FORENSIC ASPECTS OF ARSON AND EXPLOSION
Introduction

• Arson and explosions often present complex and difficult circumstances to investigate due to the fact that the perpetrator has thoroughly planned the act, is not present during the act, and the destruction is so extensive.

• The criminalist’s function is rather limited to detecting and identifying relevant chemical materials collected at the scene and reconstructing and identifying ignitors or detonating mechanisms.
The Chemistry of Fire

- Chemically, fire is a type of oxidation, which is the combination of oxygen with other substances to produce new substances.
- To start fire, the minimum temperature needed to spontaneously ignite fuel, known as ignition temperature, must be reached.
- The heat evolved when a substance burns is known as heat of combustion.
- An additional factor, besides the liberation of energy, needed to explain fire is the rate or speed at which the oxidation reaction takes place.
The Chemistry of Fire

A fuel will achieve a reaction rate with oxygen sufficient to produce a flame only when it is in the gaseous state.

- A liquid burns when the temperature is high enough to vaporize it (flash point), while a solid must be hot enough to decompose into gaseous products (pyrolysis).
- Glowing combustion or smoldering is burning at the fuel-air interface, such as a cigarette.
- Spontaneous combustion, which is rare, is the result of a natural heat-producing process in poorly ventilated containers or areas.
The Fire Scene

• The arson investigator needs to begin examining a fire scene for signs of arson as soon as the fire has been extinguished.

• Experience shows that most arsons are started with petroleum-based accelerants.

• The necessity to begin an immediate investigation even takes precedence over the requirement to obtain a search warrant.

• The search of the fire scene must focus on finding the fire’s origin, which may be most productive in any search for an accelerant or ignition device.
The Fire Scene

Some telltale signs of arson include evidence of separate and unconnected fires, the use of “streamers” to spread the fire from one area to another, and evidence of severe burning found on the floor as opposed to the ceiling of a structure, due to a flammable liquid.

• Normally, a fire has a tendency to move in an upward direction, and thus the probable origin will most likely be the lowest point showing the most intense characteristics of burning.

• Fortunately, combustible liquids are rarely entirely consumed during a fire.
Collection

At the suspect point of origin of a fire, ash and soot, along with porous materials which may contain excess accelerant, should be collected and stored in airtight containers, leaving an airspace to remove samples.

- Traces of flammable liquid residues may be located with a vapor detector (sniffer).
- It is important that a sampling of similar but uncontaminated control specimens be collected.
- A search for igniters such as matches, an electrical sparking device, or parts of a “Molotov cocktail” must also be conducted.
The Basics

- When a fire occurs, oxygen combines with a fuel to produce noticeable quantities of heat and light (flames).
- If combustion is to be initiated and sustained, a fuel must be present, oxygen must be available, heat must be applied to initiate the combustion and sufficient heat must be generated to sustain the reaction.
- A fuel will achieve a reaction rate with oxygen sufficient to sustain a fire only when it is in the gaseous state.
Gas Chromatography

... in the laboratory, the gas chromatograph is the most sensitive and reliable instrument for detecting and characterizing flammable residues.

- The vast majority of arsons are initiated by petroleum distillates such as gasoline and kerosene.
- The gas chromatograph separates the hydrocarbon components and produces a chromatographic pattern characteristic of a particular petroleum product.
- By comparing select gas chromatographic peaks recovered from fire-scene debris to known flammable liquids, a forensic analyst may be able to identify the accelerant used to initiate the fire.
Explosions

Explosives are substances that undergo a rapid oxidation reaction with the production of large quantities of gases.

• It is this sudden buildup of gas pressure that constitutes the nature of an explosion.
• The speed at which explosives decompose permits their classification as high or low explosives.
• The most widely used explosives in the low-explosive group are black powder and smokeless powder.
• Black powder is a mixture of potassium or sodium nitrate, charcoal, and sulfur.
• Smokeless powder consists of nitrated cotton (nitrocellulose) or nitroglycerin and nitrocellulose.
Explosions

- Among the high explosives, primary explosives are ultrasensitive to heat, shock, or friction and provide the major ingredients found in blasting caps or primers used to detonate other explosives.
- Secondary explosives are relatively insensitive to heat, shock, or friction and will normally burn rather than detonate if ignited in small quantities in the open air.
- This group comprises the majority of commercial and military blasting, such as dynamite, TNT, PETN, and RDX.
The Explosive Market

- In recent years, nitroglycerin-based dynamite has all but disappeared from the industrial explosive market and has been replaced by ammonium nitrate-based explosives (i.e., water gels, emulsions, and ANFO explosives).
- In many countries outside the United States, the accessibility of military high explosives to terrorist organizations makes them very common constituents of homemade bombs.
- RDX is the most popular and powerful of the military explosives, often encountered in the form of pliable plastic known as C-4.
Collection and Analysis

- The entire bomb site must be systematically searched with great care given to recovering any trace of a detonating mechanism or any other item foreign to the explosion site.
- Objects located at or near the origin of the explosion must be collected for laboratory examination.
- Often a crater is located at the origin and loose soil and other debris must be preserved from its interior for laboratory analysis.
- One approach for screening objects for the presence of explosive residues in the field or laboratory is the ion mobility spectrometer (IMS).
Gas Chromatograph

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Collection and Analysis

- Preliminary identification of an explosive residue using the IMS can be made by noting the time it takes the explosive to move through a tube. A confirmatory test must follow.
- All materials collected for the examination by the laboratory must be placed in sealed air-tight containers and labeled with all pertinent information.
- Debris and articles collected from different areas are to be packaged in separate air-tight containers.
- It has been demonstrated that some explosives can diffuse through plastic and contaminate nearby containers.
Back at the Lab

- Typically, in the laboratory, debris collected at explosion scenes will be examined microscopically for unconsumed explosive particles.
- Recovered debris may also be thoroughly rinsed with organic solvents and analyzed by testing procedures that include color spot tests, thin-layer chromatography, high-performance liquid chromatography, and gas chromatography-mass spectrometry.
- Confirmatory identification tests may be performed on unexploded materials by either infrared spectrophotometry or X-ray diffraction.