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CHEMISTRY

Explosive Used in Brussels Isn't Hard to Detect

A network of small sensors can spot bombs made of TATP

By Mitch Jacoby, Chemical & Engineering News on March 30, 2016

BRUSSELS, BELGIUM—MARCH 27: People gather in the Place de la Bourse to pay tribute to

the 31 victims of the attacks in Brussels that occured on March 22, 2016.
Credit: Sylvain Lefevre / Stringer via Getty Images

Triacetone triperoxide (TATP) is a highly unstable explosive prone to unintended detonation. Yet terrorists, such as those responsible for last week's bombings in Brussels and the November 2015 attacks in Paris, are increasingly using the compound to inflict carnage.

Despite its instability, TATP is attractive as a terror weapon because it is relatively easy to prepare and, until recently, was difficult to detect by standard explosives screening methods. Those methods, which are based on X-ray computed tomography (CT) and ion mobility spectrometry (IMS), have been modified and can now routinely detect TATP in airports and at other security checkpoints. Several other methods in various stages of commercialization, including some based on handheld scanners, can also detect TATP.

The problem that remains unsolved is figuring out how to stop terrorists from detonating explosives in crowded, unscreened public areas, such as subway stations and the unsecured sides of airports, which is where the terrorists in Brussels set off their bombs.

TATP has been implicated in several terrorist plots since 2001, when Richard Reid, the "shoe bomber," tried to ignite a supply of the compound hidden in the soles of his shoes during a trans-Atlantic flight. In addition to the terror attacks in Brussels and Paris, the peroxide was also used in the2005 London transit bombings.

Terrorists don't need extensive chemistry training to prepare TATP. And the materials required to synthesize it—hydrogen peroxide, acetone, and mineral acid—are widely available in large quantities.

But unlike TNT and other common military explosives, "TATP is incredibly dangerous" even when it's sitting on a shelf, says David A. Atkinson, who heads Pacific Northwest National Laboratory's research in explosives and biological threat detection. "It can go off with the slightest shock or a bit of friction," he notes. For that reason, TATP has typically been used in the past in small quantities as a detonator to trigger explosions of TNT or other stable explosives.

In the Brussels bombings, however, Belgian authorities reported that they recovered two undetonated bombs at the airport containing some 15 kg of TATP. The bombs, which were hidden in suitcases, also contained ammonium nitrate, metal bolts, and nails. Belgian officials reported that two additional bombs of similar description were found in a Brussels residence tied to the bombers.

Those bombs likely would have been detected had they been subjected to CT and IMS scanning. According to Jimmie C. Oxley, an explosives specialist at the University of Rhode Island (URI), manufacturers modified those instruments in response to terror plots in recent years to enable them to detect TATP.

By irradiating luggage with intense X-ray beams and measuring how much of the beam passes through an object, CT scanners probe the density and other properties of a bag's contents. Automated algorithms then compare those data with a library of density values for a group of explosives that now includes TATP. Suspicious bags can be further inspected via IMS .

Oxley, who was reached by C&EN just after her team conducted a TATP test explosion at URI's firing range, notes that commercial IMS instruments initially did not detect TATP. But they do now.

In IMS measurements, after an operator swabs a suspicious bag and inserts the swab into the instrument, a plume of sample ions enters a drift tube and interacts with a gas. Under the influence of an electric field, the ions are driven down the length of the tube, causing them to separate en route to a detector according to their mass, size, and shape. The method, which can detect picogram levels of various explosives in seconds, generates unique IMS signatures.

According to Oxley, the instruments were initially configured to detect negatively charged ions, such as the ones formed by common nitro-based explosives, but not positively charged ions, which TATP can form. Now the instruments, which are made by several manufacturers, including U.K.-based Smiths Detection and Morpho, a French company, quickly scan for both types of signals.

TATP can also be detected via fluorescence methods. Flir, a major instrument maker with headquarters in Wilsonville, Oregon, manufactures a handheld device, Fido X3, capable of detecting numerous explosives, including TATP. As an air sample is drawn into the device, explosive analyte molecules bind with specially designed conjugated aromatic polymers, causing a large change in a fluorescence signal.

Other TATP detection methods have been reported in recent years, and some of them are being commercialized. Trained dogs, for example, are often considered a gold standard in sniffing out explosives. But trainers have generally stayed away from teaching canines to find TATP because the compound is so unstable that they've feared harming the dogs and themselves. Oxley's research group has developed a safe TATP canine training kit in which the explosive is encapsulated in an inert polymer and is in the process of commercializing it.

And at the University of Illinois, Urbana-Champaign, chemistry professor Kenneth S. Suslick has developed an optoelectronic "nose" for identifying many classes of compounds, including peroxide explosives.

Along with a digital reader, the device contains a large array of dyes that change color upon reacting with explosives and other compounds. The reader compares the color patterns before and after the sensor array is exposed to a sample—a sniff of air, for example—and then generates a color difference map that serves as a chemical signature.

Recently, Suslick's group demonstrated that the device can distinguish TATP from other peroxides and can distinguish one synthesis procedure from another by detecting residual impurities. That information, which can determine, for example, the type of acid used as a catalyst to synthesize TATP, may assist law enforcement in identifying the bomb maker (*Chem. Comm.* 2015, DOI: 10.1039/c5cc06221g).

The team also recently showed that this detection strategy works quickly and reliably in an inexpensive handheld prototype device that exhibits sensitivity to TATP in the low parts-per-billion range (*Chem. Sci.* 2015, DOI: 10.1039/c5sc02632f).

Palo-Alto-based iSense, a start-up company, is continuing to develop the optoelectronic nose technology for several applications, according to Sung H. Lim. Lim was a postdoctoral researcher with Suslick in 2006 and now serves as iSense's chief technology officer.

Any of these detection methods—and others under development, including portable mass spectrometry techniques—can alert a security officer to the presence of TATP. As Oxley points out, TATP is fairly easy to detect because it has a relatively high vapor pressure and is therefore volatile. But these methods can succeed only if the source of the explosive—a suitcase, car, or terrorist's contaminated clothing or hair—is screened.

"When one passenger at a time goes through an airport checkpoint, security has the chance to get up close and personal," Atkinson says. "You don't get the chance to sample that way out in crowded public places."

Oxley proposes that one piece of the solution to this difficult security problem is using multiple small detectors to provide wide area surveillance in public places such as malls and arenas.

Suslick suggests that in some public places, operators could use small handheld units, such as his optoelectronic nose, for preliminary checks, in much the same way trained dogs are used to quickly buzz through long lines of people waiting to enter an event. He notes that, unlike dogs, electronic detectors don't need to take breaks and aren't easily distracted, for instance by little kids holding hotdogs.

Atkinson offers what's likely to be a more controversial suggestion. "My approach would be to look for the bomb factories while the would-be perpetrators are honing their craft, instead of waiting for them to fill their backpacks and head out to do the deed."

He proposes coupling intelligence information from wire taps, e-mail and chat room monitoring, and other surveillance with mobile chemical sensing. "It's not normal for a guy who lives in an apartment to bring home large amounts of acetone." Maybe he's just stripping a piece of furniture, Atkinson says. But maybe not. "If law enforcement learns of suspicious activities or odd smells, someone should do some chemical investigating."

"This is a huge, serious threat," Atkinson says, "but it's not primarily a technology problem. It's an operational problem. We have good methods for detecting explosives. But we need to be smarter about the way we use detection technology."