REVIEW ARTICLE

Utilization of analytical chemistry in crime investigation

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ABSTRACT

Due to advancement in the molecular science development, the utilization of analytical chemistry is becoming important in crime investigation. Involvement of evidence characterization in the forensic investigations is important for reconstruction of events chronology that is further associated with the commission of crime. By knowing chronology of crime events the probability of resolving the legal matter increases that further associated with accurate findings. For the detection as well as discrimination of evidence, various analytical tools and methods are being employed. Basically forensic science deals with the application of analytical chemistry in the discovery of evidence thereby we can say that utilization of analytical tools and techniques are quite relevant to investigate crime to successful extent or to resolve crime related disputes. This chapter clearly focuses on the utilization of analytical chemistry in the investigation of crime.

Key Words: *Microscopy; Spectroscopy; Chromatography; Gravimetric analysis*

INTRODUCTION

In day to day life analytical measurements plays important role such as in the determination of product composition and its qu--ality control. Such measurements also play crucial role in monitoring and protecting environment. Thereby we can say that analytical chemistry is not only confined to only chemistry area but also interlinked with other sciences such as biochemistry, pharmaceutical science, forensic and environmental science. Forensic chemistry utilizes analytical techniques to examine physical traces like fibers, body fluids, drugs and bones. Success can be achieved in analytical chemistry by performing rigorous measurements, by the utilization of problem solving approach and by employing modern instrumentation practices as well as principles [1]. For the evaluation of evidence there are various kinds of analytical techniques and their examples are given below: The first category of general type of technique is microscopic analysis and examples of such analysis are Atomic force microscopy, polarized light microscopy, atomic force microscopy and scanning electron microscopy. The second category of technique comes under elemental analysis and the examples are x-ray fluorescence spectroscopy, neutron activation analysis, atomic absorption spectroscopy and particle induced x-ray spectroscopy [2,3]. The third category is mass spectrometry and examples of such technique are ion mobility spectrometry, isotope ratio mass spectroscopy, secondary ion mass spectroscopy and matrix assisted laser desorption spectrometry. The fourth category is molecular spectroscopy and under this category fluorescence speco--py, Raman spectroscopy, uv-visible spectroscopy and x-ray diffraction. The fifth category comes under separation techniques and examples are capillary electrophoresis, ion chromatography, liquid chromatography, paper chromatography, gas chromatography and thin layer chromatography [4].The sixth and the last general technique is thermal analysis whose examples are differential thermal analysis, pyrolysis gas chromatography, thermo gravimetric analysis and differential scanning calorimeter.

Following are the analytical techniques discussed that are widely implemented.

Organic analytical techniques

For organic compound analysis organic analytical techniques are utilized. The organic compounds are like phenols, aldehyde, alcohols, alkenes, amines, carboxylic acids, ketones and esters. Analytical techniques are employed to analyze such organic compounds in unknown substances. Thus these techniques give us quantitative as well as quantitative detail and thereby identity of an unknown compound can be revealed or we can say that the analysis provides the identity (qualitative result) and the amount (quantitative result). Various analytical techniques used for analysis of organic compounds are:

- Chromatography
- UV- visible Spectrophotometery
- Infrared Spectrophotometery
- Mass Spectrometry

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- Gas Chromatography-Mass Spectroscopy
- Chromatography
- UV- visible Spectrophotometery
- Infrared Spectrophotometery

The inorganic analytical techniques are employed for the analysis of inorganic elements such as C, B, Na, Mg, Al, Si, P, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Sr, S, Ag, Sn, Ba, Pb, V, Mo etc. in the unknown substances. The analysis provides the identity (qualitative result) and the amount (quantitative result). The various inorganic substances that can be utilized to detect the crime scene are mentioned below:

Paint

Paint is made up of three main components, the carrier, the binder and vehicle. Trace elements analyzed in paint: Lead, Cadmium, Chromium, Manganese, Nickel, Aluminum, Copper Mercury, Cobalt, Zinc, Selenium. In investigations one should start to detect the paint composition during crime.

Glass

Glass can be used as evidence in crimes ranging from burglaries, RTA accidents, murder, assault, 'ram-raids, criminal damage and thefts of motor vehicles Trace elements analyzed in glass are: SiO2, B2O3, Fe_2O_3, ZrO_2, Al_2O_3, Na_2O, K_2O, Na_2CO_3.

Footwear and footprint

The print left behind at crime scene can give vital evidence in forensic analysis. These are analyzed by Raman Spectroscopy, Light Microscopy, IR Spectroscopy, Mass Spectroscopy, UV-Visible Spectroscopy, FTIR Spectroscopy, Gas Chromatography, GC-MS, and Stereo Microscopy Chemical Reagents like ninhydrin reagent, diazafluorenone.

Most analytical techniques can be classified as either quantitative or qualitative. A quantitative analysis will result in a measurable amount a quantity. Qualitative analysis, on the other hand, will result in a description or identification of the components of a mixture. Qualitative tests are based on the physical and chemical properties of the sample. Chromatography separates substances within a mixture based on their physical properties Different substances will adhere, or stick, to solid surfaces or dissolve in a solvent differently. In paper chromatography, a small amount of a liquid mixture is placed near the bottom of a piece of paper. The RF value is a qualitative comparison between the length of time the substance is in the mobile phase and in the stationary phase. In paper chromatography, the RF value is the ratio of the distance the substance traveled to the distance the solvent traveled. High-performance liquid chromatography (HPLC) is also known as high-pressure liquid chromatography which 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 (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. 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 (H2), or nitrogen (N2) 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. Spectroscopy also measures the amount of light absorbed, which can be used to determine the concentrations. There are several forms of spectroscopy. Mass spectroscopy is often combined with gas chromatography to identify atoms and molecules by their masses. A sample is loaded into the mass spectrometer and vaporized and ionized, forming charged particles called ions. The ions are then sent through a magnetic or electric field. The path of the ion depends on the ratio of its mass to its charge. The results are recorded on a photographic plate. Every chemical has a unique mass spectrum, making mass spectroscopy useful as a confirmatory test. Atomic absorption spectroscopy (AAS) measures the amount of light of a specific wavelength absorbed by atoms of a particular substance. This technique is especially useful in determining heavy-metal contaminants in air, water, and soil samples. It is also useful when analyzing paint chips. This technique can help forensic scientists determine whether soil or paint at the crime scene can be linked to another location. Ultraviolet (UV) spectroscopy measures wavelengths of light and can be used to determine the concentration of different elements in a solution. The graph produced by UV spectroscopy is compared to that of known substances as part of a quantitative analysis of the data. UV spectroscopy can be used to detect drugs in blood or urine, analyze components of dyes and food additives, and monitor air and water quality.

CONCLUSION

Hence conclusion can be made by knowing that all the techniques mentioned in this chapter have met standard requirements for crime investigation. This is the importance of the analytical chemistry in crime scene investigations, more guilty people get caught and more innocent people are freed. It is definitely one of the most considered advancement in relation with criminal justice. Its reliability also depends on advancement of techniques which in turn depends on knowledge enhancement.

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