A193 Evaporation Rates of Unconfined Explosive Liquids

Kelley M. Kitts, MS, Indiana University Purdue University Indianapolis, 402 North Blackford Street, LD 326, Indianapolis, IN 46202; and John V. Goodpaster, PhD, Indiana University Purdue University Indianapolis, FIS Program, 402 North Blackford Street, LD 326, Indianapolis, IN 46202*

After attending this presentation, attendees will understand the evaporative trends of various nitrated explosives and their relation compounds, under unconfined conditions. Attendees will also understand how evaporative theories (Langmuir, Deegan, Berry) hold up in experimental conditions; ultimately a mathematical model to be used to describe the evaporation of unconfined explosive liquids is suggested.

This presentation will impact the forensic science community by helping understand how explosives behave under different conditions and how this behavior affects a canine's ability to detect and alert to an explosive compound.

Although canines are regularly utilized by law enforcement agencies to detect explosives, the mechanism by which canines respond to explosive vapors is not well understood. In particular the factors that govern the amount of explosive vapor available for canine sampling are often confused, leading to difficulties in canine training and testing. For example, it is a common misconception that the amount of explosive itself is the chief contributor to the amount of odor available to a canine. In fact, the concept of odor availability is decidedly more complex in that it depends very little on the amount of explosive material present. More importantly, it is known that the amount of vapor generated from explosive compounds is dependent upon several factors including sample amount, vapor pressure, rate of transport, and the degree of confinement. Underlying these factors are the basic processes of evaporation of unconfined explosives, which are crucial to understanding how their vapors behave in other, more confined, systems.

The concept of odor availability remains controversial in the explosive-detecting canine community because the quantity of explosive used for canine testing and/or training is easily measured while the degree of confinement and the amount of vapor available for sampling is not. It has also been shown that vapors emanating from certain nitrated explosives tend to adsorb unto surrounding surfaces. Ultimately, odor availability is dependent upon evaporation rates, or the rate at which the mass of explosive material is decreases over time. Because evaporation involves both heat and mass transfer, the unconfined evaporation of an explosive must be modeled in order to fully account for odor availability. In this study, evaporation rates were determined for several explosive liquids using an analytical balance. These rates were compared to one another as well as to theoretical models for the evaporation of small liquid pools.

In general and as expected, the mass of explosive liquid decreased linearly with time with evaporation rates ranging from -9.57×10^{-6} mol/sec to -9.09×10^{-8} mol/sec for the most and least volatile species, respectively. Furthermore, it was shown that sample amount (i.e. surface area) and vapor pressure (as reflected in the boiling point of the substance) were determining factors in the evaporation of unconfined, nitrated liquids. For example, the mass loss of nitromethane ranged from 0.024 mg/sec (for 10µL) to 0.16 mg/sec (for 10mL) and the evaporation of nitromethane (374°C) proceeded approximately three times faster than nitropropane (405°C). The overall trend for the nitroalkane and nitroaromatic species was an exponential decrease in evaporation rate with increasing boiling point.

Overall, it was determined that the evaporation of unconfined nitrated liquids, exposed to open air, can be described by Deegan's model for the evaporation of liquid drops on flat surfaces, where the determining variables are the surface area of the pool and the vapor pressure of the substance. While several examples of solvent "pinning" on a metal surface (Deegan) were observed, these phenomena may be attributed to surface abnormalities in the container (i.e., unflatten surface and/or surface irregularities) as Deegan's model specifies the need for a completely flat surface.

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 ** Presenting Author*