 17579968.
39. ^ "Forensic Toxicology". National Institute of Justice. December 23, 2014. Retrieved October 12, 2015.
40. ^ Foley, Katherine (August 16, 2015). "The Science Behind Forensic Toxicology". Quartz. Retrieved October 12, 2015.
41. ^ Park, Seong Hwan; Zhang, Yong; Hwang, Juck-Joon (May 30, 2009). "Discolouration of the Brain as the only Remarkable Autopsy Finding in Hydrogen Sulphide Poisoning". Forensic Science International. 187 (1–3): e19–e21. doi:10.1016/j.forsciint.2009.02.002. PMID 19297107. Retrieved October 12, 2015.
42. ^ von Euler, M; Villén, T; Svensson, JO; Ståhle, L (October 2003). "Interpretation of the Presence of 6-monoacetylmorphine in the Absence of Morphine-3-glucuronide in Urine Samples: Evidence of Heroin Abuse". Therapeutic Drug Monitoring. 25 (5): 645–648. doi:10.1097/00007691-200310000-00015. PMID 14508389. S2CID 22267781.

43. ^ Melinek, Jude (September 2016). "How Designer Drugs and the Opioid Epidemic Affect Modern Forensic Practice". Forensic Magazine: 18–19. Archived from the original on October 1, 2016. Retrieved September 29, 2016.
44. ^ a b Stout, Peter; Moore, Katherine; Grabenauer, Megan; Roper-Miller, Jeri (March 2013). Expansion of a Cheminformatic Database of Spectral Data for Forensic Chemists and Toxicologists (PDF) (Report). U.S. Department of Justice. p. 2. Retrieved December 5, 2016.
45. ^ a b c d e f "Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) Recommendations" (PDF). 7.1. June 9, 2016. Retrieved January 4, 2017.
46. ^ "Validation Guidelines for Laboratories Performing Forensic Analysis of Chemical Terrorism". Forensic Science Communications. 7 (2). April 2005. Archived from the original on March 4, 2016. Retrieved October 16, 2015.
47. ^ a b c Armbruster, David A.; Pry, Terry (August 2008). "Limit of Blank, Limit of Detection and Limit of Quantitation". The Clinical Biochemist Reviews. 29 (Supplement 1) (Suppl 1): S49–S52. PMC 2556583. PMID 18852857.
48. ^ a b Melton, Lisa (November 2007). "Courtroom chemistry" (PDF). Chemistry World. Retrieved October 13, 2016.
49. ^ a b Wells, Doris (March 26, 2012). "In Brief: Law 101: Legal Guide for the Forensic Expert". National Institute of Justice. Retrieved October 13, 2016.





**INNO SPACE**  
SJIF Scientific Journal Impact Factor

**Impact Factor:  
7.512**

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
**INDIA**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details