URECA Proposal Submitted By: [redacted]

Investigation of the Weathering Effect on Less-Volatile Component Profiles in Ignitable Liquids

Introduction:

In the event of a property fire or even an explosion, the remains provide evidence for arson investigators. When the extent of the damage isn't too bad, the source of origin, fuel, and ignition are usually determineable. However, when the fire scene has been largely consumed, there may be little, if any, evidence for investigators to collect and interpret. When ignitable liquids (ILs) are suspected, fire debris are often analyzed for the presence of ignitable liquid residues (ILRs), and identification of elevated levels of ILs is used to support a claim of arson (Barnett et al., 2018). When ILs are exposed to ambient conditions, components may evaporate in a process called weathering, where volatile components with the highest vapor pressures evaporate the fastest, and can occur from room temperature to very high temperatures. With that being said, weathering alters the relative quantities of components in a mixture, making it more difficult to compare a weathered IL to a non-weathered one. For this reason, this research will instead focus on analyzing ILs with non-volatile compounds because they are more resistant to heat. The gas chromatography-mass spectrometry (GC–MS) method is commonly used to detect IL residues in fire debris (Barnett et al., 2019). Direct analysis in real-time- mass spectrometry (DART-MS) is an emerging tool in forensic laboratories which requires limited sample preparation and could be an alternative method for IL analysis with higher sensitivity to less volatile compounds.

Objective: This research aims to examine the impact of the weathering effect on the non-volatile component profiles in the ignitable liquids using both GC-MS and DART-MS methods. The capability of DART-MS for IL analysis will also be investigated.

Methodology:

For this project, five ignitable liquids (ILs) will be used: gasoline, diesel, kerosene, Japan drier, and Zippo lighter fluid. Aliquots measuring 1 mL of each IL sample will be weathered at four different temperatures– 30, 90, 150, and 210 °C – to different percentages ranging from 50 to 99% (Willis et al., 2020). Weathering will be conducted in aluminum weigh boats heated to 400°C in a kiln to remove residual contaminants. Empty weigh boats will be weighed and countersunk in a custom-made aluminum block. Before each weathering experiment, both will be heated to the desired weathering temperature in a standard oven. Then, the hot block and weigh boats will be transferred to a fume hood, with 1 mL of each IL sample spiked onto the hot weight boats (Willis et al., 2020). After reaching the desired extent of weathering, the weigh boats will be transferred to a another aluminum block previously cooled to -20 °C in a freezer to minimize any additional weathering. After weighing the weigh boats and its residues to the extent of evaporation, the weigh boats will be washed five times with 0.5 mL of pentane and combined in a GC vial. The weigh boats will be weighed after the five replicate washes to ensure that all the residues were collected to a final volume of 1 mL (Willis et al., 2020). All five IL samples will also be analyzed using the DART-MS method.

Description of Duties:

The student will be responsible for sample collection and weathering the ignitable liquids, instrumental analysis, and data comparison between GC-MS and DART-MS results to see similarities and differences. Students will compile data over a period of 6 weeks. This is the student’s first submission for URECA.

Role of Mentor:

Dr. Zhang will assist with data collection and train the student on using the two methods for analysis. He will also help with data management, interpretation, and statistical analysis.

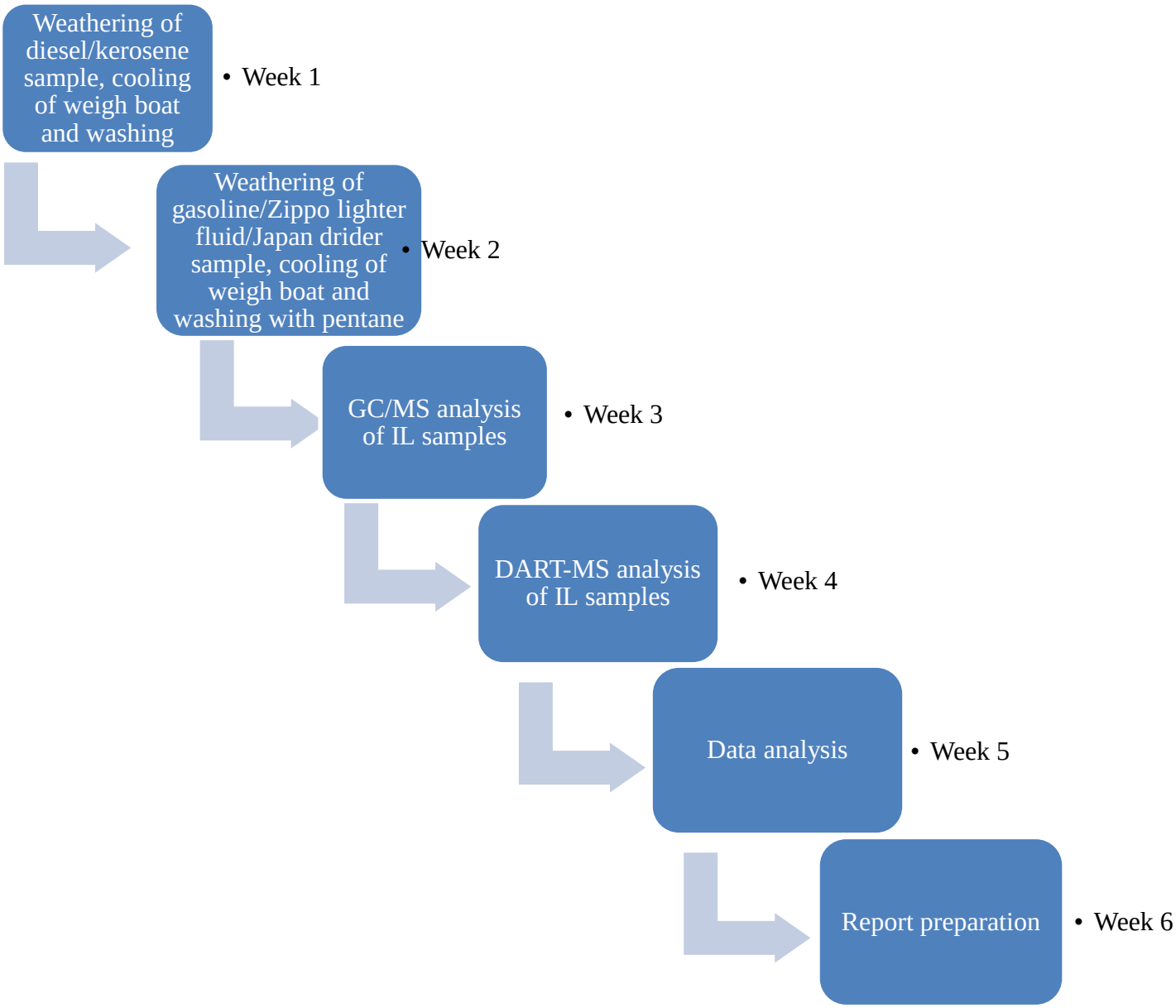
References

Barnett, I., F. Bailey and M. Zhang. 2019. “Detection and Classification of Ignitable Liquid Residues in the Presence of Matrix Interferences by Using Direct Analysis in Real Time Mass Spectrometry.” *Journal of Forensic Sciences 64*. 10.1111/1556-4029.14029

Barnett, I. and M. Zhang. 2018. “Discrimination of brands of gasoline by using DART-MS and chemometrics.” *Forensic Chemistry 10*: 58-66. 10.1016/j.forc.2018.07.003.

Willis, Isaac C., Z. Fan, J. T. Davidson and G. Jackson. 2020. “Weathering of ignitable liquids at elevated temperatures: A thermodynamic model, based on laws of ideal solutions, to predict weathering in structure fires.” *Forensic Chemistry 18*: 100215. 10.1016/j.forc.2020.100215.

Timeline:


Weathering of diesel/kerosene sample, cooling of weigh boat and washing
• Week 1
Weathering of gasoline/Zippo lighter fluid/Japan drider sample, cooling of weigh boat and washing with pentane
• Week 2
GC/MS analysis of IL samples
• Week 3
DART-MS analysis of IL samples
• Week 4
Data analysis
• Week 5
Report preparation
• Week 6

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URECA Budget

✓ URECA Assistant Hours expected: 50 hours Stipend: $500

Other Expenses:

Expenses:	Estimated Cost:
Cole-Parmer 28 mm Aluminum Crimpled-Walled Weighing Dishes with Tab, 8 mL, 500/Cs (free shipping)	$186.00
Aluminum blocks (2 pcs) + shipping	$66.00
Total:	$252.00

Budget Justification:

Aluminum weighing dishes will be used to prepare the weather IL samples.

Aluminum blocks will be customized and used to heat the IL samples to designed temperatures (e.g., 30, 90, 150, and 210 °C).

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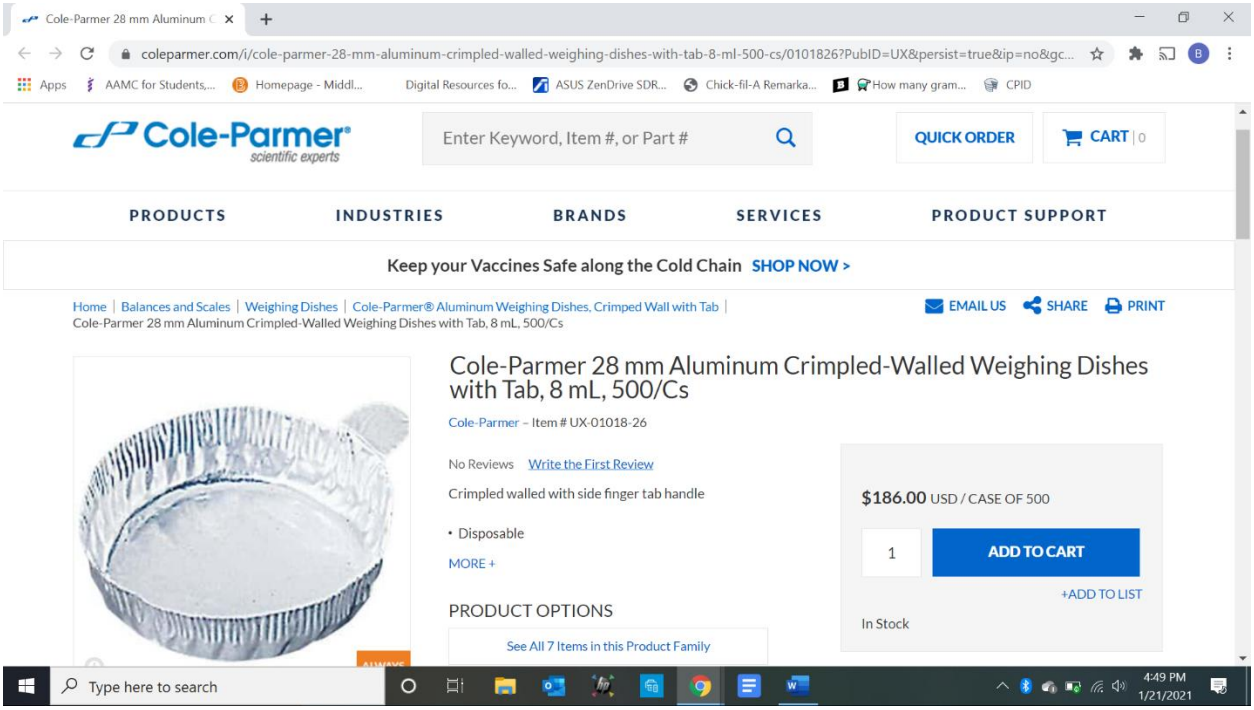
Weighing dishes:



Aluminum blocks: