PART-I
CHAPTER-I

Introduction: Forensic Science – Some relevant aspects; Need for innovative experiments based on Physico-Chemical Interactions

Forensic science forms a unique partnership with law enforcement and law. However, persons involved are completely unknown to each other. The role of a Forensic Scientist is:

i) To perform investigating examinations of forensic exhibits and laboratory tests to reach a conclusion and provide experimental proof of the crime beyond an iota of doubt.

ii) To explore innovative experiments to supplement and improve the exciting method for crime detection with irrefutable authenticity.

iii) To suggest suitable measures to improve the results.

iv) New experiments should be developed for understanding crime and criminal activities which are yet to be fully developed.

A Forensic Scientist is the communicator and interpreter of these investigating findings of the forensic exhibits associated with crime in a court before the judge, the interpreter of law.

Crime perpetrators usually try to destroy the evidences. In arson cases and explosions, much of the evidences are lost by the burning flames. Extensive fire extinguishing processes by water flushing usually wash and destroy many of the evidences before the investigating team reaches the crime scene or spot. Considerable time lapse occurs in between the crime committed, collection of
samples and sending it to the laboratory. As such the forensic scientists have to experience enormous difficulties as listed below.

1. He has no control over the highly contaminated samples collected from crime scenes. Some of the samples may even be doctored or manipulated.

2. Availability of the samples is usually small and pure samples recovered from the exhibits are minute.

3. Replenishments of the samples for examination are not possible as crime cannot be repeated.

4. Generally, there is a long time lag between the collection of the samples and their analysis in a laboratory. Considerable changes or decomposition of the experimental exhibits may take place in between the process of transportation and analysis.

5. Preferences should be given to analysis by non-destructive techniques to preserve the samples.

Analysis of the samples demands the dedication and the experimental skill of the scientists. The results obtained have to be supported with highly sophisticated instruments which can ensure accuracy and assure reproducibility, repeatability, specificity and capability of detection of trace quantities of samples in the ng region or even lower.

Forensic science is the application of science to those criminal and civil laws that are enforced by police agencies in a criminal justice system or science dealing with legal aspects, has been named as Forensic Science [1].
Forensic science is a multidisciplinary as well as intra-disciplinary subject comprising almost all branches of science of which chemistry occupies the pivotal position. Forensic science depends on physical evidences, their classification, identification (physical and chemical identity with proper comparison with known compounds) and individualization based on some cardinal principles [1-3]. These are

1. Law of individuality: every object either natural or man made has an individuality which cannot be duplicated. Thus, the crime and the criminal are firmly interrelated.

2. Principle of exchange: accordingly to Locard principle, a mutual exchange of traces takes place between the criminal and the victim and the object involved in the crime.

3. Law of progressive change: every thing changes with the passage of time.

4. Principle of comparison: only the like can be compared with the like.

5. Principle of analysis: analysis of evidences, analysis of samples collected.

6. Law of probability: arriving at a probable conclusion from the circumstantial evidences and analysis of collected samples the probable.

7. Physical evidences cannot tell lie, man can do.

Therefore, forensic science depends on physical evidences and their classification, identification and individualization.

According to Saferstein [1] crime laboratories run on physical evidences. Physical evidence encompasses any or all objects which can establish that a crime has been committed or can provide a link between a crime and its victim or a crime and its perpetrators.

Forensic science begins at the crime scene. But a forensic scientist is concerned with the evaluation of physical evidence using modern sophisticated techniques having a high
precision. Solid scientific reasoning and intuition are necessary to interpret the data available so that a criminal can be apprehended but no innocent is harassed.

**Physical evidence:** Every material in existence could become evidences at some time i.e., any object that can establish that a crime has been committed or can provide a link between a crime and its victim or between a crime and its interpreter.

Common types of physical evidence as classified by Saferstein [1,4], Eckert [2b], Kirk [5] Camp [6] etc for identification and comparison are:

1. Body fluids, viscera and body tissues of various organs to be analyzed for poisons, drugs or alcohol, quantitation for determining dosage taken.
2. Blood, semen and saliva (in liquid or in dried form related to crime and criminals) to be checked for species, type and genetic data.
3. Licit and illicit pills (unauthorized drugs and controlled substances, vegetable matter and pipe residues for the presence of controlled substances).
4. Hairs, (animal or human origin) if human, the race, body area of origin and general characteristics.
5. Fibers, to determine type (animal, vegetable, mineral or synthetic) composition, dyes used and processing marks.
6. Liquor, for alcoholic proof, trace alcohols, sugars, colorants and other signs of adulteration.
7. Paints, glass, plastics including plastic bags, rubber and other polymers, metals, soils and minerals to classify and compare to known materials.
8. Questioned documents including hand writing, type writing, ink, bounder charred documents etc. to determine type, dye content, possible age, also chemical obliterations and restoration of charred documents.
9. Swabs from the hands of the suspect (for gun shot residues).
10. Debris from a fire or explosion scene for used explosive or explosive residues or other accelerants.
11. Fire arms, ammunition and projectiles etc.
12. Oil, cosmetic products, petroleum products like grease.
13. Impressions like finger prints, palm and foot (shoe) prints, soil conditions, bite marks in skin or in food stuffs.
14. Wood and other vegetative matter, powder residues.
15. Serial numbers.
16. Tool marks.
17. Vehicle lights.

The examination of physical evidence by a forensic scientist is undertaken for identification or comparison.

**Identification:** Identification is the process of determining a substance’s physical or chemical identity. Drug analysis, species determination and explosive residue analysis are some typical examples for identification in forensic science.

**Comparison:** Comparison is the process of ascertaining whether two or more objects have a common origin. A comparison analysis subjects a suspect specimen and a control specimen to the same tests and examinations for the ultimate purpose of determining whether or not they have a common origin e.g. comparison of narcotic samples.

**Individual characteristics [4]:** Evidence that can be attributed to a common source with an extremely high degree of certainty is said to possess individual characteristics.

**Crime scene reconstruction [4]:** Crime scene reconstruction is the ultimate task for the forensic scientists. Reconstruction is the method used to support a likely sequence of events by the observation and evaluation of physical evidence as well as statements made by those involved with the incident.

**Preliminary aspects of forensic investigations:**

The determination of physical or chemical identity of the substances mostly chemicals (like drugs, explosives, petroleum products, blood etc.) and their proper identification
and quantitation require the adoption of different analytical techniques of high precision, so that the results are authentic, reproducible and can be carried out with minimum quantity of the samples. Proper handling and preservation of physical evidences left behind the crime-scene play a crucial role in reconstruction of events. Obviously, it should be a combined team effort consisting of law enforcing personnel, medical examiners, criminologists etc. However, the most important part has to be played by the forensic chemists. Most of the forensic investigations depend on the analysis of organics and inorganics, the constituents of all the substances on earth.

**Forensic Science and Drug Abuse [4, 7-12]:**

Drugs are natural or synthetic substances that are used to produce physiological or psychological effects in human or other higher order animals.

Drugs have different connotations depending on their use and intention of use. It may be used

1. to combat diseases endangering the life and thus sustaining or prolonging life.
2. to escape from the pressure of life.
3. to end life.

The last two are related to crime and forensic science.

Crime is on the increase. The ingenuity of criminals led to the development of newer and newer means of committing crimes. Moreover, in the modern society, passion for money, power, political rivalry, frivolous amusements etc. are the reasons for the social crimes to become an everyday affair. Crime and crime pattern also change with time.

Forensic investigation of crime starts from the crime scene, collection of exhibits, transportation of the exhibits to the laboratory and proper analysis. Naturally, the methods for identification and quantification change with the use of modern techniques with sophisticated instruments. However, the new methods have to be devised for the detection and quantification of forensic samples as the older methods are cumbersome and time consuming in some cases. Ingenuity and intelligence of the analysis also lead to the development of new and better methods of analysis.
In recent years, forensic examination schemes or protocols are much more formalized. This is dictated not only by technical considerations but also the recognition that procedures must meet the requirements of the legal system [13]. The forensic problems are complex and there is no single answer. The techniques to be used must all be acceptable to the scientific community and the main errors associated with particular methods must be eliminated. It was accepted that a single analysis is insufficient to make an identification but the number required depends on how mutually exclusive the techniques are [14-19].

The materials of forensic interest are both inorganic and organic chemicals. Inorganic chemicals like K/NaClO₃, K/NaNO₃, Ca/Mg(NO₃)₂, As₂S₃, Al powder etc. are extensively used. The different combinations of these ingredients are utilized for the preparation of IED (improvised explosive device) usually known as low explosives. They are, however, responsible for more than 80% devastating explosions worldwide [14-20]. NH₄NO₃ and other nitrates [21,22] form the blasting materials in commercial blasting agents and IEDs. ANFO (NH₄NO₃ + fuel oil), slurry/ emulsion/ gel explosives are some other explosives. But most of the compounds of forensic interest are organic materials like drugs, organic explosives, pesticides etc. Some of these compounds are listed in tables (1-4). There are always new additions to the lists.

Drugs are often classified according to their chemical structure and pharmacological effects they produce on the body [7-12] e.g Stimulant and anorectics, anti-depressants, analgesics anti-inflammatory, antihistamines etc. Table 1 contains a list of drugs usually abused to a high degree.
<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Stimulant and anorectics</th>
<th>Anti Depressants</th>
<th>Analgesics anti-inflammatory</th>
<th>Antihistamines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adrenaline</td>
<td>Amitriptyline</td>
<td>Amidopyrine</td>
<td>Antazoline</td>
</tr>
<tr>
<td>2</td>
<td>Amphetamine</td>
<td>Butriptyline</td>
<td>Aspirin</td>
<td>Bamipine</td>
</tr>
<tr>
<td>3</td>
<td>Benzphetamine</td>
<td>Clomipramine</td>
<td>Baclofen</td>
<td>Chlorpheniramine</td>
</tr>
<tr>
<td>4</td>
<td>Caffeine</td>
<td>Desipramine</td>
<td>Clonixin</td>
<td>Cimetidine</td>
</tr>
<tr>
<td>5</td>
<td>Chlorphentermine</td>
<td>Dibenzerpine</td>
<td>Diclofenac</td>
<td>Cinnarizine</td>
</tr>
<tr>
<td>6</td>
<td>Cyclopentamine</td>
<td>Doxepin</td>
<td>Fenbufen</td>
<td>Clemizole</td>
</tr>
<tr>
<td>7</td>
<td>Dimeflidine</td>
<td>Imipramine</td>
<td>Fenclofenac</td>
<td>Deptropine</td>
</tr>
<tr>
<td>8</td>
<td>Ephedrine</td>
<td>Maprotiline</td>
<td>Feprazone</td>
<td>Dimethindene</td>
</tr>
<tr>
<td>9</td>
<td>Fenclamfamin</td>
<td>Nialamide</td>
<td>Ibuprofen</td>
<td>Dimethothiazine</td>
</tr>
<tr>
<td>10</td>
<td>Heptaminol</td>
<td>Noxiptyline</td>
<td>Indoprofen</td>
<td>Doxilamine</td>
</tr>
<tr>
<td>11</td>
<td>Mescaline</td>
<td>Opipiramol</td>
<td>Ketoprofen</td>
<td>Halopyramine</td>
</tr>
<tr>
<td>12</td>
<td>Methamphetamine</td>
<td>Phenelzine</td>
<td>Naproksen</td>
<td>Meclozine</td>
</tr>
<tr>
<td>13</td>
<td>Methylamphetamine</td>
<td>Protriptyline</td>
<td>Paracetamol</td>
<td>Mepyramine</td>
</tr>
<tr>
<td>14</td>
<td>Nicotine</td>
<td>Tofenacin</td>
<td>Phenacetin</td>
<td>Methapyrilene</td>
</tr>
<tr>
<td>15</td>
<td>Oxedrine</td>
<td>Trazodone</td>
<td>Salicylic acid</td>
<td>Pheniramime</td>
</tr>
</tbody>
</table>
The drugs commonly encountered in forensic investigations and some of their uses are listed in Table-2.

**Table-2 [7]**

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Name of drug</th>
<th>Type</th>
<th>Mode of Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heroin</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>2</td>
<td>Morphine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>3</td>
<td>Codeine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>4</td>
<td>Acetyl-morphine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>5</td>
<td>Ganja</td>
<td>Psychomimetic</td>
<td>Smoking</td>
</tr>
<tr>
<td>6</td>
<td>Charas</td>
<td>Psychomimetic</td>
<td>Smoking</td>
</tr>
<tr>
<td>7</td>
<td>Cocaine</td>
<td>Local anesthetic</td>
<td>Injecting or snuffing</td>
</tr>
<tr>
<td>8</td>
<td>LSD</td>
<td>Hallucinogen</td>
<td>Orally</td>
</tr>
<tr>
<td>9</td>
<td>Diazepam</td>
<td>Tranquillizer</td>
<td>Orally</td>
</tr>
<tr>
<td>10</td>
<td>Nitrazepam</td>
<td>Hypnotic</td>
<td>Orally</td>
</tr>
<tr>
<td>11</td>
<td>Methaqualone</td>
<td>Sedative</td>
<td>Orally</td>
</tr>
<tr>
<td>12</td>
<td>Lorazepam</td>
<td>Tranquillizer</td>
<td>Orally</td>
</tr>
<tr>
<td>13</td>
<td>Acetylcodeine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>14</td>
<td>Alprazolum</td>
<td>Tranquillizer</td>
<td>Orally</td>
</tr>
<tr>
<td>15</td>
<td>Hashis</td>
<td>Psychomimetic</td>
<td>Smoking</td>
</tr>
<tr>
<td>16</td>
<td>Papaverine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>17</td>
<td>Narcotine</td>
<td>Narcotic analgesic</td>
<td>Orally or by injection</td>
</tr>
<tr>
<td>18</td>
<td>Dextropropoxyphine</td>
<td>Narcotic analgesic</td>
<td>Orally</td>
</tr>
<tr>
<td>19</td>
<td>Amphetamine</td>
<td>Central stimulant</td>
<td>Oral and rectal</td>
</tr>
<tr>
<td>20</td>
<td>Phenobarbitone</td>
<td>Barbiturate</td>
<td>Orally</td>
</tr>
<tr>
<td>21</td>
<td>Allobarbitone</td>
<td>Barbiturate</td>
<td>Orally</td>
</tr>
</tbody>
</table>

Explosives (Table-3) are used for military and other commercial blasting purposes like

i) road construction,

ii) tunneling,
iii) seismic studies, exploration of minerals etc.

But many of the nitro compounds in explosives have good medicinal properties.

**Table-3**

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Name</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trinitrotoluene</td>
<td>![Structure of Trinitrotoluene]</td>
</tr>
<tr>
<td>2</td>
<td>Dinitrotoluene</td>
<td>![Structure of Dinitrotoluene]</td>
</tr>
<tr>
<td>3</td>
<td>Dinitrobenzene</td>
<td>![Structure of Dinitrobenzene]</td>
</tr>
<tr>
<td>4</td>
<td>Trinitrobenzene</td>
<td>![Structure of Trinitrobenzene]</td>
</tr>
<tr>
<td>5</td>
<td>PETN</td>
<td>![Structure of PETN]</td>
</tr>
<tr>
<td></td>
<td>Compound</td>
<td>Structural Formula</td>
</tr>
<tr>
<td>---</td>
<td>------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>6</td>
<td>RDX</td>
<td><img src="" alt="RDX Structure" /></td>
</tr>
<tr>
<td>7</td>
<td>Nitroglycerine</td>
<td><img src="" alt="Nitroglycerine Structure" /></td>
</tr>
<tr>
<td>8</td>
<td>Tetryl</td>
<td><img src="" alt="Tetryl Structure" /></td>
</tr>
<tr>
<td>9</td>
<td>Picric acid</td>
<td><img src="" alt="Picric acid Structure" /></td>
</tr>
<tr>
<td>10</td>
<td>HMX</td>
<td><img src="" alt="HMX Structure" /></td>
</tr>
</tbody>
</table>
Pesticide is the general term for insecticide, herbicides, fungicides, rodenticides, molluscides and similarly active compounds. Now there are more than 10,000 different pesticides. Some pesticides commonly encountered in forensic investigations are listed in Table-4.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Malathion</td>
<td>Insecticide</td>
</tr>
<tr>
<td>2</td>
<td>Parathion</td>
<td>Insecticide</td>
</tr>
<tr>
<td>3</td>
<td>Aldrin</td>
<td>Insecticide</td>
</tr>
<tr>
<td>4</td>
<td>Chlordane</td>
<td>Insecticide</td>
</tr>
<tr>
<td>5</td>
<td>Endrin</td>
<td>Insecticide</td>
</tr>
<tr>
<td>6</td>
<td>Carbaryl</td>
<td>Insecticide</td>
</tr>
<tr>
<td>7</td>
<td>Methyl Parathion</td>
<td>Insecticide</td>
</tr>
<tr>
<td>8</td>
<td>2,4-dichlorophenoxy acid</td>
<td>Herbicide</td>
</tr>
<tr>
<td>9</td>
<td>Thiram</td>
<td>Fungicide</td>
</tr>
<tr>
<td>10</td>
<td>Zinc phosphide</td>
<td>Rodenticide</td>
</tr>
</tbody>
</table>

Various sophisticated instruments are available for identification of the compounds and their quantitative estimations with high precision [23-25]. Some of the instruments available and used in Central Forensic Science Laboratory (CFSL) in Kolkata are IC, SEM/EXDA, AAS – for analysis of inorganic ions. UV-Visible Spectrophotometry, FTIR spectrophotometer having auto image microscope with MCT detector working at 77K, TLC, HPTLC, HPLC (FID), GC-MS, LC/MS/MS for the identification and quantification of organic compounds. There is a long list of authoritative books on these instruments and their working, mention has been made only for a few used extensively for forensic analysis [26-29].
Crime and crime pattern change with time and the methods of investigation and detection of crime have been changing continuously with the development of newer techniques, with the use of new sophisticated instruments.

The forensic problems are complex and there is no single answer. The exhibits received for forensic investigations are diverse in nature and cover a large number of different topics. Naturally, one has to limit his/her studies and focus his/her attention on some specific topics of interest and utility.

In this dissertation, innovative methods were utilized to identify and also quantify some of the forensic exhibits which are of forensic, pharmaceutical and medicinal interest like

i) forensic investigation of arson, petrol and diesel adulteration,

ii) alcohol poisoning, methanol and water content in alcohol, alcohol intoxication and determination of blood alcohol concentration,

iii) determination of phenolphthalein from colorless solutions in trap cases.

There are available methods which are cumbersome and time consuming and which do not give desired results (e.g., in trap cases and arson). Moreover, new method are always welcome for better analysis and to satisfy the requirements of forensic science that the exhibits should be analyzed by more than one technique to justify the requirements of legal systems.

It is to be noted that the instrumental methods of analysis of forensic exhibits, the development of new and old technique of forensic analysis are based on physico-chemical principles and physico-chemical interactions of compounds of forensic interest with suitable agents. All chromatographic methods like TLC, HPTLC, HPLC, Gas chromatography, Ion- chromatography are based on physico-chemical principles of adsorption of compounds of interest and elution with suitable solvents. R_f and TIC values of the explosives, drugs, pesticides are dependent on the absorbent, absorbate and polarity, viscosity and time of flow of the eluting solvents etc. The detection and estimation of drugs, explosives etc. are based on complex formation of the drugs, explosives with suitable chromogenic agents.
Arson and investigations on petroleum adulterations [4, 30-32]:

Investigations on arson and explosion cases are extremely complex and difficult. The investigation patterns of arson and explosions contain both common and different features. Some aspects of arson cases are considered in this dissertation.

Arsons are usually committed by the miscreants according to their convenience and planning. They usually try to destroy the evidences as far as practicable. Moreover, extensive destruction of evidences by fire and subsequent attempts to extinguish fire by water flashing and other methods and deliberate destruction or damage of the evidences are made.

Bride burning, a deliberate and cold-blooded arson are very common in India. In many cases, it is related to non-fulfillment of promises of non-payment of dowry and other demands. Brides are burnt by sprinkling of kerosene or other inflammable materials on her garments and body and setting fire. Efforts are then made to destroy all relevant evidences by water flashing and/or other substances. In such cases, inner garments of bride, wood-flooring, debris like burnt bed-sheets, rugs, upholstery and rags are usually sent by the investigating team to the forensic laboratory for analysis.

However, in course of arson cases, collection of ash and soot debris must be done at the point of origin of fire. Porous substances and other materials supposed to contain flammable residues like wood-flooring, rugs, upholstery and rags and other collected specimens should be packaged immediately in air-tight containers (half or two-thirds full leaving sufficient air-space in the container) to avoid leakage of volatile-substances.
Plastic or polyethylene bags should be avoided. Uncontaminated substances from other areas should also be collected.

These are the jurisdiction of arson investigators. However, in many cases, investigators reach the place late. Properly sealed substances are usually sent to the Forensic science Laboratory.

The substances in the container should be heated to gel vapors of the volatile constituents in the headspace which may be analyzed by GC to get an idea regarding the fire accelerators like kerosene, diesel etc. from the resultant chromatographic pattern of the volatile constituents. The constituents present can be ascertained from library matching of the chromatographic patterns of known kerosene, gasoline samples etc. There are other modifications to get the constituents present in the debris.

Complex chromatographic analysis can well be determined using GC-MS where each of the constituents are fragmented into ions to get the constituents present.

However, the matter is complex and the important lacuna is that though the accelerants are invariably used but the chemical analysis of the accelerants present in fire debris are not properly studied. Moreover, the debris are not collected properly immediately after the fire extinguished and the containers are not properly sealed to protect the volatiles. Environmental factors (temperature, pressure, air flow) must be controlled and no contamination even during transport and storage should be allowed.

For detection, human nose is important. Sniffers can detect the volatiles but with a degree of uncertainty. However, even in the laboratory experiments, there is little chance for the detection of volatiles. From GC-MS, the constituents and their pattern recognition, important clues are obtained.

However, in recent years, direct sensing of chemicals i.e. chemical sensing is possible with advanced appliances. Sensors are classified according to the activity required by the sensing system. A system may be passive, active or semi-active. Passive sensors do not produce any emanation directed towards the target. They are based on sensing something emanated or released by the target without stimulation by the sensing
Active sensors on the other hand need no emanation or release of anything from the target. They provide some sorts of emission that interact with the targets. Active sensor senses the alteration in its emission by the targets. Semi-active sensors provide a stimulation that produces some sensible emission or emanation from the targets which then they sense in the manner of passive sensors.

These bulk sensors like X-ray techniques, Neutron $\gamma$-sensors, electromagnetic techniques like NMR and NQR, magnetic resonance imaging or computer aided tomography (CAT). There are trace sensors like differential reflection spectroscopy (DRS), aroma sensing biosensors etc.

These are not within the preview of our work and not available in CFSL. But innovative methods must be adopted in detecting the trace material in arson cases and give positive opinion regarding arson.

This led us to try a simple method using FTIR with auto-image spectroscopy and GC-MS.

**Alcohol poisoning, Alcohol adulteration and Blood alcohol concentration [4, 33-36]:**

Distribution and sale of illicit drugs and their misuse (called drug abuse) are the causes of various diseases and eventual termination of lives of drug addicts. However, ethyl alcohol or alcoholic beverage, a legal drink used extensively all over the world is the cause of anxiety both from the point of view of health and legal considerations. Determination of alcohol concentrations in alcoholic beverages is of importance for the imposition of the custom and excise duties. Contamination of alcohols by methanol or other contaminants is of importance from the social, legal and forensic point of view. The legal drinks i.e. alcoholic beverages are the causes of untold miseries like automobile death, traffic death (alcohol related), fatal injuries including loss of limbs of common peoples and properties(like automobiles), permanent disability and alcohol intoxicated murders.
Acute toxicity occurs when tranquillizers, antidepressants, sedatives are administered with alcohols. Alcohol intoxication not only causes the death of innumerable persons and in terms of compensation, billions and billions of dollars are spent world-wide.

In case of drug poisoning, drug recognition expert (DRE), medical examiners and toxicologists are associated with the determination of presence of alcohols, drugs, their metabolites and their concentrations in the body.

Toxicologists play a very significant role in detecting and identifying the presence of drugs and poisons along with their metabolites in body fluids, tissues and organs. They have additional responsibility of monitoring the intake of drugs, other toxic substances i.e. monitoring of blood and urine for children exposed to leaded paints or addicts enrolled in methadone maintenance programs.

It is not possible to describe in details the working and methodologies for toxicological examinations, their findings etc. But the following chart can be a guide for techniques used in toxicology in a nutshell.
Alcohol is extensively consumed as alcoholic beverages in all over of the world. Naturally, misuse of alcohol in various possible ways is very common. The objects of the present investigations are

i) the determination of alcohol in alcoholic beverages essential to find the strength (proof) of alcohol in beverages necessary for the imposition of customs and excise duties,
ii) methanol poisoning in alcoholic drinks and % of methanol in ethanol,
iii) alcohol concentration in blood from the forensic and medical point of view.

Alcohol is commonly consumed as alcoholic beverages. It passes across the wall of the stomach and small intestine into the blood stream and is rapidly distributed in all parts
of the body. Alcohol in blood can be detected within minutes as it reaches the peak (i.e. highest concentration) in the process of absorption and decomposition. Blood consumption is rapid in empty stomach but relatively slow if taken after food. Elimination of alcohol is accomplished by oxidation to CO$_2$ (nearly 95-98%) and the rest is excreted unchanged in the urine, breath and perspiration. However, the distribution of alcohol between the blood and alveolar air is the basis of Blood alcohol concentration determination. It has been observed that the amount of alcohol exhaled in the breath is in the direct proportion to the concentration of alcohol in blood. The decomposition at which the breath leaves the mouth is normally 34°C. At this temperature, the ratio of alcohol in the blood to alcohol in alveoli air is approximately 2100:1.

A breath test reflects the alcohol concentration in the pulmonary artery and is reflective of the concentration of alcohol reaching the brain and thus accurately reflects the affects of alcohol on the subject.

**Determination of Blood Alcohol Concentration (BAC):**

Blood alcohol concentration can be determined a) using breath analyzer and b) estimating of alcohol in blood directly. For the determination of alcohol intoxication for drivers, motorists etc. it is desirable to know the concentration of alcohol in blood of the alcoholics. But it is not physically possible to draw blood from the vein of the motorists, drivers etc. on the spot. Naturally, breath analysis is a convenient alternative. It is done using Breath Analyzer first developed by R. F. Borkenstein but it has undergone various modifications to have improved model for Breath Analyzer.

The method of estimating alcohol is based on the reaction between alcohol and potassium dichromate in presence of AgNO$_3$ as catalyst. The reaction is

$$2K_2Cr_2O_7 + 3C_2H_5OH + 8H_2SO_4 \rightarrow 2Cr_2(SO_4)_3 + 2K_2SO_4 + 3CH_3COOH + 11H_2O$$

Thus, the differences in o.d of K$_2$Cr$_2$O$_7$ solution before and after the reaction in the region 420 nm determine the alcohol concentration in breath. This is multiplied by 2,100 to get the concentration of alcohol in blood.
The testing procedure is changed to use IR light absorption at a suitable wavelength. If alcohol is present in the breath of an alcoholic, it will be captured in the breath chamber. A monochromatic light of suitable wavelength interacts with alcohol. The intensity of light is decreased and monitored by the detector of the instrument to give the concentration of alcohol in the breath analyzer.

The process is akin to the working of a fuel cell which converts fuel (here alcohol) and oxidant (atmospheric O$_2$) generating a current (electrical) that is proportional to the quantity of alcohol present in the breath.

**Direct determination of Blood Alcohol Concentration:**

Blood is taken from the vein of the individuals and Gas-Chromatography is used to separate the other volatiles and concentration of alcohol can be determined with known blood alcohol standards. Enzymatic method of blood alcohol estimation is known but not used in forensic laboratories.

**Alcohol and the Law:**

According to the recommendations of the American Medical Association and the National Safety Council, a person having blood alcohol concentration in excess of 0.15% w/v (150 mg per 100 ml) can be considered to be under the influence of alcohol. But experimental studies indicate that there is a clear correlation between drinking and driving impairments for blood alcohol levels much below 0.15% w/v. American Medical Council (1966) and the National Safety Council recommended that any individual exceeding a defined blood alcohol level (usually 0.10% ) shall be deemed to be toxicated. However, the safety levels are different in different countries.
Trap cases and Examination of chemicals used [37,38]:

The illegal transaction (bribe) of money is a common phenomenon in Indian scenario. Other countries like Bangladesh, Pakistan and Myanmar etc. also have the phenomenon of illegal money transaction. The problem is acute in India. Law Enforcement Agencies arrange a trap for illegal money transaction with the help of complainant where the accused is given currency notes smeared with phenolphthalein powder. Phenolphthalein in traces is transferred on his hands, fingers and in places like bag or briefcase where the notes are kept (Locard principle of exchange). The hands, bags and pockets etc. of the accused are washed with saturated solutions of sodium carbonate. The solution turns pink confirming the touching of currency note by the accused and his involvement in illegal transactions. The washings are collected and sent to the forensic laboratory along with relevant articles to establish the presence of phenolphthalein i.e. vital evidence in the court. The pink color of the solution persists for months. But in certain cases, colored solution became colorless when the presence of phenolphthalein can not be established which means falsification of graft charges and embarrassment for the law enforcing authorities. Suitable technique should be developed to find a proper solution in such cases. The details are given in appropriate places.

The brief introduction will help the readers to understand the background of our works described in the chapter to follow.
References:


2. (a) B. Lane, The Encyclopedia of Forensic Science, Publisher Press, Headline, 1992.


33. R. B. Forey et al. Alcohol distribution in the vascular system: concentrations of orally administered alcohol in blood from various points in the vascular system and in rebreathed air during absorption, Quarterly Journal of Studies on Alcohol, 25, 1964, 205.


