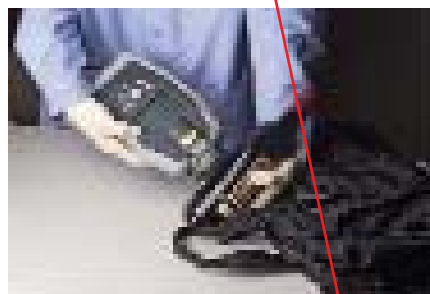


THE autumn brought with it a “new” threat: the fear of terrorists smuggling liquids onto aircraft with the view to creating a weapon – either explosive or chemical. This threat, newsagents screamed and “intelligence sources confirmed”, was a real one. Not only were your drinks, toothpaste and other accoutrements confiscated, but the threat even went down as low as baby milk (a masterful piece of press handling that suggested the depths to which terrorists would stoop). This brought in draconian baggage rules and it seemed for a fortnight that we would soon regress to steamer travel. Yet during this whole time there was a piece of technology that was available that would be able to calm the hysteria and provide an adequate level of technology – raman spectroscopy. Raman works by firing a laser at a nearby sample (exactly how close depends on the power of the laser). This causes photon-molecular interaction between the materials and the laser, subsequently causing an inelastic raman scattering. The frequency and intensity of these scattered photons provides a unique chemical signature of the substance, allowing it to be identified. (In layman’s terms, you fire a laser at a liquid, or solid, and measure the results that come back from it.)

There are a great many detectors out in the market that do chemical identification, but most of them require a sample – raman works with the sample in situ. It doesn’t matter whether it is plastic, glass or any other transparent material – if a laser can shine through it, it will provide a signature. For operatives in the field, this provides a major health and safety boost. Dr Michael Pixton, a Senior Hazardous Substance Scientist at the Californian Department of Toxic Substance Control, uses raman spectroscopy and explained why: “We have an individual in the lab responsible for reviewing the available equipment and portable instrumentation, to try and get as comprehensive a suite as possible for our mobile lab for field use,” he said. “He asked me to assist as I had trained for three years as an analytical chemist, spent ten years doing a lot of hazardous inspections and seven years as emergency response worker. So I had a good background to assist the lab in looking at the capability of different instruments and what would help them best. Raman spectroscopy – in our case Ahura’s First Defender – was great because it sees through glass, whether clear or opaque, meaning you don’t have to take a sample – a big health and safety factor. First Defender has

Message in a bottle

In light of the alleged
UK airline plot this year,
Gwyn Winfield peers
into the world of raman
spectroscopy



a good library and spectral analysis algorithms that identify what it is most likely to be. It is a simple instrument to use, but still rugged, which is a big bonus as we have to give quick training to people in the field and send them out to examine samples. We want to have a high level of confidence that it operates properly and get something back.”

Ahura is not the only company to be manufacturing raman devices, however, Smiths Detection has produced a complementary product to accompany its FTIR based Hazmat ID, and ITT are currently developing a stand-off raman, called Inspector. As useful as raman is, it is not the answer to all prayers. “Everyone wants the tricorder – the device that answers all questions. Raman is not that,” said Doug Kahan, Ahura’s CEO. “We continue to look at other technology that can complement that, but raman is a tool in the tool box; it is excellent for identifying solid and liquid chemicals which are dangerous chemicals. Our database is quite robust in

regards to dangerous chemicals; it also has a record function, so if there is an agency that has a particular concern about a substance about which we don’t have access then we can add that to the database. They can be screened for anything which they want to screen for.

“That said, raman has some limitations. The scientist and government believe that raman is probably the best way for chemical detection and identification, although it is not the only one. It has two limitations. Firstly, some substances don’t have much of a raman signature, and the other problem is some products have a great deal of fluorescence – in radio terms it would be noise – and it might take too long or get back too much noise to find the signal. There are a small number of substances that have these traits and fortunately they tend not to be the substances that every one is worried about – but water has no raman signature so we can’t look at something and say that is water. We can say there is no nitro-glycerin or TATP here; we can do that because we know what those chemical signatures are, but something that has no raman response is not going to show up. If you put something in the water that has a raman signature then we would pick that up – our technology and software on the machine allows us to identify mixtures of up to five different substances in that mixture, but only if those substances are reasonably well represented in the slurry – ten per cent or more. You complement it with something like FTIR, and FTIR tends to pick up all the things that Raman doesn’t. If you use each of those two devices you should be able to identify nearly every chemical, and with our tech mixtures of chemicals. The next step for us is to add further techniques which will allow further identification of the unknown substances. Frankly we are looking to others to do the role of detection; our role is that of identifying the content.”

A Smiths Detection spokesman agreed: “Raman is limited in its capability; it is better to use it in collaboration with Hazmat ID, or something similar. You can then use a probability algorithm whereby if one doesn’t detect, then the other one should. It is a limited science for it to be used on its own, although it should be used to bolster up FTIR. What it is good at is picking up low levels of substances; raman will pick up three-four per cent while FTIR starts picking it up at 10 per cent.”

Dr Pixton suggested that, while raman was a useful tool, part of its attraction came from the increased value that a specialist could get

from it. "The First Defender can only tell you so much," he said. "You point, you shoot, you get a spectrum back and it will give you its best guess. There is a lot more information contained in that spectrum than just what it is telling you on the screen. The trick is to bring that information back, put it on a laptop and then have a specialist look at it and get more information from it than you could with just a hazmat tech."

While both Smiths and Ahura have seen significant interest from customs and security officials, the real drive has come from more traditional users. "We have sold more than 300 units in the 15 months of the product's



Glass, plastic, coloured glass and mixtures are all in a days work for a raman spectrometer. © Ahura



life to hazmat teams," said Doug Kahan. "They represent the largest application because they have to identify toxic waste, or TICs, like in the Katrina clean up; when things come floating by and they need to work out what they are and how they can be best disposed of – using specialist handling, etc. There is also the military, as they come across substances they need to identify quickly and make decisions about. Law enforcement is also important; they also come across substances such as drugs and they need to know what the white powder in the bag is – will it cause concern or not? Then agencies like the TSA, that have responsibility for some form of security, are finding themselves in an environment where unknown substances continue to be discovered and they need to know whether it is dangerous and how they should handle these individuals." Smiths Detection agreed: "We have had interest from other agencies, but the police and first responder market is the most attractive."

Mr Kahan went into more detail: "The UK incident created a greater sense of urgency in the TSA," he said. "They had a project underway for bottle screening, but have undergone a personnel change and Admiral Cohen has taken over the agency and has made sure that TSA and DHS are actively pursuing solutions to the bottle screening challenge. We feel a new level of energy and new level of interest in our technology for bottle screening. A lot of the hazmat people who have FTIR technology realise when we expose them to the First Defender that this is also a necessary tool in their arsenal, that there are big holes in their FTIR solution and when they marry it up with Raman they have a more robust toolset."

One of the advantages over FTIR is the ability to run mixtures of substances, rather than a pure substance. This allows a hazmat operative the chance to piece together the toxic soup he might be looking at. Dr Pixton agreed this was one of the items that had driven him towards raman: "We commonly come across mixtures, and once you have established what sort of mix you are working with you can then run that mix through the library mode and log a spectra for it. Then the Ahura will positively identify any other samples much more readily than it would otherwise."

Doug Kahan admitted that the First Defender's ability to identify up to five mixtures made it very popular. "A typical scan takes about 20 seconds – ten seconds of laser exposure and ten seconds of analysis where we look at the spectrum and compare it to the

database – but if it is a mixture then it takes a bit longer to do the analysis as you need to find a pattern in what you've seen."

Yet there are some disadvantages to raman that Smiths Detection had identified: immiscible liquids, problems with coloured glass, proteins (which fluoresce and increase the "noise") and a smaller library than FTIR. While some are product-specific, Ahura have no difficulty with coloured glass, for example, while the immiscible liquids are a problem. This is when two liquids sit on top of each other without mixing. This could mean that then operative would scan the top, or bottom, of a sample, only noticing the benign source. Dr Pixton admitted this was a problem. "It is a solution that needs to be solved by both technology and training. Immiscible solutions and bi-lated or tri-lated solutions are difficult; if there is no colour difference to distinguish those layers then it is not obvious. To be able to shoot through the container to get the immiscible layers, however, is far easier than having to pull out a compound sample, let it separate and then identify it. Instead, we can just shoot through the glass. Plus you get certain chemistry happening at that dividing layer depending on what the mix is – we had a case where we had an acid solution sitting on top of a salt crust and beneath the salt crust was cyanide. If that crust had been broken through and the acid and cyanide combined, it would have released the cyanide as a gas, which would have been problematic."

The Smiths Detection spokesman also suggested that there was a problem with ruggedisation. Since raman uses a sensitive laser, and first responders don't always treat their tools with the greatest of respect, there is the chance that throwing a raman spectrometer into the back of a truck would not do its sensitivity any good. Doug Kahan suggested that this could be a problem: "We knew that our product was going to be used by the military and firemen," he said. "Neither of these are a part of the population that is known to be delicate with equipment. So we built the unit to conform to the military 10F standard – a four foot drop test onto concrete. It is waterproof and made out of material that is easily decontaminated – they tend to drop it in a chlorine bath and it comes out kicking. We knew early on that we couldn't use lab lasers as they are not stable enough, use too much power and are too large, so we built our own – we grow the crystals here at the atomic level. We built the laser in our unit from scratch at our manufacturing facility and that is necessary to have

the kind of durability and low power consumption and accuracy that is built into our product. Without that we wouldn't be able to get the high quality roc curve and performance."

While raman might not be the tricorder, presumably it could have a greater role than just chemical identification. Currently work is being done on biological lasers and fluorescence where certain proteins, such as NADH, fluoresce under a laser indicating that it might be a biological attack. Surely it would be simply a matter of changing the wavelength to allow First Defender to do the same? "In addition to chemical identification, raman technology can also be used to identify biological specimens," said Doug Kahan. "Its effectiveness has been validated in laboratory settings, and current research and development activities are focused on evaluation of various wavelength lasers and pre-separation techniques for amplifying desired signals and filtering undesired ones. Highly specialised software for analysis and codification of spectra from various species and sub-species is also required. While the development task is challenging, particularly given the ubiquity of proteins and the complexity of living organ-



Smiths Detection have released their own raman device to complement their Hazmat ID © CBRNe World

isms, raman spectroscopy holds great promise for fast and accurate field identification of biological threats." You saw it here first!

Raman technology is not the tricorder, despite whatever promise it might hold in the future. It is, however, another tool in the chemical identification toolset and one, moreover, that complements FTIR. It is likely that future operations will see these being used

jointly – which is why it is no surprise that Smiths Detection have released one to partner their Hazmat ID – and, as Dr Plixton suggested, once users and scientists get together raman will probably enjoy applications that it was never planned for. Whether this will mean we can now take toothpaste on board a plane, however, is a question above all our pay-grades.



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