

Evaluation of field sampling techniques including electronic noses and a dynamic headspace sampler for use in fire investigations

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Abstract

Arson is a serious crime but the cause of an arson fire can be difficult to find. Field portable electronic noses are evaluated in this study for their ability to detect the presence of accelerants in specific areas of a fire scene. Several common household materials are tested, with and without being burned with common accelerants, to determine the readings achieved with the electronic noses. Most samples were found to have detectable amounts of volatile compounds after burning. Some of the matrix materials alone were found to have levels similar to those of the accelerants. A proficiency test designed for accelerant detecting canines was replicated using one of the electronic noses. The detector was found to successfully discriminate between samples containing only matrix and those which also contained accelerants. However, it was not able to alert to the location of a small amount of accelerant spiked onto a pine board. For the extraction and collection of accelerants from fire debris, a portable dynamic headspace sampler is used. Volatile compounds are drawn off the headspace of a sample and deposited in an adsorbent filled tube. The desorbed samples are analyzed by gas chromatography/mass spectrometry. This method has demonstrated ability to concentrate small amounts of a range of volatile accelerants from burned debris. The three field portable instruments have shown to be useful and will continue to be evaluated for their ability to detect and collect accelerants in fire debris.

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1. Introduction

The cause of an arson fire is difficult to find. Many fires are started by the use of a flammable liquid accelerant. Accelerants have been classified, based on the volatility range of their components, as light, medium, and heavy ignitable liquids [1,2]. Residues of these accelerants (ignitable liquid residues or ILRs) can be extracted from the debris, but the process can be difficult and inefficient. Some of the methods used include solvent extraction, passive headspace extraction using activated charcoal strips, solid phase microextraction, and dynamic headspace sampling [3–7].

Electronic noses can be used for the initial evaluation of a fire scene. Electronic noses are portable instruments that can detect the presence of volatile compounds. Accelerant detecting canines can be used for the same purpose [8]. However, canines can be limited in their operating time and ability to work in hazardous scenes. These instruments, while possibly not as selective as canines, can be inexpensive and do not require a highly skilled operator.

Several types of instruments are available, but this study utilizes the TLV Sniffer® (Bacharach Inc., Pittsburgh, PA). The TLV Sniffer® can be used for measurement of hazards in an industrial environment, location of gas leaks, and for the possible presence of accelerants at a fire scene [9]. The device is not complex in design (see Fig. 1). A small pump pulls samples of air into the instrument. Here, the samples reach a catalyst coated resistance element. As volatiles are oxidized by the catalyst, they produce heat, which changes the resistance of the element proportionally to the amount of volatiles in the sample. This change is measured and expressed on the meter in parts per million of hexane. A calibration curve published in the instrument's man-

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Fig. 1. The TLV Sniffer®.



Fig. 3. The Portable Arson Sampler.

ual relates ppm of hexane to other compounds such as toluene and benzene.

Another commercially available detector, the tpi®Pocket Combustible Gas Leak Detector (Professional Equipment Inc., Hauppauge, NY, see Fig. 2) [10], has also been tested. It functions with the use of a metal oxide semiconductor sensor. Oxygen adsorbs to the metal oxide. When a gas interacts with the negatively charged oxygen, the charge decreases, therefore decreasing the resistance of the sensor. The change in resistance is related to the concentration of the volatiles by the equation

$$R_S = A[C]^{-\alpha}$$

where R_S is the electrical resistance of the sensor, A a constant, $[C]$ the concentration of the gas, and α is the slope of the resistance calibration curve generated for various concentrations of gases [11]. This particular device does not give a numerical value of the amount of hydrocarbons in the headspace like the TLV Sniffer®; it gives an audible alarm and four lights indicating the level of alert. The level of alert is recorded for the sample. The advantage of these types of instruments for arson investigation is that they can help determine where accelerants may be present in a scene, thus limiting the area of debris that needs to be sampled.



Fig. 2. The tpi®Pocket combustible gas leak detector.

Once the location of a possible accelerant is determined, the debris needs to be sampled and evaluated more conclusively. One sampling method for extraction of ILRs from fire debris, dynamic headspace sampling, takes advantage of the volatility of accelerant residues. A gas is passed over the sample to move volatiles from the headspace to be deposited onto an adsorbent. Dynamic headspace sampling has been said to cover the entire boiling point range of ignitable liquid residues [12]. Because the process is dynamic, the sampling tube is not competing with the air in the chamber for adsorption of the sample [13]. In this study, a commercially available dynamic headspace sampling instrument, the Portable Arson Sampler (Portable Arson Samplers, Tooele, UT) [13], has been evaluated for its ability and usefulness in collecting samples of accelerants from fire debris. The device consists of a chamber heated to 50 °C and a pump that pulls volatiles from the headspace of the chamber through an adsorbent filled tube (see Fig. 3). The pre-packed tubes contain charcoal or polymer beads as an adsorbent. Twenty of the tubes used in this instrument can easily be carried in a shirt pocket [13]. Use of this instrument in the field potentially eliminates the need to transport large volumes of debris to the laboratory. Traditionally, debris is collected in paint cans and needs to be stored until it can be analyzed. Additionally, debris that would be difficult to transport may be sampled on scene. For example, the chamber may be inverted to sample concrete [13].

Analysis of these samples was performed by gas chromatography/mass spectrometry. Many interferences occur in arson debris samples. Extraction solvents and background, pyrolysis and combustion products from the material can complicate the process and lead to false positive or negative results. The data analysis methods used are intended to help confirm or exclude the presence of an accelerant in a suspected arson sample, despite these interferences. The spectra are examined for the characteristic patterns of known accelerants. Care must be taken in this process as interfering substances and fire conditions may obscure some of the data. Samples have been collected and tested to show the efficiency of the portable system both in the presence of a complex debris matrix, such as carpet and padding, and without.

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