B175 The Effects of Elevated Temperatures and Substrates on the Weathering of Ignitable Liquids

Caitlyn Wensel, BS, West Virginia University, Morgantown, WV 26505; Isaac Willis, BS, Michigan State University, East Lansing, MI 48823-8325; Zilin Fan, PhD, Tianjin Fire Research Institute of MPS, Morgantown, WV 26506; J. Tyler Davidson, MS, West Virginia University, Morgantown, WV 26505; Glen P. Jackson, PhD, West Virginia University, Morgantown, WV 26506-6121*

Learning Overview: After attending this presentation, attendees will better understand how elevated temperatures, the type of substrate, and the penetration of the ignitable liquid into each substrate affect the relative evaporation rates of different components of the ignitable liquid. Attendees will better understand the different phenomena that lead to the observed weathering of ignitable liquids in fire debris.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing a better understanding of how the volatiles within a mixture evaporate at different rates when they are spiked onto different common household substrates and evaporated at elevated temperatures that mimic casework. Such understanding will assist analysts in making more reliable inferences on the presence and identification of ignitable liquids in authentic casework samples.

Hypothesis: Two central hypotheses are that the temperature at which weathering occurs and the penetration depth of an ignitable liquid into a porous substrate will both affect the relative evaporation rates of the components in the mixture. An additional hypothesis is that the surface chemistry of a non-porous substrate will not influence the weathering of an ignitable liquid.

Methods/Results: Analyses involved the development of a synthetic gasoline sample and a variety of sample treatments and weathering conditions. A simplified, synthetic form of gasoline was created using nine compounds that represent a wide range of volatilities and chemical classes in fresh gasoline, including alkanes, substituted aromatics, an indane, and a polyaromatic. To achieve the desired weathering, an aluminum block with an aluminum weight boat in the center was preheated to the desired temperature in a vacuum oven, while a second aluminum block was cooled to -20˚C in a freezer. Once the heating block and weight boat reached the appropriate temperature, a measured aliquot of the synthetic gasoline was spiked into the weight boat and weathered at the desired temperature to the desired extent, at which time the weight boat was transferred to the cold block to prevent additional evaporation.

The five substrates included a hard wood, a soft wood, nylon carpet, olefin carpet, and cotton. To simulate the expected conditions of casework samples, different delay times were studied between when the ignitable liquid was spiked on each substrate and when the weathering was initiated. Penetration times ranged from 30 seconds to 30 minutes.

Preliminary results corroborate this evaporation model, which is based on equilibrium theory, in which the temperature of evaporation plays a major role in the relative distribution of the residues in weathered ignitable liquids. For example, when a synthetic gasoline sample is weathered 90% at 30˚C, the molar fraction of toluene—the most volatile component in the mixture—decreases from the original value of ~35% to a value that is below the threshold for detection on the Gas Chromatography/Mass Spectrometry (GC/MS). However, when the same mixture is weathered to the same extent at 210˚C, toluene is readily observed at a molar ratio of ~1% after weathering. The model shows that compounds of disparate boiling points have a narrower range of vapor pressures at elevated temperatures, which explains why the disparate compounds evaporate at more similar rates at elevated temperatures than at room temperature.

Experiments regarding the effect of substrate are still ongoing, but preliminary results show that short (e.g., 30 seconds) penetration times on different surfaces do not significantly influence the weathering pattern of the gasoline simulant. The effects of longer penetration times are currently undetermined.

Ignitable Liquids, Weathering, Household Substrates