

Forensic Chemistry is an Important Part of any Forensic Investigation

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ABSTRACT

Forensic chemistry is applied chemistry in a legal environment. Experts in this field have a wide range of methods and instruments to help identify unknown substances. The range of different methods is important because of the destructive nature of some instruments and the number of possible unknown substances that can be found at the scene. Chemical-physical expertise has a continuous tradition that stretches back several decades. Whether they are an integral part of a department, division or service as an organizational unit, from its beginnings until today, chemical and physical expertise covers the widest area of work, which includes expertise of traces left after explosion, arson, traffic accidents, burglary, pollution environment, etc. In order to be as objective as possible, they apply a number of instrumental methods of analysis in their work. Which method will be applied depends primarily on the type and amount of trace, and it is always necessary to choose the method that will reduce the possibility of sample contamination. Since it is necessary to ensure the preservation of material evidence during the expertise, whenever possible, non-destructive methods certainly have an advantage. Developed methods can analyze a variety of materials including: pigments, glass, building materials, soils, minerals, metals, metal alloys and their corrosion products, organic and bioinorganic materials such as wood, textile, paper, oil-based binders, sugars, adhesives, natural or synthetic coatings, then adhesive tapes, cosmetics, plastics, flammable liquids, post-explosion residues and a whole range of organic and inorganic chemicals.

Keywords: Chemistry; Forensics; Toxicology; DNA

INTRODUCTION

Chemistry is the study of the composition of matter and the changes it undergoes [1]. Forensic chemistry is a specialized area of forensic science involving the applying of chemical principles and techniques to the sector of forensic investigation. The role of forensic chemistry in criminal investigations is vast and ranges from techniques used to collect and preserve evidence, to complex chemical procedures used to identify elements and compounds. Identification procedures are highly reliable

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and are frequently based on the chemical and physical properties of the substance supported by data obtained from analytical analysis. Most chemical techniques used for isolation, purification, and identification is valid forensic techniques; however, chemical analysis differs from forensic chemical analysis in two ways: regulatory and judiciary.

The results of forensic investigation may have a significant impact on lives. Therefore, techniques performed during forensic analysis must be closely regulated to confirm the accuracy and integrity of experimental results. Forensic laboratories must develop two operating manuals designed to fulfil the precise needs of every laboratory. The technical procedures manual outlines the step-by-step details of all procedures utilized in forensic examinations. The quality-control manual is designed to take care of the best standards of reliability and integrity of work done by scientists within the lab. Adherence to both the technical procedures manual and lab quality manual may be a crucial part of any analysis and is strictly enforced both internally and externally. Internal quality control includes, but isn't limited to, periodic instrument calibration, checking reagents for expiration, and performance evaluations on scientists working within the laboratory.

MATERIALS AND METHODS

This work is the result of the expert knowledge of its author and the literature available to him. The paper processing desk method was used.

Biochemistry

Biochemistry is the study of the chemistry that happens in living systems and it focuses on the biomolecules that are the building blocks of living organisms [2]. Biomolecules are organic molecules that (roughly) fall into four categories. Each class serves one or more physiological purposes and is categorized on the premise of largely its organic functional groups. First are carbohydrates or sugars. Carbohydrates are ketones or aldehydes that also contain multiple alcohol groups. Carbohydrates are used primarily for energy storage and structure (at least in plants and insects). Proteins are polymers of amino acids, which contain, not surprisingly, an amine functional group and an acid functional group. These two functional groups are condensed into amide functional groups that knit the amino acids into a polypeptide chain (aka, a protein). Proteins serve as structural elements in animals and, more critically, as chemical catalysts called enzymes that make life possible. Nucleic acids are polymers of sugars, joined together by phosphate ester linkages, which

contain aromatic amines whose shape forms the chemical genetic code through hydrogen bonding. Nucleic acids are the architects and construction contractors of proteins. Finally, lipids are a very diverse group of biomolecules that are characterized by a property, instead of a characteristic organic functional group. Lipids are biomolecules that are more soluble in organic solvents, like ether, than in water. Lipids are largely comprised of nonpolar hydrocarbon functional groups, in additionally to a little proportion of polar functional groups (primarily alcohols, ethers, esters, and ketones) that establish the form and function of the molecule.

Physical Evidence

As automobiles run on gasoline, crime laboratories "run" on physical evidence [3]. Physical evidence encompasses any and every object that may establish that a crime has or has not been committed or can link a criminal offense and its victim or its perpetrator. But if physical evidence is to be used effectively to help the investigator, its presence first must be recognized at the crime scene. If all the natural and commercial objects within a reasonable distance of a crime were gathered so the scientist could uncover significant clues from them, the deluge of material would quickly immobilize the laboratory facility. Physical evidence can achieve its optimum value in criminal investigations only its collection is performed with a selectivity governed by the collector's thorough knowledge of the crime laboratory's techniques, capabilities, and limitations.

Although current technology has given crime laboratory capabilities far exceeding those of past decades, these advances aren't any excuse for complacency on the part of criminal investigators. Crime laboratories don't solve crimes; only a thorough and competent investigation conducted by professional law enforcement officials will enhance the probability for a successful criminal investigation. Forensic science is and will continue to be, a crucial element of the whole investigative process, but it's only one aspect of an effort that has got to be a team effort. The investigator who believes the crime laboratory to be a panacea for laxity or ineptness is sure a rude awakening.

Forensic science begins at the crime scene. If the investigator cannot recognize physical evidence or cannot properly preserve it for laboratory examination, no amount of sophisticated laboratory instrumentation or technical expertise can salvage the case. The know-how for conducting a proper crime scene exploration for physical evidence is

within the grasp of any police department, no matter its size. With proper training, police agencies can ensure competent performance at crime scenes. In many jurisdictions, police agencies have delegated this task to a specialized team of technicians. However, the techniques of crime-scene investigation aren't difficult to master and lie within the bounds of comprehension of the average police officer.

Forensic Science

When the topics of forensic science and crime laboratories are discussed, people tend to think in local terms: One person commits a criminal offense against another within a given jurisdiction, and evidence from the scene is gathered and analyzed [4]. However, crime can have much broader dimensions, often becoming national or international in scope. Consider the ever-present danger of terrorism. Terrorists have traditionally used explosives to inflict damage on targets. The danger of adding to such explosives radioactive material from poorly secured nuclear plants presents an even greater danger and may be a source of concern worldwide.

Forensic science is brought to bear on crime at all levels, from thefts at a local store to the disappearance of radioactive material from a nuclear plant thousands of miles away. Forensic science isn't simply a way of determining what happened at a criminal offense scene. It's the way of thinking and approaching an issue in a very scientific manner that in the end will provide a scientifically sound explanation of past events. We hope that by the top of this course you may know more about chemistry and forensic science, in addition to their importance in solving crimes within the global society.

Forensic science is the application of scientific principles to matters involving the law [1]. This area of science is mostly considered quite fascinating and it continues to experience growing popularity. Many would agree that the present public interest in forensics could be a direct result of CSI-related television programming. These weekly shows have brought a once relatively unknown area of science to the forefront of the public mainstream. Viewers are captivated and intrigued by well-informed scientists working in spotless labs with ominous lighting and a modern music background. The use of cutting-edge technology provides last-minute revelations culminating in the solution of a complex crime. These programs are entertaining and have certainly increased public awareness of the sphere of forensics; but alas, television isn't reality. Although forensic science has indeed experienced tremendous growth, few

would (or should) believe this to be the result of fictional television programming.

Media coverage of high-profile cases has increased over the last decade in both numbers and content. Crime-scene investigation and forensic analysis are brought out of the lab and into the public's "scrutinizing eye." Forensic science, once a broad field, has become segregated into highly specialized disciplines. For instance, forensic chemistry, forensic pathology, forensic dentistry, forensic entomology, and forensic DNA analysis have evolved into independent fields of forensics. It seems more appropriate—and more realistic—to attribute the unprecedented popularity of forensic investigation to enhanced public awareness and a rise in the availability of career opportunities.

DNA

Over the last twenty years, many advances are made in forensic science like DNA technology which has demonstrated that some disciplines in forensic science have made progress with the support of law enforcement [5]. However, there are great differences within the practice of forensic science across various jurisdictions, many because of funding, equipment, and therefore the availability of skilled and well-trained personnel. This fragmentation exists because many of the operational principles and procedures within the forensic science disciplines aren't standardized. Generally, there are not any standard protocols directing the practices for a given discipline. Therefore the standard of practices, in most disciplines, varies greatly thanks to the shortage of adherence to standardized protocols, stringent performance standards, and effective oversight. Because forensic data is mostly used in a court of law (criminal and civil), it's critical to determine whether the forensic data is accepted as evidence. There are two important questions that must be answered before the court should accept and depend on forensic data as evidence in a court trial. They're (1) the insurance that the forensic discipline and practice are founded on a reliable scientific methodology that has the capacity to accurately analyze evidence with known variation, and level of uncertainty to report its findings and (2) the extent to which the results are supported human subjective interpretation which may introduce bias because of the lack of sound operating procedures and stringent performance standards.

Except DNA, our police and prosecutorial agencies are very skeptical about the employment of science in how evidence is collected, and tested, and the way conclusions are drawn

from it. So as to do and understand the resistance observed to the use of science in criminal investigation, we should always first observe the DNA story. DNA did not develop from within a police-driven forensic investigation, but from a typical scientific approach. Due to the use of the methodology, DNA testing utilizes proven standard protocols, and calculated parameters like accuracy, precision, selectivity, confidence levels, and robustness supported rigorously analyzed data. Disciplines like forensic chemistry and toxicology also are derived from the methodology approach, however, they're missing the use of a standardized protocol to use the technology in an exceeding manner which might be acceptable within the scientific community which developed and utilizes the technology.

CSI

Crime scene investigation consists of the documentation, development, collection, and preservation of physical evidence at the scene of a crime [6]. The duties of the crime scene investigator (CSI) are manifold. Crime scene investigators are experts in one or more forensic disciplines like DNA analysis, bloodstain pattern analysis, toxicology, chemistry, and impression evidence (footwear, tire and power marks, and fingerprint technology).

Criminalists are employed with municipal, state, or federal enforcement agencies. While some criminalists work primarily within the laboratory, others respond to crime scenes. The investigator's duties at the crime scene include the thorough documentation of the characteristics and specifics of the scene via notes, photographs, and sketching the scene additionally as including physical evidence, and marking, measuring, collecting, and preserving evidence. Some physical evidence isn't always visible to the naked eye, like latent fingerprints, and often involves additional processing. Casting shoe and tire tracks and analysis of bloodstain patterns provide information about the events that led to the bloodshed. Bullet trajectory provides information about the placement of the shooter and also the victim during the incident. Special equipment is required to perform those special tasks. Professionalism within the handling and application of forensic tools, whether it's a trajectory laser or chemicals to detect blood, is imperative for a thorough crime scene investigation.

The field of forensics has never been black and white [7]. The answer to many questions regarding the analysis of evidence may be summed up by the phrase "it depends on the case circumstances." Investigation at crime scenes specifically is

an ever-evolving matrix of circumstances, and no two scenes will ever be treated exactly alike. Confounding the problem of situational uncertainty is the proven fact that crime scene investigations are often conducted by multiple individuals and agencies. Like cogs in a wheel, everybody encompasses a different responsibility that matches along with the work everyone else is doing. From sworn First Responders to Forensic Specialists, Criminalists, and other nonsworn professional staff, everyone has their part to play.

For crime scene investigators (CSI), the gathering, documentation, and preservation of evidence are the most important and significant aspect of their job. An investigator needs to think outside the box to successfully perform his or her duty, which function doesn't stop at evidence collection; it extends to report writing and potentially testifying in court. A CSI generally only sees the aftermath of a crime, and it's the responsibility of that investigator to assist put the pieces of what happened back together. Like producing a puzzle, these pieces will ultimately provide the jury with the massive picture they need to form a decision within the case.

Generally, CSIs tend to operate in hazardous and demanding situations, often where body fluids, like blood or semen, are shed [8]. These body fluids, together with other body materials, like vomit and faeces, carry varying degrees of risk of infection to the CSI through blood-borne viruses. The most blood-borne viruses the CSI should be aware of are those which can cause hepatitis or human immunodeficiency syndrome (HIV). the foremost likely cause of infection for a CSI is coming into direct contact with contaminated blood through splashes into the eyes, nose, mouth or an open cut, or an injury caused by a needle or broken surface like glass or wood. When handling small quantities of body fluids or related material, like taking a swab at a crime scene, a CSI should as minimum wear latex or nitrile gloves, goggles, and a mask or respirator that covers both nose and mouth. The mask or respirator must be of a kind that has been specifically designed to stop ingestion of blood-borne viruses. If larger quantities of blood are shed then the CSI would also wear a disposable over a suit (most of which are resistant to splashes) and plastic overshoes in order to prevent the transfer of body fluids to his/her own clothing. If sharp surfaces are to be handled for evidence recovery then 'slash resistant' gloves must also be worn.

This type of clothing is termed personal protective equipment (PPE) and includes any items which are to be used or worn by the CSI to stop injury or illness and may

be made available by the employer. Disposable PPE, like over suits, could also be retained as evidence to indicate that they were worn within the crime scene by the CSI, thus preventing the contamination of evidence from their own clothing. However, the retention of all disposable articles worn as PPE raises issues in relevancy the quantity and sort of storage available. If there's any likelihood that the clothing has come into contact with body fluids, they must be disposed of through a clinical waste contract arranged by the law enforcement agency. The CSI must make a written note of the disposal of the things and therefore the reason why they have been disposed. All CSIs would be strongly advised to consider inoculations against hepatitis A, B, and tuberculosis and also to receive a tetanus booster.

The actual processing of things of evidence within the scene could be a significantly intrusive action [9]. Powder deposits, superglue fuming, or other chemical enhancement techniques for latent prints clearly change an item's original condition while also altering the scene. Luminol, fluorescein, or leuco-crystal violet enhancements of bloody prints and pattern transfers can alter the scene yet. Oftentimes, this alteration doesn't change the outward appearance of an item; rather, it introduces chemicals which will damage or alter the original condition of other evidence (e.g., DNA [deoxyribonucleic acid]). Regardless of the mechanism, processing will alter the evidence being processed and, more than likely alter the scene. Processing techniques for various items of evidence are nearly always the last actions taken by the technician within the overall scene-processing methodology. Ultimately, all of those items of evidence must be analysed to establish what all defines in and of itself and what the various interrelated pieces may define about events that occurred during the crime. Scientific analysis is usually an intrusive act.

The crime scene technician constantly considers every method and process employed at the scene in an endeavour to determine where within the overall sequence it belongs. Only by conscious effort and careful consideration can the technician hope to prevent unnecessarily altering or damaging the scene, its contents, and also the associated context. Obviously, there are instances during which the rules are ignored. Consideration of fragile evidence, initial searches of the scene for a suspect and lifesaving efforts all require immediate emphasis. But beyond these exigent situations, scene processing falls into an orderly and relatively simple sequence of events. During this simplest form, the order is to watch, document, search, collect, and

process, all the while assessing the situation and remaining flexible. Interestingly enough, technology advances haven't changed this order. Adherence to the current basic order provides the best probability of achieving the underlying purpose of crime scene processing.

Laboratory

The chemistry section of a crime lab is named on to consider differing types of evidence in a variety of different crimes [10]. They'll be asked to conduct examination of suspected drugs, to identify some unknown substance located within the crime scene, to look for and isolate accelerant residues in fire scene evidence, to isolate and identify toxins used in poisonings, or to evaluate blood samples for drugs and alcohol. With the efforts now directed at environmental crimes, chemical analysis may play a significant role in identifying contaminants dumped or deposited in an environmental crime scene. There really is not any limit to the questions which may be posed about some substance found or related to a criminal offense. Analysis is accomplished using a form of instrumentation, including gas chromatography (GC)-mass spectrometry, UV and infrared spectrometry, as well as a host of other procedures (e.g., microcrystalline test, pyrolysis).

In the crime scene, evidence that will require chemical evaluation is collected in its entirety unless there's a big volume. Unknown dried substances are often packaged in paper bindles and enclosed in envelopes or other containers. Liquid samples are often collected using a clean pipette and contained in a sealable glass or plastic bottle. If large volumes of liquids are present, a sample of 10 cc is typically sufficient for subsequent analysis. Evidence that will be examined for the presence of accelerants is usually collected and sealed in clean, unlined paint cans or glass jars. Plastic isn't impervious to petroleum products, so storing arson evidence in plastic has the potential for trace amounts of the accelerant to interact with the plastic, thus eliminating or changing the evidence. The most effective response for temporary storage is arson bags available from forensic suppliers. When used, these bags must be double-sealed to prevent any vapors from escaping. Additionally, these bags are used as an outer seal for paint cans or other final containers holding suspected accelerants. When seized, suspected accelerant evidence should be submitted to the lab immediately for analysis.

Many types of laboratories engage in the chemical analysis [11]. In forensic science laboratories, a wide variety of chemical, biological, and physical analyses are undertaken.

The principal difference between forensic analysis and more general analysis is that the degree of certainty required of the results. The technical issues depending on the nature of the sample: particularly, on whether bulk samples or invisible traces are being sought. Bulk samples are considered to be anything that's visible to the naked eye and may range from micrograms to several kilograms of material.

The most obvious difference between analyses of bulk versus trace samples is that the relationship between the sample and the environment. Sometimes the required analyte is also within the environment, and sometimes a species within the environment (e.g., water, oxygen, iron particles) may degrade the sample or affect the results. The analyte within the environment isn't generally a problem in bulk samples. In trace samples, the amount of contamination is also large enough to distort results. Thus, if the sample contains a little amount of the analyte sought and also the environment contains an oversized concentration of that species, extreme precautions will have to be taken to protect the sample and exclude contact with the environment. Conversely, if the sample contains an oversized concentration of the analyte and also the environment a small amount, the issue is trivial. An understanding of the composition of the background environment is therefore highly desirable, but not always possible. This needs to be considered when reporting results.

Unfortunately, forensic chemists don't always have control over the vital aspect of the collection and packaging of the materials they have to examine. There's a world of difference between the effort and preplanning required for managing an oversized bombing attack which is required for the investigation of a bombing of a mailbox or single residence. Most forensic scientists will only deal with the latter. Nonetheless, preplanning will be worthwhile. Clean containers and packaging materials should be procured and stockpiled ready to be used. Samples of such items are disposable scoops, scrapers, dustpans, and brushes, as well as metal cans and nylon bags of various sizes. Similarly, collection devices like brushes, scoops, scrapers, vacuum pumps, and filters should be obtained. Mini vacuums can be constructed from disposable plastic tubing, syringe filters, and plastic syringes.

Preferably all items used for collection should be subjected to quality assurance tests before use. The easiest way to make sure the cleanliness of tools used for the collection of trace explosive evidence is to use disposable items from a known supplier which have just come from the box. If possible, a statistical sample of every item should be pre-screened

before operational employment. However, if a pre-screen isn't possible, a more rigorous regime of analysis of blank and control samples can be substituted. It's to be understood that this could entail the risk of loss of evidence if a control is analysed as being positive. It should even be noted that suitable control samples should still be obtained, even with the use of pre-screened materials.

CONCLUSION

Analysis by forensic chemists can provide clues to investigators and they can confirm or refute their suspicions. Identifying the various substances found at the scene can tell investigators what to look for during a search. For example, during a fire investigation, forensic scientists can determine how the fire occurred, or what caused it. If traces of fuel are found, this suggests that the fire was intentionally set. During a poison investigation, the existence of certain poisons can give investigators an idea of which direction the further course of the investigation should lead.

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