Fast, Accurate Detection of Explosives on Airport Luggage Possible

WEST LAFAYETTE, Ind. – Fast, highly reliable detection of residues that could indicate the presence of explosives and other hazardous materials inside luggage is now possible with technology under development at Purdue University.

A research team led by R. Graham Cooks has found a way to determine the presence on a surface of trace quantities of chemicals – such as those found in biological and chemical warfare agents, as well as several common explosives – within a few seconds. The researchers' method uses a tool common in many chemistry and biology labs called a mass spectrometer that has been modified to analyze samples directly from the environment rather than requiring the lengthy pre-treatment that laboratory mass spectrometry samples typically require. According to Cooks, no portable device is currently on the market that can analyze samples in this manner. The team had previously developed a prototype device that detects nanogram-sized samples, but with recent improvements the device has proven successful at detecting at the picogram (trillionths of a gram) level in lab tests, about 1,000 times less material than previously required.

Cooks said he thinks a portable tool based on the technology could prove valuable for security in public places worldwide. "In the amount of time it requires to take a breath, this technology can sniff the surface of a piece of luggage and determine whether a hazardous substance is likely to be inside, based on residual chemicals brushed from the hand of someone loading the suitcase," said Cooks, who is the Henry Bohn Hass Distinguished Professor of Analytical Chemistry in Purdue's College of Science. "We think it could be useful in screening suspect packages in airports, train stations and other places where there have been problems in the past. Because the technology works on other surfaces, such as skin and clothing, it also could help determine whether an individual has been involved in handling these chemicals."

J.L. Beauchamp, a chemist at the California Institute of Technology who has worked in mass spectrometry for more than four decades, said the team's research on desorption electrospray ionization, or DESI, can solve a number of problems. "The nature of explosive materials has made them difficult to detect with mass spectrometry," said Beauchamp, who is also a member of the National Academy of Sciences. "Cooks' group has solved this problem with DESI, and combined with recent developments in the field has developed what may be a practical and widely deployable method for detecting and positively identifying not only explosives, but also a wide range of substances that might be employed by terrorist groups."

The research announcement appeared as an accelerated article in the journal Analytical Chemistry's Web site. Cooks developed the method with the assistance of his Purdue colleagues Ismael Cotte-Rodríguez, Zoltán Takáts, Nari Talaty and Huanwen Chen.

Mass spectrometers are the workhorses of many chemistry labs because these machines can deliver highly accurate and reliable analyses of substances interesting to scientists, including pharmaceutical developers. The devices also are often used by law enforcement to test suspicious looking residues that could indicate the presence of explosives or drugs inside packages. But most mass spectrometers are unwieldy, cabinet-sized machines that require samples to undergo hours of intensive preparation before testing, which can be a problem if officials need to test a large number of containers quickly.

"A mass spectrometer is one of the best tools we've got, but scientists have known for years that without a way to streamline the analytical process, mass spectrometry will have limited use in the field," said Talaty, a graduate student in Cooks' lab. "But with the present technology, we can now analyze samples rapidly, without any pretreatment. It has already been used to analyze pharmaceuticals at up to three samples per second."

Cooks' team has made several strides in improving mass spectrometry over the past few years, having found ways to both decrease the size of the spectrometers and analyze samples rapidly under standard environmental conditions. Their most recent work with DESI, which involves directing a spray of reactive chemicals onto a surface to dislodge suspicious chemicals and sucking the mixture into a spectrometer for analysis, has allowed them to detect hazardous substances at unprecedented low quantities and with equally unprecedented speed. "Trace and residue analysis of explosives has been a difficult task due to deliberate concealment, the small quantities of material available and the presence of other compounds that can interfere with the analysis," said Cotte-Rodríguez, also a graduate student in Cooks' lab. "But the 'spray' technique we use, combined with small tandem mass spectrometers that can confirm the identity of a particular explosive, gives this method both unusual sensitivity and quick turnaround time, even compared with what we achieved earlier this year."

Talaty said the team's forthcoming spectrometry gear, which will weigh less than 25 pounds, fits into a backpack and returns a negligible number of false readings, both factors that are also important to law enforcement officials. The small instrument is currently being fitted to work with the DESI ionization method described in the team's paper. "You don't want to lug around gear that you can't carry on your person, and once you get it to a site, you want it to give you the straight story on what you're looking at and be able to confirm it," he said. "This technology can do both."

Although DESI sensors still have difficulty classifying compounds with many different components, he said, this limitation would not likely be much of an issue in bomb detection because explosives do not generally contain that many. "If you tried to detect a particular compound out of a mixture of thousands of different substances, you might begin to see the limitations of this method," Talaty said. "But real-world explosives are not that complex. In any case, the sensitivity of DESI is high enough that officials could find what they need to if it's there. No system is flawless, but if we deployed this technology to transportation centers throughout the world, it would make it far more difficult for terrorists to get away with planting bombs where people congregate."

Cooks' team is associated with several research centers at or affiliated with Purdue, including the Bindley Bioscience

Center, the Indiana Instrumentation Institute, Inproteo (formerly the Indiana Proteomics Consortium) and the Center for Sensing Science and Technology.

Two graduate students in the lab of Purdue University's R. Graham Cooks demonstrate the method by which their modified mass spectrometer, a common piece of equipment in chemistry labs, can be used to detect trace quantities of hazardous materials on documents, luggage, skin and other surfaces. Ismael Cotte-Rodriguez, on left, holds a passport up to the sensing port of the mass spectrometer while Nari Talaty performs the computer analysis. Portable gear that uses the technology should be able to detect picogram-sized samples (trillionths of a gram) of explosives, chemical weapons, and other hazards within 5 seconds. (Purdue News Service photo/Chad Boutin)

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