Effects of Various Substrate Types on E1618 Pattern Classification of Ignitable Liquids Present in Fire Debris

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Abstract

Previously, little research had been performed examining the effects of various substrate types on E1618 analysis of ignitable liquid residues in fire debris. The effects of varying substrates was studied using charred and uncharred carpet, carpet pad, and yellow pine samples spiked with three different ignitable liquid evaporates. It was determined that substrate may affect E1618 classification of ignitable liquid patterns, as uncharred yellow pine proved virtually impossible for ignitable liquid classification due to the vast abundance of precursory products present in the substrate. Future study in this field could expand this work to include additional substrates, including different wooden substrates to allow for comparison to the yellow pine results, additional ignitable liquids, and varying the ignitable liquid spike volume.

Introduction

The National Fire Protection Association estimates 3,320 civilian fire deaths, an additional 100 firefighter deaths, and 16,705 civilian fire injuries occurred in 2008. Therefore, fire debris analysis is of great importance to the forensic community. One of the largest problems that can arise in the analysis of fire debris is interference from the sample substrate. Due to the extraction procedure for ignitable liquid residues, compounds present in the substrate and products generated during the burning of the substrate (such as pyrolysis and combustion products) may co-adsorb with ignitable liquid residues to the activated charcoal strip during collection affecting the chromatographic analysis of ignitable liquids. As crime laboratories receive a wide variety of both wooden and non-wooden substrates submitted as fire debris, it is important for fire debris analysts to be aware of the difficulties such substrates may cause in ignitable liquid analysis. This study sought to understand the effects various common fire debris substrates may have upon analysis. It was hypothesized that each substrate will produce various interfering products which analysts must be aware of during analysis to prevent misclassification of ignitable liquids present in the debris.

Materials and Methods

Procedure

- Substrates: carpet, carpet pad, yellow pine; uncharred and charred approximately 50 % (by weight)
- Ignitable Liquids: 10 µL of 50 %, 75 %, and 90 % evaporates of gasoline, kerosene (heavy petroleum distillate), and charcoal lighter fluid (medium petroleum distillate)
- Method blank(empty, un-spiked sample container), uncharred blank, charred blank, and E1618 standard also analyzed with each run
- Ignitable liquid vapors concentrated according to the ASTM E1412 method
- Adsorbed residues extracted in a solvent of 0.2% 3-phenyltoluene in carbon disulfide
- E1618 classification of ignitable liquid residues

Gas Chromatography-Mass Spectrometry

- Varian CP-3800 Gas Chromatograph
- 30 m x 250 µm x 0.25 µm J&W Scientific HP-1MS
- Helium: 0.7 mL/min
- Injection: 1 µL, 250 °C
- 20:1 split ratio
- Solvent delay: 0-2.00 min
- Analysis: 2.00-39.00 min
- Saturn 2200 Mass Spectrometer: 40-500 m/z, 0.5 s/scan

Figure 1. Propane torch charring of wooden sample.

Results

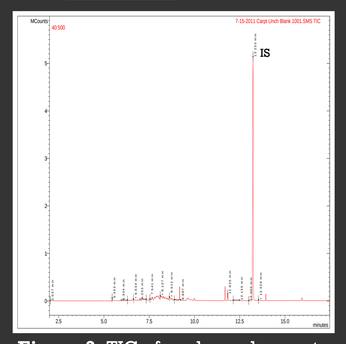

Figure 2. TIC of uncharred carpet substrate blank.

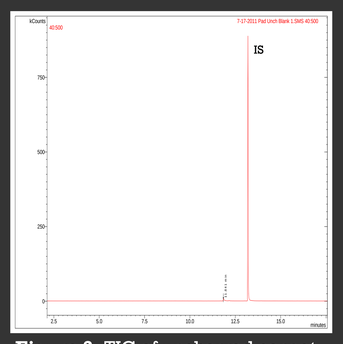

Figure 3. TIC of uncharred carpet pad substrate blank.

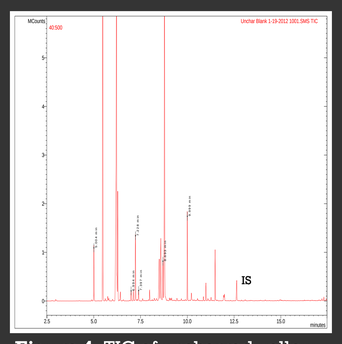

Figure 4. TIC of uncharred yellow pine substrate blank.

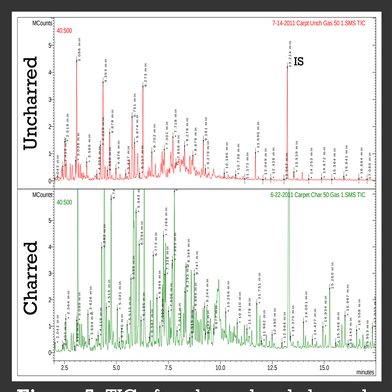

Figure 5. TIC of uncharred and charred carpet samples spiked with gasoline.

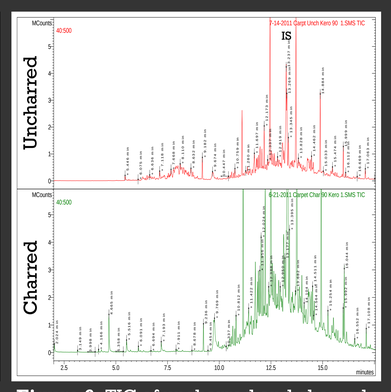

Figure 6. TIC of uncharred and charred carpet samples spiked with kerosene.

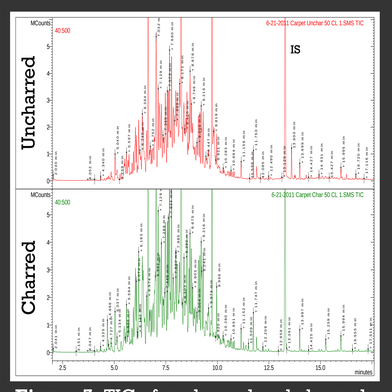

Figure 7. TIC of uncharred and charred carpet samples spiked with charcoal lighter fluid.

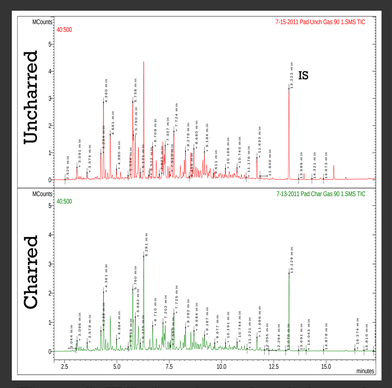

Figure 8. TIC of uncharred and charred carpet pad samples spiked with gasoline.

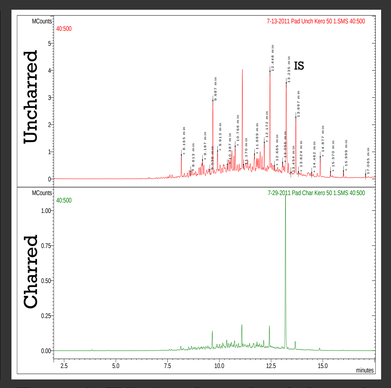

Figure 9. TIC of uncharred and charred carpet pad samples spiked with kerosene.

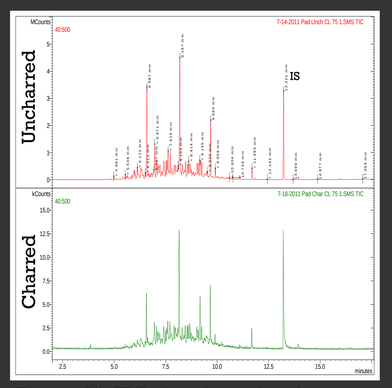

Figure 10. TIC of uncharred and charred carpet pad samples spiked with charcoal lighter fluid.

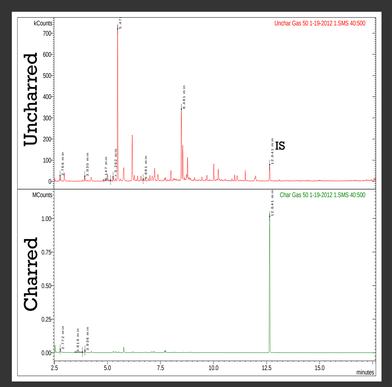

Figure 11. TIC of uncharred and charred yellow pine samples spiked with gasoline.

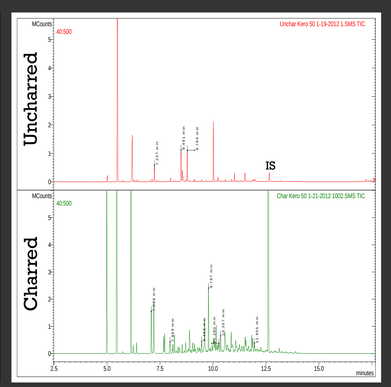

Figure 12. TIC of uncharred and charred yellow pine samples spiked with kerosene.

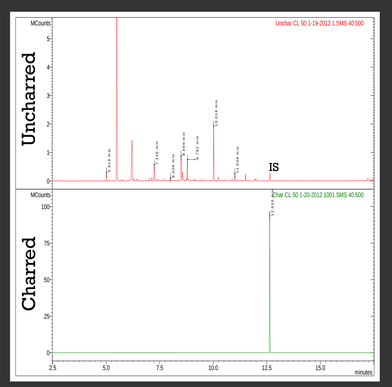

Figure 13. TIC of uncharred and charred yellow pine samples spiked with charcoal lighter fluid.

Discussion

- Carpet: precursory products present in substrate blanks (olefins, such as dodecene, Figure 2: 8.6 min); insignificant in spiked samples
- Carpet pad: few detectable precursory compounds in blanks present in minor concentrations; insignificant in spiked samples
- Yellow pine: numerous precursory products present in great abundance in un-charred blanks but insignificant charred samples

Conclusion

- Substrate may affect E1618 classification
- Precursory products identified in carpet and carpet pad samples had little to no effect on analysis
- In yellow pine, abundant precursory products inhibited E1618 classification of ignitable liquids in uncharred samples
- Yellow pine precursory products greatly reduced in charred samples (compounds present likely volatilized by charring process)
- Concluded that unburned yellow pine substrates, or yellow pine substrates that have not been completely charred, may inhibit E1618 classification of ignitable liquid residues
- Amount and type of precursory products in yellow pine likely variable based upon manufacturer and manufacturing processes
- Future studies: additional substrate-ignitable liquid analyses, analyzed substrates with additional ignitable liquids, additional wooden substrates for comparison to yellow pine results

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Figure 14. Wooden sample during charring.