A14 Percutaneous Absorption of Organic Gunshot Residue Associated With Polymeric Membranes Using Ion Mobility Spectrometry

Jordan W. Moran, BS, Rt 1, Box 311, Grafton, WV 26354*

After attending this presentation, attendees will gain an understanding about dermal absorption principles and how the dermal absorption of organic gunshot residue (GSR) can be used in gunshot residue casework studies.

This presentation will impact the forensic science community by highlighing potential uses of Ion Mobility Spectrometry (IMS) for the detection of organic gunshot residue that has been transferred to human skin after the use of a firearm and has been percutaneously absorbed. IMS analyses are fast, inexpensive, and generate a minimum amount of waste. The data showed that the method could play a valuable role in the definitive analysis of gunshot residue in casework samples.

Smokeless powders are a class of propellants that were developed in the late 19th-century to replace black powder. Organic additives, such as diphenylamine (DPA), are used as stabilizers and are also present in gunpowder composition. DPA stabilizes the energetic composition by binding nitrous oxide gases that have originated from the decomposition of nitrocellulose and converts them into stable compounds. Identification of stabilizers like DPA has become of importance in forensic science because it can provide valuable evidence in firearm discharge cases. Additionally, DPA is frequently used in the construction of improvised explosive devices (IEDs) related to criminal and terrorist acts.

Previous work has demonstrated that DPA can be detected on the skin of persons who have fired a weapon for about four hours, after which the concentration of DPA and other organic residues drops below IMS detection limits. These loses are not due to secondary transfer, which suggests that at least some portion of the compounds are being absorbed into the skin. To test this hypothesis, preliminary dermal absorption studies in the laboratory using polymeric membranes have shown that DPA possesses penetrating properties. The cumulative amount of DPA that permeated through the membranes increased over the course of 24 hours, which correlated well with the aforementioned persistence study. The calculated values of three key dermal absorption parameters were as followes: steady-state flux (J_{ss}, $\mu g/cm^2/hr$) 5.6 ± 1.7, permeability coefficient (K_p, cm/hr) $2.9 \times 10^{-3} \pm 8.5 \times 10^{-4}$, and lag time ($\tau$, hr) 1.1 ± 0.7. These results are comparable with the calculated values using the Potts and Guy skin permeation equation calculator available on the National Institute for Occupation Safety and Health's (NIOSH) website. The goal of this study was to build upon the DPA results and expand into evaluating the dermal absorption of other organic compounds present in gunshot standards and gunshot residue samples. Ion mobility spectrometry (IMS) was used for the qualitative analysis of organic gunshot residue for *in vitro* transdermal Franz diffusion cell (FDC) experiments.

IMS analyses were performed using an IONSCAN-LS™. IM station software (version 5.389) was used for data acquisition and processing. For the analysis of organic gunshot residue samples, the sample introduction into the IMS was performed through thermal desorption on a Teflon membrane. Organic gunshot residue was analyzed in the positive ionization mode while nicotinamide served as the calibrant. To simulate human skin, polydimethylsiloxane (PDMS) membranes (0.006" thick), were used for *in vitro* release testing. The membranes were the appropriate size to fit the FDC diameter (1" o.d) and their surface areas were 0.64 cm^2. Organic gunshot standards and gunshot residue samples were applied to the surface of the PDMS membranes and sampling occurred at regular time intervals. The cumulative amount of DPA found in the receptor fluid (μg) was plotted against time (hr). Linear regression was performed on the steady-state part of the curve to calculate the steady-state flux, skin permeability, and lag time.

In conclusion, results to date indicate that organic compounds associated with GSR are absorbed dermally and as such could be developed into another avenue for making a shooter/non-shooter decision based on chemical evidence.

Ion Mobility Spectrometry, Diphenylamine (DPA), GSR

 ** Presenting Author*