WHITE PAPER

On-site Identification of Improvised Incendiary Devices: Integrated Chemical ID and Decision Guidance with MIRA DS and HazMasterG3®

Homemade petrol bombs, also known as «Molotov Cocktails», have been used to instill fear and wreak havoc by small-scale military operations and during episodes of civil unrest since the 1930s. Although less lethal than conventional munitions, they are effective weapons of terror that can be easily and affordably assembled in large numbers for acts of aggression. To identify clandestine operations used for the assembly of explosives and gather forensic evidence, it is incumbent that First Responder, law enforcement, and military entities have portable analytical technologies to identify incendiary devices and their components. The MIRA DS handheld Raman spectrometer, used with HazMasterG3®, is shown to exceed these criteria and provide investigators with a material identification solution that brings quick decision making to the street.

Metrohm Raman

IMPROVISED INCENDIARY DEVICES

Molotov Cocktails (MC) are improvised incendiary devices that are easily assembled from common inexpensive household materials. At its most basic, the MC is comprised of a glass bottle containing a flammable fuel that engulfs the intended target in flames when ignited and thrown. The success of MCs in military skirmishes, arson, and civil protest has led to improved incendiary devices like the Chemical Ignition Molotov Cocktail (CIMC), which is activated by the strong exothermic reaction of chemical reagents upon mixing. The primary advantage of CIMCs is that they do not require an external ignition source. First deployed during WWII, CIMCs were effectively used by the Polish Home Army as an effective resistance weapon against Nazi occupation forces [1].

As shown below, the CIMC is a capped bottle containing a mixture of liquid fuel propellant and strong acid to which a mix of oxidizer and fuel is affixed. The bottle shatters when thrown, and all contents combine: the acid and oxidizer react vigorously and exothermically with the sugar, initiating the dispersal of an intense gasoline fire.

Identification of such devices is well-suited to handheld Raman analysis, which is primarily used for onsite chemical identification. Herein, MIRA DS quickly and accurately identifies materials used in the production of incendiary devices as part of a larger exercise, where specific threats are elucidated from theoretical combinations of chemicals.

CIMC IDENTIFICATION WITH MIRA DS AND HAZMASTERG3®

MIRA DS is a ruggedized, high-performance handheld instrument used for rapid, nondestructive identification of illicit materials including explosives, precursor materials, and hazardous agents. It offers:

- a wide variety of Smart Tips for no-contact sampling of solid and liquid materials
- fast, easy data collection capabilities for non-technical users, including defense and security professionals at the scene, with Smart Acquire
- the largest libraries available on the market for identification of thousands of substances and mixtures, with the KnowItAll® Raman Spectral Library (Handheld) by Wiley

Integration of MIRA DS with **HazMasterG3® software** combines robust material identification with chemical reaction modeling and product prediction to generate potential outcomes of specific mixtures. Such predictions are accompanied in HazMasterG3® by chemical warnings, providing guidance for the appropriate response and actionable safety measures. Simply import MIRA DS results into HazMasterG3® software, which analyzes possible combinations, ranks likely products, and provides chemical guidance. Flexible options for seamless communication with MIRA DS include software installation on a mobile phone, tablet, or computer.

METHODOLOGY

Raman spectra were collected for white sugar (sucrose), bleach, gasoline obtained from local vendors, and potassium chlorate and sulfuric acid from Sigma-Aldrich.

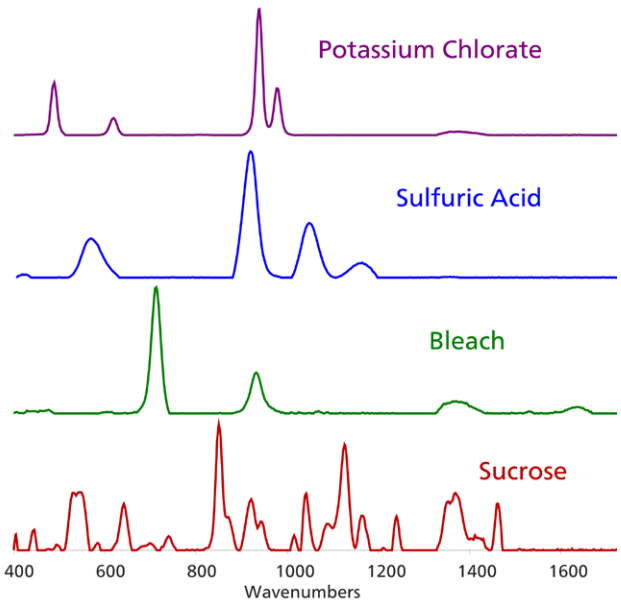
> The appeal of CIMCs is partly due to access to readily available precursor materials. For example, potassium chloride is easily purchased as salt substitute or as a water softener, and some drain cleaners are comprised of concentrated sulfuric acid. In the case of sulfuric acid, HazMasterG3® carries warnings for common consumer products that contain high concentrations of H_2SO_4.

Each reagent was sampled in a borosilicate glass vial with the MIRA DS vial holder to simulate a scenario in which raw reagent materials are found in a location

used for assembly of CIMC incendiary devices. Acquisition parameters including laser power, integration time, and spectral averaging were automatically optimized by Smart Acquire routines on MIRA DS for best quality spectra.

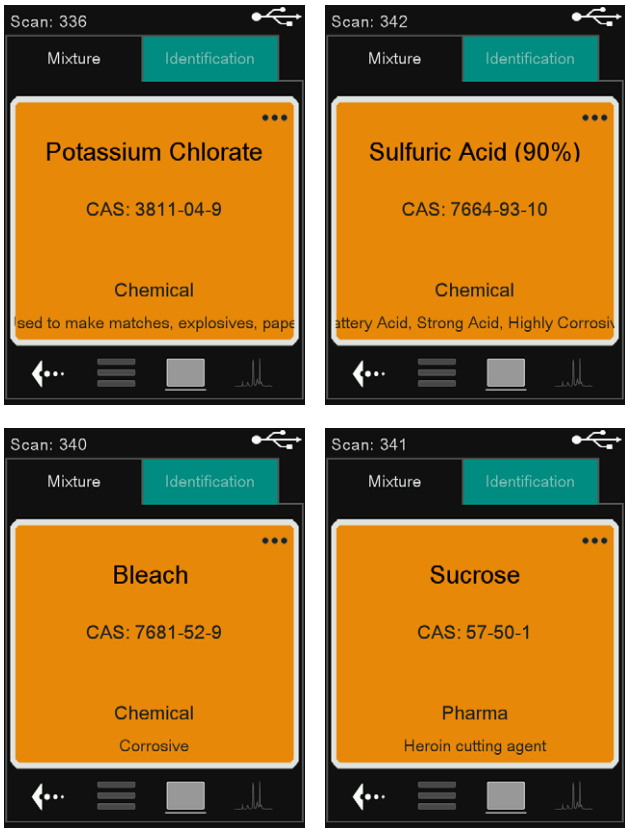
RESULTS AND DISCUSSION

The figure below contains baseline-corrected Raman spectra acquired for CIMC reagents (with the exception of the spectrum for gasoline, which is not shown).



Each spectrum is unique, characterized by intense peaks that are used to identify each material. Spectra for bleach and potassium chloride (NoSalt™) were also acquired, as potassium chlorate can be easily prepared from commonly available materials [2]. Previously published methods for investigating homemade incendiary devices indicate that potassium chlorate is rarely found as an innocuous contaminant and is, therefore, a robust indicator of intent to produce CIMCs [3, 4].

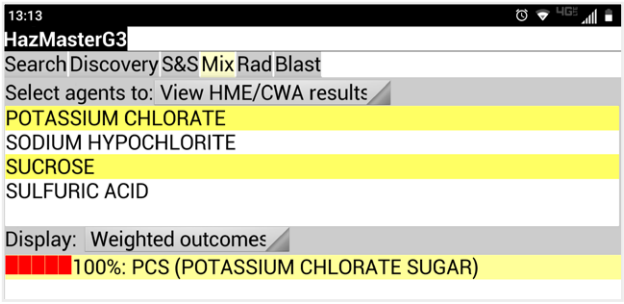
MIRA DS automatically performs library correlation searches within its on-board libraries and then displays color-coded results (actual screenshots below) with chemical information and warnings, and HazMasterG3® completes the story.

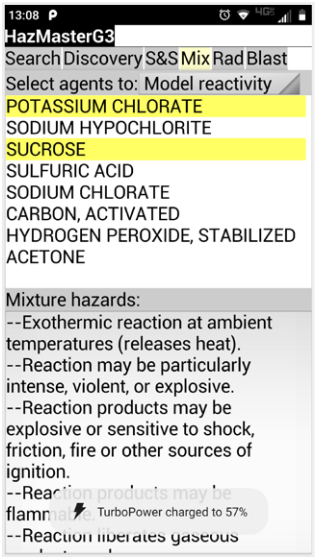


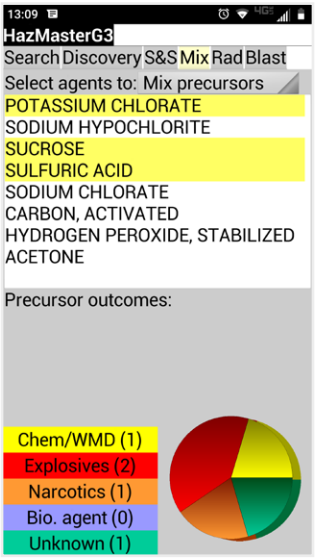
PRODUCT PREDICTION WITH HAZMASTERG3®

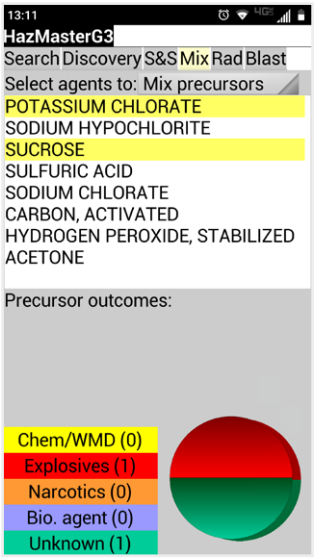
Importing Raman-identified materials into HazMasterG3® enables a host of operations, including predicting weighted outcomes of mixtures.

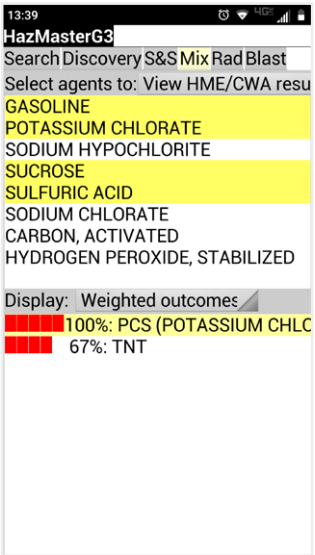
The following screenshots show that the input of potassium chlorate and sucrose favors the formation of explosives, alerting the user to possible health and safety dangers. As more information is imported, HazMasterG3® predicts both chemical weapons of mass destruction (WMD) and explosives as the suggested results for this chemical cocktail. Predicted probabilities of final products, personal protective equipment (PPE) recommendations, and emergency planning based on entered reagents are all easily accessed in HazMasterG3®.











CONCLUSION

MIRA DS with HazmasterG3® arms defense and security professionals with a portable device that has sensitive identification capabilities *and* the industry's leading tool for mounting effective response to HazMat threats. The HazMasterG3® database has more than 167,000 materials and trade names including toxic chemicals, biological warfare agents, and radiological compounds. The combination of the KnowItAll® Raman Spectral Library (Handheld) by Wiley and HazMasterG3® make MIRA DS the most versatile Hazmat instrument in the world.

In forensic investigations of clandestine operations, the MIRA DS/HazMasterG3® package delivers on-site actionable insight. This resource not only identifies materials, but also assesses intent-to-harm and hazards posed by a broad range of precursors or their finished products. This effectively reduces investigation resources and response times.

With MIRA DS and HazMasterG3®, terror cannot hide.

References

[1] Stolarski R.E. The Production of Arms and Explosive Materials by the Polish Home Army in the Years 1939–1945. *London Branch of the Polish Home Army Ex-Servicemen Association*, Article 25, 1–4.

[2] How to Make Potassium Chlorate at Home From Bleach and Salt Substitute. **https://sciencenotes.org/how-to-make-potassium-chlorate-at-home-from-bleach-and-salt-substitute/** (accessed May 27, 2021)

[3] Martín-Alberca, C.; Saíz, J.; Ferrando, J.L.; et al. Qualitative determination of inorganic anions in incendiary device residues by capillary electrophoresis. *Anal. Methods*, **2012**, *4*, 2680–2686.

[4] Martín-Alberca, C.; Ferrando, J.L.; García-Ruiz, C. Anionic markers for the forensic identification of Chemical Ignition Molotov Cocktail composition. *Science and Justice*, **2013**, *53*, 49–54. **DOI:10.1016/j.scijus.2012.11.004**

Subject to change | Layout by RTS Rieger Team, printed in Switzerland by Metrohm AG, CH-9101 Herisau
WP-070EN – 2021-07

Contact

Dr. Melissa J. Gelwicks & Mark Harpster
Metrohm Raman; Laramie, WY, United States of America
info@metrohm.com