



Portable Instrumentation for On-site Chemical Analyses

Chris Lennard & Val Spikmans

School of Science and Health University of Western Sydney

Vincent Otieno-Alego

Forensics Australian Federal Police

Overview



- Advantages of on-site analyses
- On-site analytical capabilities within the Australian Federal Police (AFP)
 - Field-portable equipment and mobile labs
 - Casework examples
- Current / ongoing research
 - On-site analysis of ignitable liquid residues in fire debris
 - Air and water analysis at fire scenes
- Relevance for environmental analyses



Evolution of Instrumentation



- Instruments are becoming:
 - Smaller, more portable
 - Smarter (microprocessor control), easier to operate
 - *More sensitive (smaller samples required)*
 - Cheaper to run per analysis

Lab → Portable Instrumentation



University of Western Sydney

X-Ray Fluorescence (XRF) Spectrometry



Fourier Transform Infrared (FTIR) Spectrometry

Lab \rightarrow Portable Instrumentation



University of Western Sydney

Lab → Portable Instrumentation



University of Western Sydney

Gas Chromatography – Mass Spectrometry (GC-MS)



Lab → Portable Instrumentation



Portable GC



Portable GC-MS





Advantages of On-site Analyses

- Rapid, preliminary results
- <u>Proactive</u> (actively assisting site assessments and incident investigation) rather than <u>reactive</u> (laboratory analyses undertaken later)
- Rapid screening for source determination
- Screening of samples prior to submission for full laboratory analysis
 - Only more relevant samples retained
 - Less samples requiring full laboratory analysis
 - On-site results can help direct laboratory analysis
 - Reduced backlogs and improved turnaround times



- Focus on explosives analysis in the lead-up to the Sydney 2000 Olympic Games
 - Mobile laboratory capability established
 - Ion mobility spectrometry
 - Gas chromatography









- Use of field-portable equipment fully exploited in response to terrorist bombings in Indonesia
 - Bali bombings 2002 (202 dead)
 - Marriott Hotel bombing, Jakarta 2003 (12 dead)
 - Australian Embassy bombing, Jakarta 2004 (10 dead)
 - Bali bombings 2005 (24 dead)
- AFP assistance to INP
- Portable instruments set up in hotel rooms (sample screening)









• Overseas deployments:

- Indonesia, Thailand, Solomon Islands, Philippines
- Spain (Madrid bombings; 2004), Netherlands (MH17; 2014)





• Cache of suspected explosive materials (Indonesia, 2007)









- Clandestine explosives laboratory:
 - Mobile laboratory deployed on-site to assist with chemical ID
 - Substances identified included ammonium nitrate, acetone, hydrogen peroxide, sulfur, hydrochloric acid, nitromethane, smokeless powder and iron filings
 - Removes the need to transport potentially dangerous materials



- Instruments need to be kept ready for deployment
- Field tests do not replace and should not compromise subsequent lab analyses
- Non-confirmatory results
 - Limitations of on-site testing
 - Field and lab results can be different
 - Investigators need to be aware of this
- Logistical problems
 - Transport of equipment, consumables, chemicals
 - Link to central laboratory





- Evaluation of field-portable GC-MS for forensic applications
- Partnership with Torion (now part of PerkinElmer)
 - TRIDION-9 GC-MS
 - Low thermal mass GC
 - Toroidal ion trap MS (45-500 amu)
 - Battery / He canister
 - 32 lbs (14.5 kg)
 - Person-portable
 - Analysis < 3 min







- Preliminary study (2011–2012):
 - Explosives (results for TNT, PETN, TATP)
 - Illicit drugs (range of underivatized samples, including cocaine, amphetamine and methamphetamine)
 - Hydrocarbons (range of ignitable liquids)





- On-site analysis of ignitable liquid residues in fire debris
- Laboratory optimisation
 - 0.1 μ L of IL in 1 L tin
 - 3 min SPME sampling time
 - < 2 min GC-MS analysis time</p>
 - Neat and weathered ILs



- Range of common substrates, unburned and burned
- Field trials
 - Burn exercise with Fire & Rescue NSW
 - Portable GC-MS operated from the trunk of a car



Gasoline





Mineral Turpentine





Kerosene



Diesel







- Publication from initial study:
 - Australian Journal of Forensic Sciences, 2015
- Follow-up project with Fire & Rescue NSW:
 - On-site ILR analyses and comparison with lab results
- Broader study has commenced on analysis of air and water samples at fire scenes:
 - Screening for toxic compounds to alert first responders
 - Detection and identification of compounds that may cause environmental harm
 - Detection and identification of compounds that may be of interest from a forensic investigation perspective

Environmental Analyses





- Effluent from stormwater drain in residential area
 - Samples taken for lab analysis with GC-MS confirming presence of methamphetamine (runoff from clan lab)

Environmental Analyses







- Polluted waterway
 - Dead crayfish
 - Lab analysis confirmed pesticide leaching from residential area

Environmental Analyses







Conclusions

- Portable instruments are improving in performance
- Full laboratory analyses are costly and time-consuming
- The screening of samples on-site provides benefits:
 - Quick presumptive results (can help direct the investigation and facilitate source determination at the scene)
 - Only samples of interest require subsequent lab analysis
 - On-site results can help focus / prioritise lab testing
 - Better use of the central lab (less samples require full lab analysis
 → reduced costs / backlogs / turnaround times)
- Whether for forensic investigations or environmental monitoring, the benefits / issues are the same!
- Important that we learn from our shared experiences