The Analysis of Various Burnt and Unburnt Accelerants Using Laser Induced Breakdown Spectroscopy

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Overview

- Laser Induced Breakdown Spectroscopy (LIBS) was used to obtain and analyze the elemental composition of various accelerants.
- Elements investigated included Carbon, Oxygen, Hydrogen, Sodium, Calcium and Potassium.
- The average intensities for each element were analyzed to find trends that could be used to identify accelerants.

Introduction

- In arson investigations, identification of the accelerant used is important because it can help give investigators leads on where an accelerant was obtained and by who.
- The current most popular way to analyze fire debris for trace of accelerant today is by using gas chromatography. (Choi 2017)
- Some disadvantages of using this method are that accelerants can only be tested if enough of the accelerant remains in the gas phase to be contained in the headspace and the analysis also requires the accelerant sample to be prepared before it can be tested.
- Laser Induced Breakdown Spectroscopy (LIBS) is a relatively new technology that is used to find the elemental composition of a sample. LIBS determines composition by using light emitted from laser generated micro plasma. (Gottfried 2009)
- LIBS has already been used to test for trace explosive material by looking at the elemental composition of samples, specifically the oxygen, nitrogen, carbon and hydrogen levels as these are elements commonly found in explosive materials. (Brady 2013). LIBS has also been used to analyze fire debris to determine ignition source and to see if accelerant was present (Choi 2017).
- In this study, LIBS was used to detect changes in elemental profiles based on substrate and whether it is was burnt or not to determine if the accelerant can be identified with a variety of parameters

Materials and Methods

- Accelerants (6): Pure acetone, Non-acetone Nail Polish Remover Gasoline 1 (West Haven, CT 87 grade), Gasoline 2 (Middletown, CT 87 grade), Diesel Fuel 1 (West Haven, CT), and Diesel Fuel 2 (Middletown, CT)
- Substrates (2): Cotton Cloth and Nylon Rope
- For all samples, spectra were obtained in three different locations and three trials were preformed.
- Baseline spectra of the substrates were collected
- Spectra of the unburnt accelerant were obtained by soaking the substrates in accelerant overnight and then analyzing the sample
- Spectra for burnt samples were obtained by soaking substrates in accelerant overnight and then allowing them to be burnt for 60 seconds before being analyzed.
- For this experiment a J200 Laser Induced Breakdown Spectrometer from Applied Spectra was used.
- Laser parameters included: laser energy of 50%, spot size of 40µm, a gate delay of 1 µsecond, Number of shots per trail of 3 shots, and Rep Rate of 20Hz

Results

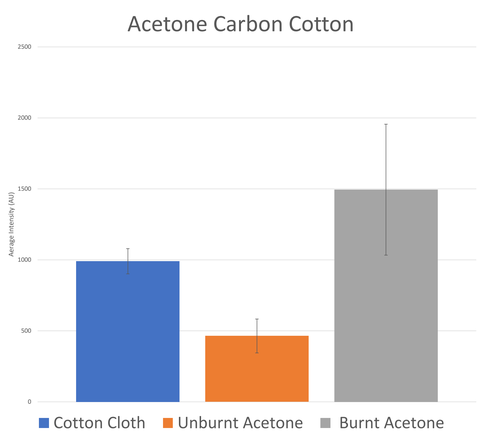

Figure 1: Average Relative Intensity of Carbon for Acetone Samples on Cotton Substrate

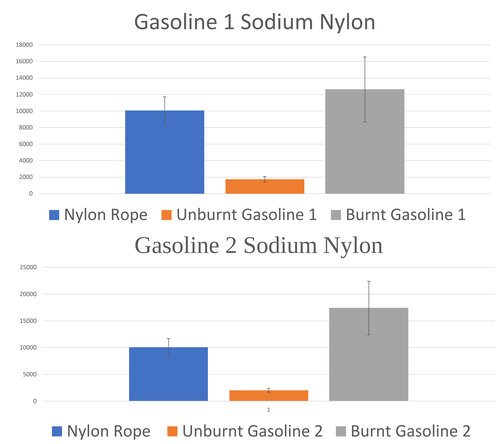

Figure 2: Average Relative Intensity of Sodium for Gasoline 1 and Gasoline 2 Samples on Nylon Substrate

- The trends for the each elements mostly showed similar results for both the cotton and the nylon substrates
- The average intensity of Carbon that had the highest value was found in the burnt accelerant; it was higher in the burnt samples than compared to the unburnt samples
- The trends for all of the elements analyzed followed the same pattern for both Gasoline 1 and Gasoline 2.
- The average intensity of Oxygen varied from substrate to substrate.
- The average intensity of Calcium, Nitrogen and Potassium were the highest for the burnt samples

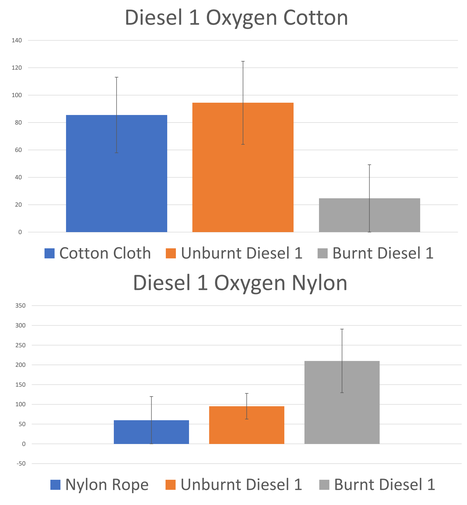

Figure 3: Average Relative Intensity of Oxygen for Diesel 1 Samples on Nylon and Cotton Substrates

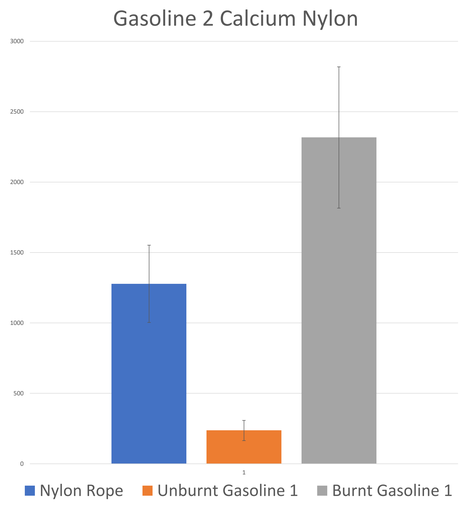

Figure 4: Average Relative Intensity of Calcium for Gasoline 2 Samples on Nylon

Conclusions

- Since most of the trends for the elements analyzed were similar for both substrates, the elemental analysis was not effected by the type of substrate used when analyzing accelerants.
- Since the trends were similar for the two different gasolines and diesel fuels, LIBS analysis would not be an optimal method for the analysis of accelerants obtained from different locations.
- Since Calcium, Sodium, and Potassium were found in the burnt accelerant in high quantities, these elements might be used as an indicator that an accelerant could be present.
- Carbon increases in the burnt samples because as the samples were burnt, carbon deposits formed
- The decrease in Calcium, Sodium and Potassium in the unburnt sample could be from the presence of the accelerant overpowering the sample. The increase in the burnt samples because some accelerant was burnt off or some of the salts ions could have been released during the burning process
- LIBS was unable to differentiate between accelerants and was unable to link burnt and unburnt samples from each accelerant.
- LIBS profiles for the same type of accelerants i.e gasoline and diesel fuel showed similar trends
- The type of substrate did not seem to effect the elemental profiles for the accelerants except in the case of Oxygen

Future Directions

- Analyzing different accelerants: lighter fluid or kerosene for new accelerants or testing the same type of accelerants from a wider range of areas to see if there can be any differences found
- Analyzing different substrates: wood or other fabrics for new substrates
- Looking ay a wider range of elements for similar trends
- Analyzing accelerants with other instrumentation for comparison: Infrared Spectroscopy or Raman Spectroscopy

References

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Acknowledgements

I would like to thank the SURF program at the University of New Haven for this opportunity, especially Carol and Lynn. I would like to thank Dr. Alyssa Marsico for her guidance along with Lauren Vallee for her help and patience. I would like to thank Sandra Hartmann-Newmann for all of her help. I would finally like to thank the Forensic Science Department at the University of New Haven for providing me with the resources to conduct this research.