MediPharm

International Journal of MediPharm Research

ISSN:2395-423X www.medipharmsai.com

Vol.02, No.01, pp 10-16, 2015

The Role of Chemistry in Processing Crime Scenes

Manika barar

Department of Chemistry, SIMT College Meerut, India

Corres Email ID-dr.manikabr@gmail.com, Contact no: 7500877347

Abstract: Learning about crimes scenes can be interesting. This article will explain the premise of crime scene chemistry and how it is used to collect evidence for law enforcement agents. The knowledge of and technology associated with crime scene chemistry is one of the most important advances in criminal investigations. Firstly, the knowledge of chemistry allows law enforcement to find evidence which would previously have been completely hidden. Secondly, and more importantly, it let's them find evidence which is almost entirely accurate.

Keyword- Law enforcement agents, Finger print, Chemical technique.

The History of Forensic Chemistry

Poisons were employed by early Egyptians and ancient Greeks and Romans. Democritus was probably the first chemist to study poisons, and he communicated some of his findings to Hippocrates. Poisons were used both for murder and as a means of execution; the philosopher Socrates was condemned to death by drinking hemlock. Ancient Roman civilization had laws against poisoning in 82 B.C.E. Before the development of systematic, scientific criminal investigation, guilt was determined largely by circumstantial evidence and hearsay. Arsenic was a popular poison in Roman times. It was referred to as inheritance powder in early France. The Blandy trial of 1752 was the first instance of an actual chemical test for poison, and the Marsh test, developed in 1836, was the first reliable analysis that could show scientifically that arsenic was present in the body of a victim. [15]

Introduction

Every chemist is schooled in general, organic, and analytical chemistry, but forensic chemists also specialize in specific areas of expertise. For example, an inorganic chemist may examine traces of dust by using microchemistry to identify the chemical composition of tiny particles. Another chemist might employ thin-layer chromatography during the analysis of Forensic scientists examine evidence from crime scenes in an effort to solve crimes. This scientist is removing a piece of blood-stained material gathered at a crime scene for DNA testing.

The physical contact between a suspect and a victim, vehicle or a crime scene during the commission of a crime, can and often does result in the transfer of materials such as blood, semen, saliva, hairs, fibers, paint, plastic and adhesives. Also, in the investigation of fires, the analysis of fire debris samples for the identification of ignitable liquids is necessary to help determine the cause and origin of the fire. The Forensic Chemistry Section of the Crime Laboratory is responsible for the examination, identification and/or comparison of these types of materials which may be present at the crime scene, on the victim, the suspect, clothing articles, vehicles, weapons, tools and other objects. In order to conduct these examinations, various serological, chemical, microscopic, and/or instrumental techniques are utilized.[11]

The truth is that a forensic scientist is often a chemist. This because the analysis of gunshot residues, hair or traces of blood that can link a suspect to a crime scene, is above all a process that uses the techniques of chemistry, instruments developed for chemistry and (note!), the methods for solving problems of chemists!.In fact, modern criminal investigation puts the limits and capabilities of the so called Analytical Chemistry to the test: a branch of chemistry that focuses on identifying the quantities of substances present in a sample.What about blood tests? Analytical chemistry, of course!

The development of analytical chemistry made it possible to detect the presence of substances in miniscule quantities, through a variety of techniques capable of recognizing the specific characteristics of each substance.

For example, with chromatography (a technique that allows to separate the various components of a sample), it is possible to detect absolutely minute quantities of sample in the order of nanograms per milliliter.And how much is that? Less than a packet of sugar dissolved in an Olympic swimming pool!

In the case of metals, can go up to 10 times further. Using a technique of vaporization of the sample at 10 000 degrees Celsius, it's possible, for example, to detect the presence of a toxic metal in a hair in a proportion equal to one gram of metal into four Olympic pools!

But the great challenge of analytical chemistry applied to criminal investigation goes beyond identifying the presence of drugs, explosives or poisons. It's about how to characterize the materials found at the crime scene and trace them back to their origin.In fact, the composition of materials such as glass fragments, traces of paint, textile fibers, paper or even the ink used to write a letter, can provide very important clues in the investigation of a crime. The combined use of analytical techniques allows identifying even the geographical origin or date of manufacture of many materials.[14]

The Role of Forensic Chemists

Forensic chemistry encompasses organic and inorganic analysis, toxicology, arson investigation, and serology . Each method of analysis uses specialized techniques and instrumentation. The process may be as simple as setting up a density gradient column to compare soil samples or as complicated as using a mass spectrometer or neutron activation analysis to characterize an unknown substance. A wide array of laboratory techniques and instrumentation is used in forensic studies. This includes ultraviolet, infrared, and visible spectrophotometry; neutron activation analysis; gas chromatography and mass spectrophotometry; high pressure liquid chromatography; and atomic absorption spectrophotometry.

Some important techniques of forensic chemistry are following-

1. Trace Evidence

Trace evidence includes materials that are often microscopic in size and are easily transferred between victims, suspects, clothing articles, vehicles, weapons, tools and other objects. These types of materials mainly include paint, hair, fibers, plastics and adhesives (tape). Also encountered are fabrics, fabric impressions, cosmetics, gunshot residue particles and ropes and cordage. These types of materials which may be found and collected during investigations are compared to known or reference samples using various chemical, microscopic and instrumental techniques. The types of microscopes used include the stereomicroscope, the compound microscope, the comparison microscope and the polarized light microscope. Instruments used include the Fourier Transform Infrared Spectrophotometer (FTIR) and the micro spectrophotometer (MSP). The Forensic Chemistry Section participates in the Paint Debris Query (PDQ) system, sponsored by the Royal Canadian Mounted Police (RCMP) and Federal Bureau of Investigation (FBI). The PDQ database allows an examiner to process an automotive paint chip and potentially determine the make, model, and year of a vehicle. The PDQ database is especially important in difficult cases where investigators do not have a clear suspect vehicle.[17]

2. Fingerprinting

Fingerprints on smooth surfaces can often be made visible by the application of light or dark powder, but fingerprints on checks or other documents are often occult (hidden). Occult fingerprints are sometimes made visible by the use of ninhydrin, which turns purple due to reaction with amino acids present in perspiration. Fingerprints or other marks are also sometimes made visible by exposure to high-powered laser light. Some fingerprints can be treated with chemical substances, resulting in a pattern that fluoresces when exposed to light from lasers. Cyanoacrylate ester fumes from glue are used with fluorescent dyes to make the fingerprints visible. There's an older tactic that often comes in very handy in a crime scene. This tactic also relies on chemistry. It's the age old art of dusting for fingerprints. The days of dusting for prints is not gone, it is still a commonly used tactic for identifying fingerprints. However, there are also other methods. Some investigators use lasers, which react with the oils and chemicals that form a fingerprint. There is also work being done to attempt to extract enough DNA from a single fingerprint to properly identify someone. This would be extremely helpful, as often fingerprints are very smudged and can not be used to properly identify someone.[14,16]

3. Testing for Alcohol

Accidents caused by intoxicated drivers kill nearly 15,000 persons a year in the United States alone (almost half of fatal auto accidents are alcohol-related), so a Breathalyzer kit is standard equipment in most police squad cars or state patrol vehicles. Breathalyzers are used to estimate the blood alcohol content of drivers suspected of being intoxicated; the driver may appear sober, but still have a blood alcohol level above the legal limit. Although it is impractical to take blood samples on the highway, research has shown that the concentration of ethanol in the breath bears a definite relationship to its concentration in blood. Many communities have now set a legal limit of 0.08 percent (meaning that 100 milliliters [3.38 fluid ounces] of blood would contain 0.08 grams [0.0028 ounces] of ethanol). In fact, authorities now consider that a person's driving ability is probably impaired at a blood ethanol level of 0.05 percent.

Several types of analytic devices are available to administer Breathalyzer tests. One test makes use of a portable infrared spectrophotometer, another uses a fuel cell, and the most common test employs several glass or plastic tubes and some common chemical reagents. The person being tested blows through a tube, which bubbles the breath through a solution of chemicals containing sulfuric acid, potassium dichromate, water, and silver nitrate. **Oxidation** of the alcohol results in the reduction of dichromate ion to chromic ion, with a corresponding change in color from orange to green. An electrical device employing a photocell compares the color of the test solution with a standard solution, giving a quantitative determination of the alcohol content. The test provides a quick and reproducible determination of the amount of alcohol in a person's breath and is a numerical measure of the amount of alcohol in the bloodstream. Use of a chemical test helps to avoid subjective opinions of sobriety and provides reliable evidence for court proceedings. The test can be readily and quickly administered by trained law enforcement personnel, but forensic chemists test and calibrate the equipment and testify to its accuracy.[1,9]

4. Serology

In homicide, sexual assault, aggravated assault, motor vehicle accident, burglary and other investigations, the Forensic Chemists routinely conduct serological examinations on clothing articles, weapons, vehicles, scene samples or other items in order to locate possible bloodstains, identify the blood by presumptive chemical testing, determine if the blood is of human origin and then select suitable and relevant samples for DNA analysis. The chemists also make observations of bloodstain patterns on evidence items and/or at crime scenes. When evidence is submitted in sexual assault cases, the Forensic Chemists examine the contents of sexual assault evidence kits, clothing articles, bedding or other items for the presence of semen. Possible semen stains are located visually or by alternate light source and then tested for a component of seminal fluid by presumptive chemical tests. Further testing is conducted microscopically for sperm cells. In the absence of sperm cells, further testing is carried out for an additional semen component in order to confirm the presence of seminal fluid. Suitable and relevant samples are then selected for DNA analysis. In some instances, saliva analysis is also requested. Stains are generally located visually or by alternate light source. Amylase, a chemical component of saliva, is identified to confirm the presence of saliva. Suitable and relevant samples are then selected for DNA analysis. [15,14]

5. Bloodstain Pattern Analysis

Bloodstain pattern analysis involves the examination and documentation of bloodstains, namely their size, shape and distribution. Bloodstain patterns are often indicative of the types of actions that produced or caused these patterns. This information is used to help reconstruct the sequence of events that occurred during the commission of a crime[9,14]

6. Fire Debris Analysis

The Fire Debris Analysis Unit examines evidence collected at fire scenes and is a part of the Forensic Chemistry Section of the laboratory. The purpose of this examination is to determine if an ignitable liquid is present. Most ignitable liquids are petroleum products, however other non-petroleum products can be identified. Fire debris evidence is packaged in mason jars, paint cans, or fire debris evidence bags and generally consists of charred fire debris or clothing items. The examination procedure involves extracting ignitable liquids from the evidence using one of three extraction techniques or a combination of techniques. The three extraction methods used by this laboratory are Passive Diffusion Headspace, Simple Headspace, and Solvent Extraction. The extract is then analyzed on a Gas Chromatograph – Mass Spectrometer, which provides data that the examiner will then analyze. Based on the pattern, or appearance of the data, the examiner will identify the type of product, if any, in the extract. [14,3]

7. Toxicology

Toxicologists examine a wide range of materials such as blood stains, urine, and blood gases for traces of poisons or drugs. Many businesses now require the drug screening of employees; it is the responsibility of the technician to distinguish between the presence of illegal drugs and metabolites from foods such as poppy seeds. Such tests may be as simple as paper or thin-layer chromatography or as complicated as gas chromatographic or electrophoretic and serological analysis of a blood sample. Following death by unknown cause, samples of the victim's lungs, blood, urine, vitreous humor, and stomach contents are examined for traces of poisons or medication. Insects found on or near corpses are also collected and examined; they may actually absorb traces of drugs or poisons from the body, and in fact, traces of poisons sometimes are found in the surrounding insects long after concentrations in the body have fallen below detectable limits.

Forensic biochemists perform blood typing and enzyme tests on body fluids in cases involving assault, and also in paternity cases. Even tiny samples of blood, saliva, or semen may be separated by electrophoresis and subjected to enzymatic analysis. In the case of rape, traces of semen found on clothing or on the person become important evidence; the composition of semen varies from person to person. Some individuals excrete enzymes such as acid phosphatase and other proteins that are seldom found outside seminal fluid, and these chemical substances are characteristic of their semen samples. The presence of semen may be shown by the microscopic analysis for the presence of spermatozoa or by a positive test for prostate specific antigen.

In cases of sexual assault, tiny samples of DNA in blood, semen, skin, or hair found on the victim may be purified and the amount of DNA increased by the use of a polymerase chain reaction to produce quantities large enough to analyze. Since DNA is as specific to a person as fingerprints, matching the DNA of a perpetrator to a sample found on a victim is considered to be proof of contact. The Federal Bureau of Investigation (FBI) is currently in the process of establishing a national Combined DNA Index System (CODIS) that will collect data from many states and law enforcement agencies and index it so that particular DNA patterns from evidence collected at many crime scenes can be compared and matched. Many perpetrators of crimes have been convicted and many innocent persons set free after years in prison as a result of DNA analysis.[6]

The Role of Analytical chemistry in Forensic Science

Analytical measurements are essential to everyday life, required to determine the composition and control the quality of many products, to protect the environment and to monitor health. Consequently Analytical Chemistry has a major impact, not only in chemistry, but also in fields such as biochemistry, and the forensic, food, environmental and pharmaceutical sciences. Forensic chemistry is the application of analytical chemistry to the law and involves the examination of physical traces, such as body fluids, bones, fibres and drugs. Success in analytical chemistry requires the ability to make rigorous measurements, an appreciation of the principles and practice of modern instrumentation, and a problem-solving approach. This course aims to develop these skills, with an emphasis on the use of coupled chromatography-mass spectrometry techniques, a powerful combination with applications in the analysis of complex mixtures relevant to forensic, atmospheric and biological systems. As technology infiltrates every aspect of our lives, it is no wonder that solving crimes has become almost futuristic in its advances. From retinal scanning to trace evidence chemistry, actual forensic technologies are so advanced at helping to solve crimes that they seem like something from a science fiction thriller.[1]

1. Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) :

When broken glass is involved in a crime, putting together even tiny pieces can be key to finding important clues like the direction of bullets, the force of impact or the type of weapon used in a crime. Through its highly sensitive isotopic recognition ability, the LA-ICP-MS machine breaks glass samples of almost any size down to their atomic structure. Then, forensic scientists are able to match even the smallest shard of glass found on clothing to a glass sample from a crime scene. In order to work with this type of equipment in conjunction with forensic investigation, a Bachelor's Degree in Forensic Science is usually necessary.[5]

2. Alternative Light Photography :

For a forensic nurse, being able to quickly ascertain how much physical damage a patient has suffered can be the difference between life and death. Although they have many tools at their disposal to help make these calls quickly and accurately, Alternative Light Photography is one of the coolest tools to help see damage even before it is visible on the skin. A camera such as the Omnichrome uses blue light and orange filters to clearly show bruising below the skin's surface. In order to use this equipment, you would need a MSN in Forensic Nursing.[3]

3. High-Speed Ballistics Photography :

You might not think of it right away as a tool for forensic scientists, but ballistics specialists often use high-speed cameras in order to understand how bullet holes, gunshot wounds and glass shatters are created. Virtually anyone, from a crime scene investigator to a firearms examiner, can operate a high-speed camera without any additional education or training. Being able to identify and match bullet trajectories, impact marks and exit wounds must be done by someone with at least a Bachelor's of Science in Forensic Science.

4. Video Spectral Comparator 2000 :

For crime scene investigators and forensic scientists, this is one of the most valuable forensic technologies available anywhere. With this machine, scientists and investigators can look at a piece of paper and see obscured or hidden writing, determine quality of paper and origin and "lift" indented writing. It is sometimes possible to complete these analyses even after a piece of paper has been so damaged by water or fire that it looks unintelligible to the naked eye. In order to run this equipment, at least a Bachelors degree in Forensic Science or a Master's Degree in Document Analysis is usually required.

5. Digital Surveillance For Xbox (XFT Device) :

Most people don't consider a gaming system a potential place for hiding illicit data, which is why criminals have come to use them so much. In one of the most ground-breaking forensic technologies for digital forensic specialists, the XFT is being developed to allow authorities visual access to hidden files on the Xbox hard drive. The XFT is also set up to record access sessions to be replayed in real time during court hearings. In order to be able to access and interpret this device, a Bachelor's Degree in Computer Forensics is necessary.[10]

6. 3D Forensic Facial Reconstruction :

Although this forensic technology is not considered the most reliable, it is definitely one of the most interesting available to forensic pathologists, forensic anthropologists and forensic scientists. In this technique, 3D facial reconstruction software takes a real-life human remains and extrapolates a possible physical appearance. In order to run this type of program, you should have a Bachelor's Degree in Forensic Science, a Master's Degree in Forensic Anthropology or a Medical Degree with an emphasis on Forensic Examination and Pathology.[3]

7. DNA Sequencer :

Most people are familiar with the importance of DNA testing in the forensic science lab. Still, most people don't know exactly what DNA sequencers are and how they may be used. Most forensic scientists and crime lab technicians use what's called DNA profiling to identify criminals and victims using trace evidence like hair or skin samples. In cases where those samples are highly degraded, however, they often turn to the more powerful DNA sequencer, which allows them to analyze old bones or teeth to determine the specific ordering of a person's DNA nucleobases, and generate a "read" or a unique DNA pattern that can help identify that person as a possible suspect or criminal.[2]

8. Forensic Carbon-14 Dating :

Carbon dating has long been used to identify the age of unknown remains for anthropological and archaeological findings. Since the amount of radiocarbon (which is calculated in a Carbon-14 dating) has increased and decreased to distinct levels over the past 50 years, it is now possible to use this technique to identify forensic remains using this same tool. The only people in the forensic science field that have ready access to Carbon-14 Dating equipment are forensic scientists, usually with a Master's Degree in Forensic Anthropology or Forensic Archaeology.[10]

9. Magnetic Fingerprinting and Automated Fingerprint Identification (AFIS) :

With these forensic technologies, crime scene investigators, forensic scientists and police officers can quickly and easily compare a fingerprint at a crime scene with an extensive virtual database. In addition, the incorporation of magnetic fingerprinting dust and no-touch wanding allows investigators to get a perfect impression of fingerprints at a crime scene without contamination. While using AFIS requires only an Associates Degree in Law Enforcement, magnetic fingerprinting usually requires a Bachelor's Degree in Forensic Science or Crime Scene Investigation.[10,2]

10. High-Performance Liquid Chromatography-

High-performance liquid chromatography (HPLC) also know as high-pressure liquid chromatography is an instrumental system based on chromatography that is widely used in forensic science. The "HP" portion of the acronym is sometimes assigned to the words high pressure (versus high performance), but it refers to the same analytical system. HPLC is used in drug analysis, toxicology, explosives analysis, ink analysis, fibers, and plastics to name a few forensic applications. Like all chromatography, HPLC is based on selective partitioning of the molecules of interest between two different phases. Here, the mobile phase is a solvent or solvent mix that flows under high pressure over beads coated with the solid stationary phase. While traveling through the column, molecules in the sample partition selectively between the mobile phase and the stationary phase. Those that interact more with the stationary phase will lag behind those molecules that partition preferentially with the mobile phase. As a result, the sample introduced at the front of the column will emerge in separate bands (called peaks), with the bands emerging first being the components that interacted least with the stationary phase and as a result moved quicker through the column. The components that emerge last will be the ones that interacted most with the stationary phase and thus moved the slowest through the column. A detector is placed at the end of the column to identify the components that elute. Occasionally, the eluting solvent is collected at specific times correlating to specific components. This provides a pure or nearly pure sample of the component of interest. This technique is sometimes referred to as preparative chromatography.[7,13

11. Gas Chromatography

Gas chromatography (GC) is an instrumental technique used forensically in drug analysis, arson, toxicology, and the analyses of other organic compounds. GC exploits the fundamental properties common to all types of chromatography, separation based on selective partitioning of compounds between different phases of materials. Here, one phase is an inert gas helium (He), hydrogen (H_2), or nitrogen (N_2) that is referred to as the mobile phase (or carrier gas), and the other is a waxy material (called the stationary phase) that is coated on a solid support material found within the chromatographic column. In older GC systems, the stationary phase was coated on tiny beads and packed into glass columns with diameters about the same as a pencil and lengths of 6 to 12 feet, wound into a coil. The heated gas flowed over the beads, allowing contact between sample molecules in the gaseous mobile phase and the stationary phase. Called "packed column chromatographs," these instruments were widely used for drug, toxicology, and arson analysis. Around the mid-1980s, column chromatography began to give way to capillary column GC, in which the liquid phase is coated onto the inner walls of a thin capillary tube (about the diameter of a thin spaghetti noodle) that can be anywhere from 15 to 100 meters long, also wound into a coil. Capillary column chromatography represented a significant advance in the field and greatly improved the ability of columns to separate the multiple components found in complex drug and arson samples.[8,18]

12 . Ion Chromatography-

Ion chromatography (IC) is an instrumental technique that can be used to detect anions (negatively charged atoms or molecules such as Cl-) and cations (positively charged species such as Na+). IC has been applied in forensic science for the analysis of gunshot residue (GSR) and explosives. The ions of interest include ammonium (NH4+), nitrate (NO3-), and chlorate (ClO4-), species that are often detected using color change or presumptive tests. The advantages of IC in these cases include specificity (presumptive tests are subject to false positives and false negatives) and increased sensitivity, down to the part-per-billion (ppb) range. A part per billion is 1 microgram (µmg) per liter of water, and a microgram is 1/1,000,000 of a gram.[19]

Conclusion

Thanks to the chemistry of crime scene investigations, more guilty people get caught and more innocent people are freed. It is definitely one of the most important advances when it comes to criminal justice and as our technology and knowledge increase, it will only become more reliable.

References

1. Ho, Mat H. (1990). Analytical Methods in Forensic Chemistry. New York: Horwood.
2. Inman, Keith, and Inman, Norah (1997). An Introduction to Forensic DNA Analysis. Boca Raton, FL: CRC Press.
3. Saferstein, Richard (1998). Criminalistics: An Introduction to Forensic Science. Upper Saddle River, NJ: Prentice Hall.
4. "A Simplified Guide to Forensic Drug Chemistry" (PDF). Retrieved September 24, 2015.
5. Watson, Stephanie (June 9, 2008). "How Forensic Lab Techniques Work". How Stuff Works. Retrieved September 24, 2015.
6. 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.
7. "HPLC - High Performance Liquid Chromatography". Retrieved September 26, 2015.
8. 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. Retrieved September 27, 2015.
9. Kapur, BM (1993). "Drug-testing methods and clinical interpretations of test results". Bulletin on Narcotics 45 (2): 115–154. Retrieved September 27, 2015.
10. 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. Retrieved September 24, 2015.
11. "Forensic Science Communications". Federal Bureau of Investigation.April 2006. Retrieved September 24, 2015.
12. Carlysle, Felicity. "TLC the Forensic Way". Glasgow Insight Into Science & Technology. Retrieved October 10, 2015.
13. "High-Performance Liqiud Chromatography". Just Chromatography. Retrieved October 8, 2015.
14. Read more: http://www.chemistryexplained.com/Fe-Ge/Forensic-Chemistry.html#ixzz3oEUF9sfx
15. Forensic Science. Available from http://www.forensicdna.com/ .
16. http://www.geocities.com/CapeCanaveral/4329/ .
17. http://www.facstaff.bucknell.edu/mvigeant/univ_270_03/Derek/
18. Gas chromatography".Just Chromatography.Retrieved October8,2015.
19. Ion chromatography". Just Cromatography.Retrieved October 8,2015.

*****