Accelerant Identification: Influence of Variables on Possibility of Detection of Accelerant Traces Using Solid Phase Microextraction and Gas Chromatography

Abstract
Arson is statistically one of the most difficult types of case to solve. For many years, researches have studied the effects of fire on materials. One particular aspect of arson cases is accelerant use. Accelerant identification can be useful to the investigator. In order to determine if certain variables have an influence on detectability, samples will be tested under various conditions and then analyzed using gas chromatography.

Introduction
The research proposed herein is an attempt to determine if variables of burning affect the ability to identify an accelerant. Accelerants are substances that contribute to the development and intensity of a fire. Identification of these accelerants has been studied for several years as a tool to help arson investigators. Each type of accelerant yields a unique profile when analyzed with a gas chromatogram (GC). We will endeavor to observe any profile differentiation based on varying treatments of burned samples. With this research we will be better able to distinguish if this particular method of identification will be beneficial to the investigator.

Background
Accelerant identification has been a topic of investigation for decades. As early as 1996, solid phase microextraction (SPME) has been a preferred method given its versatility and mobility. The SPME syringe is handheld and can be used an infinite amount of times as long as there is no damage to the fiber. An extensive amount of research has been done in terms of SPME/GC analysis of accelerants. Multiple detectors have also been used along with the GC, namely flame ionization detection (FID) and mass spectrometry (MS). Many accelerants have also been tested, with the
majority from the petroleum industry. Some research has been done on actual char samples, though many simply used the pure accelerants in an attempt to determine limits of detection (LOD). Our research will focus entirely on simulated fire samples by creating a “real-life” burning scenario on a smaller scale. We will also focus on accelerants that can be found in a household, rather than focusing on industrial chemicals, which would not necessarily be available to arsonists. Due to the limitations of the GC, all accelerants will be limited to eight carbons or fewer.

**Description of Proposed Research**

**Method:**
The first portion of the project will be spent optimizing the headspace-solid phase microextraction (HS-SPME) and instrumental parameters. There are several variables of analysis that must be considered, e.g. extraction time of sample, extraction temperature, desorption time, and GC program. In previous research it has been shown that the addition of aqueous sodium chloride has also increased the extraction efficiency. Due to the fact that the GC instrument is simplistic in nature, increasing extraction efficiency will be important. For extraction time, we will expose the SPME fiber to the headspace of a sample for varying times. For extraction temperature, we will vary the temperature of the sample while the SPME fiber is exposed. This can be done with hot or cold-water baths. We will also need to optimize desorption time of the fiber to be sure all volatiles from each sample has been removed prior to moving on to another sample. This is anticipated to be a more challenging aspect as most literature cites injector ports temperatures around 250-270°C and our GC has a maximum temperature of 120°C. For all optimization, we will be working with one compound, a component of a common accelerant, such as heptane (found in unleaded gasoline). Optimal conditions will be considered as those with the greatest peak areas when analyzed with the GC. This process is expected to take several weeks.

The second portion of the project will focus on sample preparation and collection. Each student will select a single variable of the process to examine. Possible variables include but are not limited to:
- Time soaked in accelerant
- Type of burn material (wood, carpet, plastic)
- Accelerant (limited to 8 carbons or fewer, and available in households)
- Time burning
- Method of extinguish

Students will determine the sample parameters then follow through with sample preparation and analysis. The student will first generate a profile of the pure accelerant for comparison purposes. As sample preparation includes burning materials, safety must be considered. The student will have a controlled ignition under a fume hood, as well as a controlled extinguish. We will maintain control by limiting the burn material size. The ignition will be done with a long match to reduce possibility of burn. The sample will burn for the pre-determined time in the fume hood in a glass petri dish. For general extinguish, the sample will be "blown out" by the student. Samples must eventually be transferred into a small vial with a septum cap (~20mL) so they will need to be trimmed, cut, or scraped to fit. Once the sample has been transferred to the vial, the SPME syringe will be introduced through the septum and the fiber will be exposed to the headspace for the predetermined time. Then, the syringe will be injected into the GC and the fiber will be exposed for desorption of the accelerant material.

Analysis of the sample will be a comparison of the pure accelerant chromatogram profile to those of the treated samples. Elution time will be the main aspect of the profile as there is no other detector on the GC.

Given that all materials used are household items, waste disposal should be uncomplicated. The burned materials should have vaporized the accelerants so there will be little hazardous material that remains in liquid form. The burned materials will be doused with water, then they can simply be discarded.
Description of Relevant Institutional Resources

Materials & Equipment:  

<table>
<thead>
<tr>
<th>Item</th>
<th>Price (USD)</th>
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</thead>
<tbody>
<tr>
<td>Glass vial with septa (40 mL, amber)</td>
<td>129.68</td>
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<tr>
<td>SPME fiber holder (57330-U)</td>
<td>355</td>
</tr>
<tr>
<td>SPME fiber assembly (PDMS coating)</td>
<td>315</td>
</tr>
<tr>
<td>Glass petri dishes</td>
<td></td>
</tr>
<tr>
<td>Carpet samples (free samples provided by home improvement stores)</td>
<td></td>
</tr>
<tr>
<td>Wood samples (untreated framing wood sample)</td>
<td>2.83</td>
</tr>
<tr>
<td>Plastic samples (water bottles, Tupperware, shower curtains)</td>
<td></td>
</tr>
<tr>
<td>Matches</td>
<td></td>
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<tr>
<td>Vernier GC Mini</td>
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<tr>
<td>Vernier Labquest</td>
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<tr>
<td>Carbon dioxide fire extinguisher</td>
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<tr>
<td>ABC fire extinguisher</td>
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<tr>
<td>AFFF or FFP fire extinguisher</td>
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</table>

Chemicals:

- Acetone (found in nail polish remover)
- Ethyl acetate (found in nail polish remover)
- Ethanol (found in liquor)
- Toluene (found in paint thinner)
- Methyl ethyl ketone (found in paint thinner)
- Isopropyl alcohol (found in rubbing alcohol)
- Sodium chloride
- Deionized water

First accelerant attempts will be done with the household items. If, due to impurities, a chromatogram cannot be ascertained, technical grade liquids will be used.

All research will be carried out at the South Seattle College Campus.
List of References


- Kruger, Simone, Jan Deubel, Martin Werrel, Ina Fettig, and Tina Raspe. "Experimental Studies on the Effect of Fire Accelerants during Living Room Fires and Detection of Ignitable Liquids in Fire Debris." Fire and Materials
Personnel

At minimum, 2 students along with an instructor will be necessary to complete this project. Each student should be willing to dedicate two to five hours per week, including one hour each week for a group meeting and literature review. The instructor will also be expected to dedicate two to five hours per week, including supervision of students while in the laboratory and planning future directions and troubleshooting. Students will meet one evening per week for one hour for literature review and group meeting. Students will work in a laboratory setting one afternoon/evening per week and every other Saturday.

Students will be required to have a background in polarity and an introduction to chromatography. Strong record-keeping skills are desired, but will also be learned throughout the project.

At the end of every quarter, students will be expected to prepare a report summarizing results.

At the end of every other quarter, students will be expected to prepare and present a poster of their research. The goal will be to present at the University of Washington Undergraduate Research Symposium. Another potential conference at which to present is the American Academy of Forensic Science Annual Conference (held in February).