A Guide To Detecting Accelerants
For Fire/Arson Investigators

As US arson investigator Terrence Hoyle said in 1962[1], ask the average citizen, "Who burned Rome?" and they will immediately answer, "Nero!" but ask a trained fire investigator the same question and they will probably say, "Who knows? The fire was never properly investigated". The principal goal for fire investigators remains figuring out how and where the fire started using forensic fire investigation methods.

Size of the arson problem

According to the National Fire Protection Association, there were 19,000 intentionally set fires in the US during 2014 accounting for around 4% of all structural fires equating to more than $700m worth of damaged property. UK figures[2] would suggest that more than 40% of fires in business premises and more than 20% in residential properties are intentional, whether for profit, revenge or just 'kicks'.

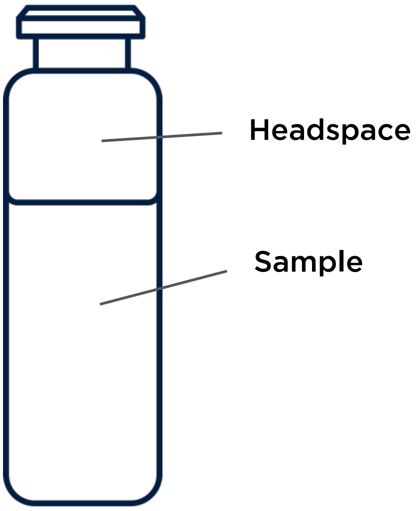
But despite the fact that fire is a common, everyday phenomenon, it is a very complex chemical, physical, and thermal event. Investigative work will focus on the 'fire triangle' of oxygen, fuel, and source of heat or ignition, and in cases of arson at least one of these will have been tampered with.

Figure 1: Fire Triangle

Arson investigations may be particularly challenging, because evidence is likely to have been destroyed in the fire or contaminated during firefighting operations. It normally takes longer to investigate than an episode of TV programme Crime Scene Investigator CSI might suggest because there can be literally tons of debris to sift through in search of chemicals that may have been used as a so-called accelerant. Traces of these can remain detectable even after a major conflagration. Highly-trained sniffer dogs are a traditional resource but these animals may not be available when needed or have insufficient, unsafe access. Many accelerants are hydrocarbon-based fuels such as gasoline (petroleum), diesel fuel, kerosene, turpentine, butane, and various other flammable solvents collectively known as volatile organic compounds (VOCs).

1. However, scientific methods for detecting accelerants for evidence of arson have developed in the 56 years since Hoyle's comments were penned. Instrumentation has moved from the laboratory to the actual fire scene vastly reducing the amount of evidence that needs to be subsequently analysed in the lab and hence the time taken to reach a conclusion.

One such tool for the detection of accelerants at fire scenes recommended by investigators[3] is the photoionisation detector (PID) which has already proven to be an ideal solution for the detection of relatively low level VOCs for health & safety and environmental applications. These devices are battery powered and portable and can be deployed rapidly and safely to test areas between floorboards and under carpets where residual traces of accelerant may remain.



Where positive indications of accelerant residue are discovered, grab samples can be taken and carefully stored for subsequent analysis using headspace sampling and gas chromatography (GC). During headspace sampling, debris is collected in a part-filled, sealed jar and allowed to stabilise as debris is collected in a part-filled, sealed jar and allowed to stabilise at room temperature.

Any VOCs present will volatise (evaporate) and concentrate in the 'headspace' leading to a positive, reading on the PID. PIDs are 'broadband' in nature whereas GCs can speciate exact chemical makeup, therefore, only samples which incite high or significant PID readings need to be sent for more detailed analysis, saving time and money.

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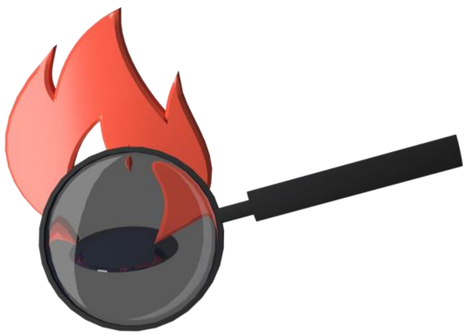

PID theory of

Figure 2 is a schematic of a proprietary PID sensor system. A UV lamp generates high-energy photons, which pass through the lamp window and into the sensor chamber. Ambient air is pumped over the sensor and about 1% of it diffuses through a porous membrane filter into the other side of the sensor chamber. The inset on the lower right of figure 2 shows what happens on a molecular level. When a photon with enough energy strikes a molecule M, an electron (e-) is ejected. M+ ion travels to the cathode and the electron travels to the anode, resulting in a current proportional to the VOC concentration. The electrical current is amplified and displayed as a part per million (ppm) or part per billion (ppb) concentration. Not all molecules can be ionized. Conveniently, the major components of clean air i.e. nitrogen, oxygen, carbon dioxide, argon, etc., do not cause a response, but most accelerants do give a broadband response.

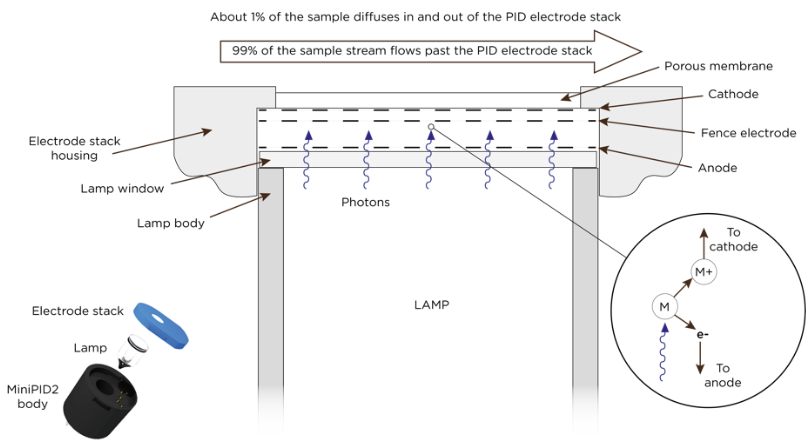

Figure 2: Ion Science Ltd PID sensor design

Effects of high humidity

Like many sensors and measurement instrumentation, PIDs can be affected by changes in environmental conditions found in the real-world outside the controlled environment of a laboratory. The situation in the immediate aftermath of a fire is therefore not ideal and in particular the presence of high humidity and contamination can disrupt PID measurements leading to false low or high readings. This is either because water vapour absorbs the photons shown in figure 1 leading to a low reading or contamination sits between the electrode effectively short circuiting it, leading to a high, ‘false positive’ reading.

In the case of this proprietary design, looking again at figure 2, the presence of a hydrophobic porous membrane should be noted which rejects the ingress of water and mitigates the chance of low readings. The additional fence electrode overcomes high readings since it behaves as a conductive break and stops the excess current flow caused by the presence of high humidity which would otherwise lead to a false positive.

Summary

In summary there are several good reasons to use a PID for arson investigation:-

- PIDs are portable and battery powered making them ideal for field applications
- PIDs are a quick, simple to use and accurate method for the detection of accelerants at a fire scene
- PIDs are very sensitive to commonly found accelerants and will detect hundreds of gasses and vapours
- PIDs are non-destructive and will not affect the air sample which can be captured for further lab analysis
- PIDs reduce the quantity and cost of lab samples required to reach a conclusion as to the cause of the fire

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References

1. Techniques of Fire Investigation, Terrence R Hoyle, Jan 1962
2. https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables
3. http://www.crime-scene-investigator.net/practical-applications-of-hydrocarbon-and-photoionization-detection-units-in-arson-investigations.html

About ION Science

Ion Science provide a portfolio of handheld, fixed and portable photoionisation (PID) detection instruments for the rapid, accurate detection of volatile organic compounds (VOCs). Find out more about our industry leading range of VOC detection solutions by clicking on the links below.

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