Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-11, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Analytical Chemistry: Core of forensic science

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Abstract*: The forensic sciences are indispensable to resolve civil disputes, to justly enforce criminal laws and government regulations. Forensic investigations involve the discovery and characterization of evidence that can be used to reconstruct a chronology of events associated with the commission of a crime or other matters being adjudicated. Sophisticated analytical tools and methods are being employed to detect and discriminate evidence. The term forensic science is infact, associated with the application of analytical tools and techniques in the discovery of evidence deemed relevant in the investigation of a crime or in some other legal proceeding.*

1. Introduction

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 [1-3]. 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.

The major analytical techniques that are widely implemented are discussed below:

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

The broken glass involved in a crime could provide 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 [4].

1.2. Alternative Light Photography :

Using ultraviolet light through to infrared light we can uncover a lot of information that may not be seen in visible light. We look at using ultraviolet light to enhance bruises and bite marks, and search for trace evidence. Infrared photography is used to enhance difficult to see blood on dark and patterned clothing, and tattoos post-mortem difficult to see due to decomposition, lividity and burning [5].

1.3. DNA Sequencer :

Most people are familiar with the importance of DNA testing in the forensic science lab. Most forensic scientists and crime lab technicians use 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 [6].

1.4. 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 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 [7].

1.5. Automated Fingerprint Identification (AFIS) :

Using this technique 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 allows investigators to get a perfect impression of fingerprints at a crime scene without contamination [7].

1.6. 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. 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, 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 [8].

1.7. 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, hydrogen or nitrogen 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 [9].

1.8. 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 (NH^{4+}), nitrate (NO^{3-}), and chlorate (ClO^{4-}), species that are often detected using color change or presumptive tests [10].

2. Conclusion

Forensic Science involves the analysis of biological chemical or physical samples collected as evidence during a criminal investigation. Analytical chemistry is the science that addresses methods used to determine the quantitative or qualitative composition of unknown samples. The use of the analytical chemical information plays important roles in selecting and executing the appropriate chemical analysis technique. The skills of the forensic scientist provide crucial scientific evidence which may link a suspect with the scene of the crime, the victim or the weapon.

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