Superior analytics

Forensic science and the gases industry

How R&D and technology evolution in gas analysis is benefiting even the most overlooked of applications.

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Forensic science: It's the stuff of blockbuster movies and high profile serial dramas, immortalised in fictional print, on TV screens, and at the box office.

As the application of a broad spectrum of sciences and technologies for investigative purposes, forensic science is also embedded in the pages of history, used in criminology, archeology, biology, geology, and more. It is perhaps the criminal world that we most associate this technology with and we can all picture the scene; hair samples and fibres, blood stains in the carpet, and investigators sporting white suits as they delicately brush a coffee table with fine carbon powder to reveal the faintest of fingerprints.

For over 150 years, fingerprints have been helping to ensure the clear identification of the perpetrator in a criminal investigation, more conclusive than DNA testing and generally an effective investigative tool. But rendering them visible often takes a great deal of time and finesse on the part of the crime scene technicians – as well as a cocktail of chemicals. This is especially significant when exploring porous, absorbent materials such as paper or wood, which present a far greater challenge.

Now, however, the task is being made easier and more efficient with the use of technology developed by the industrial and specialty gases business.

Superior analytics

Gas chromatography-mass spectrometry (GC-MS) is emerging as the perfect analytical tool for the many thousands of forensic science technicians around the world.

GC-MS is one of few techniques capable of qualitatively identifying the actual nature of chemicals in the sample, with its simplicity, sensitivity and effectiveness in separating and identifying components ensuring that GC-MS is now one of the most important tools in analytical chemistry today.

In GC, molecules in a sample separate in the chromatography column due to the differences in their chemical properties. The MS breaks components into ionised species and separates these based on their mass-to-charge ratio. This is the great advantage of the combination of GC as the first separation step, and the MS as the qualitative detector.

Similarly, liquid chromatography-mass spectrometry (LC-MS) is also a qualitative analytical chemistry technique that combines the physical separation capabilities of high performance liquid chromatography with the qualitative analysis capabilities of mass spectrometry technology.

Both techniques involve using a mass spectrometry detector, but while GC-MS is used to screen a sample using a gaseous phase component separation process in the GC column, LC-MS is able to detect and identify chemicals using a liquid phase component separation process in the LC column.

The medium in which the sample exists and is most effectively separated in the chromatography column determines which technique is more appropriate. While many samples can be vaporised for GC-MS, other samples are better dissolved in a suitable solvent and examined using LC-MS.

As a result of continued R&D in the gases and equipment industry, these technologies have evolved through the years from a cumbersome, large-scale analytical solution to a portable instrument in the world of forensic science. The use of a mass spectrometer as the detector in gas chromatography was developed in the US during the 1950s, comprising a bulky technology limited to laboratory settings. In the decades that have followed, GC-MS equipment has accelerated both its level of its analysis and end-user applications, while shrinking its physical scale to a much more accessible instrument.

"The first gas chromatography mass spectrometer I ever saw filled a large room," testified Stephen Harrison,

"Gas chromatography-mass spectrometry is emerging as the perfect analytical tool for forensic science technicians..."

Head of Specialty Gases and Specialty Equipment at The Linde Group. "It was bigger than a dining room table and cost a fortune. Today, there is a big contrast. You can put a GC-MS into a small suitcase and carry it to any location on a plant or factory, or even a crime scene."

"Over the past 20 to 30 years, this technology has moved from being hallowed and rare, to still being hallowed and important, but very commonplace and portable. It's still a relatively expensive analytical instrument, but nowhere near what it was in the past."

Harrison added, "As a result of its rapid evolution as an increasingly accessible technique, applications for

FORENSICS IN FOOD

It is not just in criminal applications that GC-MS technology is deployed as a means of forensics. GC-MS is also commonly used to screen for contaminants in food and drugs.

Using qualitative techniques like GC-MS enables the identification of the presence of a specific chemical, such as dioxin. This was especially pertinent in Europe in recent years, when elevated levels of dioxins showed up in small amounts of German farm produce.

Similar applications have occurred in the beverage industry, with one of the most notable being the benzene in soft drinks episode of the 1990s. Another example is the global issue of distilled spirits being made in unlicensed stills. On occasion, these beverages may contain toxic alcohols such as methanol, which can cause blindness and death. GC-MS technology in the hands of food safety officials and forensic policing teams would be able prove the presence of the toxic molecules – and protect the consumer.

GC-MS are opening up in a big way."

One such application is of course forensic science. Industrial gases vacuum technology is also being applied to another realm of forensics and in 2012 Linde Gases announced a significant leap forward in fingerprint identification technology through the introduction of its automated processing system.

The company's ADROIT™ FC 300 system provides increased precision and reduced complexity through a dry, non-contact technology which uses a gaseous application process for developing latent fingerprints. The system eliminates hazardous carrier solvents used in traditional processing methods and the physical application of these materials by dipping, spraying, brushing and drying.

At its core lies the vacuum chamber, into which the forensic scientists place the evidence to be examined. There is even space for an entire rifle. Detection chemicals are applied by sublimation and dilution in a proprietary carrier gas injected into a low pressure environment. The gas mixture expands, uniformly coating all exposed surfaces (the evidence) and depositing a thin film which adheres to, or chemically reacts with, the print residue making it visible to the unaided eye or under alternate light source (ALS) or laser excitation. Further, the ADROIT™ FC 300's programmable logic controller (PLC) enables remote monitoring from a central command centre via network, allowing agencies with satellite systems to control the processing regimens and update new process recipes anytime, anywhere in the world.

Speaking back in 2012, Calvin Knaggs, Marketing Manager, Specialty Markets Equipment at Linde, said of its launch, "The new Linde technology is a flexible tool designed with both the forensic investigator and research scientist in mind. It's a dry gaseous process, capable of developing latent prints on a wide range of porous and non-porous materials including thermal papers."

"The programmed recipe control lends itself to standardised practices, ensuring precision while eliminating the complexities and potential inaccuracies associated with mixing and applying solvent carriers. This is truly a step change in fingerprint development technology, eliminating many of the storage, safety and environmental problems associated with the current art."

"It's a dry gaseous process, capable of devleoping latent prints on a wide range of porous and non-porous materials including thermal papers"

While it houses a sophisticated combination of vacuum, thin-film and gas technologies, the ADROIT™ FC 300 looks fairly unremarkable – simply a grey steel box with a viewing window, switches, tubes and a display.

But its significance in forensic science is far from unremarkable; investigators can work much more efficiently without the need for manual laborious dabbing, spraying and brushing with chemical agents. These more conventional means also came with the potential to damage the prints, a challenge averted with this new technology.

As well as the capability to develop fingerprints at room temperature, leaving the heat-sensitive layer intact to reveal any important signs, traces of DNA or drugs on a piece of evidence remain equally unscathed for subsequent examination and analysis.

The game is up…

R&D in the gases industry has evolved the early and perhaps unwieldy GC-MS technology of the past to a portable, lightweight and altogether more accessible means of analysis. Chemistry that is largely overlooked as a precision tool for such invaluable applications.

With such advances in industrial gas and equipment capabilities and their application in forensic science, fiction authors around the world may soon find that the game is up for the classic murder mystery.

But could this also lead to a more widespread deployment or roll-out in forensic applications in the future? According to Linde, the answer is yes. Similar LC-MS and GC-MS techniques have been used in the recent horsemeat/beef food supply chain issues. Furthermore, similar techniques were used during the London 2012 Olympics for screening blood and urine samples from athletes to ensure a 'clean' and fair sporting event.

DEMANDS

GC-MS requires high quality specialty gases for instrument operation and for calibration. Specialty gases are used as carrier gases (helium is most common), collision gases (nitrogen or helium), and can also include reagent gases. Further, the effect is two-fold; such high demands in gas purity place rigorous requirements on associated equipment such as regulators and valves.

"Demands made on regulators and valves in these environments are extremely high. Components must be capable of dealing with high and low pressures, large and small flows. They must be suitable for high-purity inert gases as well as reactive, flammable, corrosive or toxic gases," explained Linde's Stephen Harrison.