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A Report on the Detection and Identification of Explosives by Tagging

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ABSTRACT: The Explosives Tagging Program was begun to help law enforcement personnel prevent crimes committed with explosives and to improve apprehension of criminals after a bombing. The detection phase of this program involves long-lived vapors in microcapsules. These vapors are perfluorocarbons that may be detected by electron capture detectors, ion mobility spectrometers, mass spectrometers, and possibly animals. In the future, computer-assisted dual-energy tomography may detect explosives not tagged. For identification after detonation, tags must survive the heat and shock of the explosion and ensuing fire and the firefighters' water. A multilayered particle of melamine alkyd, each layer of which may be any one of ten colors, is suitable. Combinations of colors give a code that refers to the manufacturer's production lot, which enables the explosive to be traced to the last licensed holder.

KEYWORDS: criminalistics, explosives, identification systems, tagging, detection, tracing

The Explosives Tagging Program is a research and development program to tag explosives so that they may be detected before they explode or traced after an explosion. The overall goal is to reduce deaths, injuries, and property damage from bombings. The first objective is to prevent the detonation by using detection tags. The second objective is to improve the arrest rate in crimes involving explosives by using identification tags.

The idea of tagging explosives has been around for a long time in the minds of the law enforcement officials who deal with bombings. Bombings destroy most clues. Worse than that, timing devices allow the bomber to be on the beach in Hawaii when the bomb goes off in New York. Fortunately, with bits and pieces of physical evidence, forensic science laboratories do a remarkable job. In bomb debris, such items as explosive residue, clock parts, battery parts, fragments of containers or detonators, and pieces of leg wires may be recovered. From these particles the forensic science laboratories can often develop evidence for use in prosecution. Most often, however, the search of the bomb scene yields little positive evidence. Regrettably, in less than 10% of bombing crimes is a criminal forwarded for prosecution. While the frequency of terrorist attacks in the United States is not as great as in some European countries, around the world the most used weapon of the terrorist is the bomb.

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Background

In 1973 the Bureau of Alcohol, Tobacco and Firearms (ATF), having just been made an independent agency in 1972, decided to take the lead in tagging explosives. In the Omnibus Crime Control Act of 1970 its predecessor agency was assigned the mission of preventing the illegal use of explosives.

In 1974 ATF formed an advisory committee and the small technical subcommittee on explosives tagging. The members were representatives of government and some nongovernment agencies concerned with bombing. Represented on the advisory committee (Table 1) are such agencies as the U.S. Postal Service for letter bombs, the FBI for terrorism, the Federal Aviation Administration for aircraft hijacking, the Air Line Pilots Association for bombs in the air, and the American Society for Industrial Security for defense of corporations. In the last two years there have been about 25 bombings of corporate computer centers in Europe. Many of these companies are American. The hardware loss in each case can easily be a million dollars, but one cannot estimate the dollar value of the lost records and information necessary for that business.

The technical subcommittee to the advisory committee held hearings around the United States, and any idea was listened to and evaluated. Not many practical approaches were presented.

ATF requested funding without success until the summer of 1976 when Congress approved $1.2 million for fiscal year 1977. Neither ATF, which is a small bureau, nor the Treasury Department, to which it reported, had ever had a research and development program. The Office of Management and Budget (OMB) opposed funding on the grounds that once an agency got into research and development it never got out, and therefore it simply wanted to keep Treasury out of that field.

In fiscal year 1977 ATF started the program on explosives tagging by engaging the Aerospace Corp. to act as technical systems manager of the program. Aerospace Corp. is a not-for-profit scientific group established to help the Air Force with missiles and space work and has qualified scientists in many disciplines. Its jobs were to draw up the specifications for the research projects and to monitor the work. In 1979 it had about 45 subcontractors across the country working on the program. In 1980 there were 23. At first there were four phases to the tagging program:

(1) tagging for identification,
(2) tagging for detection,
(3) detection without tagging, and
(4) identification (after the blast) without tagging.

We soon realized that Phase 4 was beyond current technology. Of course, some work in this field is now done if residue of the explosive can be recovered. However, it was thought Phase 4 had no technological promise for guaranteeing identification.

The Federal Aviation Administration was vigorously purusing detection without tagging. From its work, ATF and Aerospace believed that since some explosives appear not to release anything measurable, a workable system would require an outside energy source. Furthermore, the resultant excitation would probably have to be in more than one mode for discrimination. Several ideas were examined, and now work is concentrated on one—dual-energy computerized tomography. Since it has an energy source stronger than that which can be used on people, we cannot ignore tags.

In identification tagging, at least this much information after the bombing was desired: the manufacturer, the type of explosive, and the date and batch of the explosive. AFT sought to have a coding system that would identify five years of production of explosives in the United States, or something over a million codes. Three organizations originally proposed techniques: Ames National Laboratory, Westinghouse Electric Corp., and the 3M Co. The

TABLE 1—*Advisory Committee on Explosives Tagging.*

Bureau of Alcohol, Tobacco and Firearms	Office for Combating Terrorism (Department of State)
U.S. Customs Service	
U.S. Postal Service	Federal Aviation Administration
Federal Bureau of Investigation	Washington College
U.S. Army (Department of Defense)	Department of Energy
Bureau of Mines	Louisiana State Police Department (IABTI)
Environmental Protection Agency	Sandia Laboratories
Law Enforcement Assistance Administration	U.S. Secret Service
	Department of Transportation
Institute for Defense Analyses	American Society of Industrial Security (ASIS)
Air Line Pilots Association	Sporting Arms and Ammunition Manufacturer's Institute (SAAMI)

3M Co. system eventually proved the best of that group. As a backup, in recent months the General Electric Co. has shown the feasibility of still another system.

The 3M system is a nine-layer plastic particle from 40 to 400 μm in length. The plastic is a melamine alkyd. Each layer is colored with any one of ten pigments to conform with the Universal Electric Code, which provides a series of numbers coded to relate to specific production units of manufactured explosives. The tags are incorporated into the explosives during manufacture.

Current Developments

A five-year coverage was selected as the first goal because 95% of explosives are used within three years. Some stay around for 25 or 30 years, but that is rare. By that time explosives have usually lost their reliability.

The identification tag must carry the information necessary to trace the explosive to its last legal holder. Once the manufacturer and the type, date, and batch of the explosive are determined, the explosive can be traced through its commercial channels to the last legal holders. If the explosive has been used in a crime, this trace provides the investigator with several valuable clues. First, the investigator knows where the explosive passed into illegal hands; second, the investigator knows a reasonable period of time in which this could have occurred; and finally, the investigator knows what the explosive was. Tracing of explosives is done by the National Explosives Tracing Center, operated for all law enforcement agencies by ATF. With identification tags, explosives can be traced in the same way firearms used in crimes can be traced by the serial number. To trace a firearm, the gun must be recovered, but explosives can be traced with tags because they will always be left at the scene of the crime. It is up to the investigator to find them.

Thus, with tags, a clue is designed into the weapon. To help the police officer investigating the bombing, some tags are made with a layer that fluoresces under ultraviolet light (Fig. 1). In the debris following a bombing, the identification tags appear as specks of light under ultraviolet light. The fluorescers are color-coded so that permissible and nonpermissible explosives can be distinguished immediately. (Some explosives are specially formulated so as not to cause fires and explosion of residual methane gas sometimes found in coal mines. These are the permissible explosives. Those without the special formulation, which are more likely to cause methane fires and explosions, are prohibited in coal mines and are called nonpermissible.) Finally, since it is difficult to pick up a single grain of sand out of many, a magnetic layer was added. The tags can be extracted from the debris with a magnet. While this may sound easy, it can be a laborious, painstaking task for an

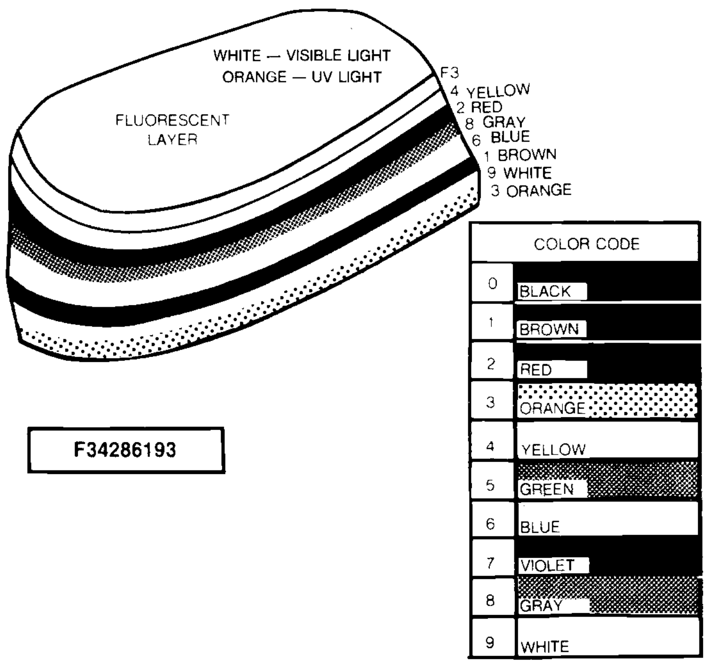

FIG. 1—*Schematic of the 3M particle and the color code adopted.*

investigator. Working at a bomb scene is rarely a pleasant or convenient effort. Nevertheless, in hundreds of experiments to date, tags have been recovered.

The performance requirements of the identification tags are specific. They must have at least one million codes. They must survive the power of the most violent commercial explosive. They must survive fire and the torrent of water some firefighters may use. In addition, they must have no adverse effects on the atmosphere or health. Finally, they must not present any safety hazard during the manufacture of explosives or afterward.

Originally it was thought the detection tag would be easier to develop than the identification tag. The reverse proved to be true. The required characteristics of the detection tag are these:

1. It should not exist in nature so there would be no required adjustment for ambient background in tests.
2. It should continue to release its vapor for at least five years, preferably ten.
3. It should be detectable down to parts per trillion.
4. It should have an insignificant effect on the atmosphere or health, both in its original state and in its products of combustion after the detonation.
5. A later requirement eliminated most of the prospective vapors: that the vapor should not be adsorptive on normal articles in luggage. Most vapors could not pass this test.
6. Finally, it must be safe in the explosives.

Hundreds of prospective vapors were examined and five acceptable ones were found. The surviving contending vapors are perfluorinated alkanes: perfluoromethylcyclohexane (PMCH), perfluorodimethylcyclohexane (PDCH), perfluorodecalin (PFD), perfluorodimethylcyclobutane (PDCB), and perfluorohexylsulfur-pentafluoride (L-4412).

After some vapors were found, a method of packaging them was needed. Microspheres—the small containers of ink on the back of carbonless copy paper—were examined. One can detect them in advertisements for perfumes in which a pretty card sent in the mail has printed words extolling the brand of perfume and microcapsules of the perfume attached to the paper. Sometimes these are called "scratch-and-sniff" cards.

One might liken the detection tags to minute ping-pong balls about 40 μm in diameter (Fig. 2). The current problem is to develop the optimum wall material, wall thickness, and ratio of core to wall material. The objective is to control the release rate to achieve a five-year life as a minimum.

To make the detection system work, sensors were needed. Those with current promise are new versions of the continuous electron capture detector, an ion mobility spectrometer, and a special purpose mass spectrometer. Since many people report animals are still better, some analyses with animals are being pursued to try to find out if they are more or less effective than instruments. The detection system with tags works. The Aerospace Corp. has successfully tested the detection tag vapors in luggage on a conveyor and in a closed-up aircraft.

For every concept being pursued, several more have been offered. Frequently, they incorporate radioactive materials that cannot be used in the United States because of possible danger to people. In other cases the costs are too high or the instrumentation is so big it could never be made portable.

When the program was started, the dynamite family of explosives accounted for more than three fourths of the deaths, injuries, and property damage. These explosives include the dynamites, water gels/slurries, and other emulsions. In the past few years, smokeless and black powders have been used with increasing frequency. One can buy a pipe, have it threaded, have a hole drilled in its side, and have two end caps made for maybe $2; a 0.4-kg (1-lb) tin of smokeless powder costs $7.50, and a detonator $1.00. For a little over $10 one can conveniently obtain a deadly and destructive device.

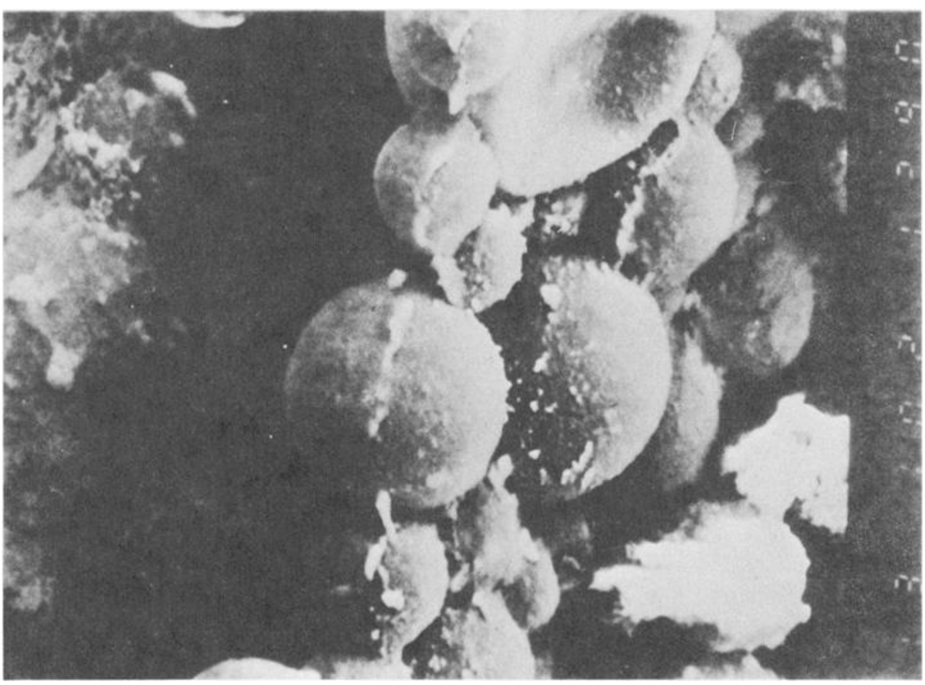

FIG. 2—*Scanning electron micrograph of PDCH microcapsules.*

Testing with identification tags is well along for the dynamite family. Black powders have also been well tested. One manufacturer of smokeless powders is now completing compatibility testing, a long series of tests to insure that the tags can safely go through the manufacturing process. Much remains to be done on the smokeless powder.

In 1977 and 1978 manufacturers produced about 3 Gg (7 000 000 lb) of dynamites, water gels, and slurries containing identification tags. The plan was to test tagged explosives in the commercial distribution system. That amount was about 1% of the two-year total production of this group of explosives.

Identification tags have been accepted in court. In May 1979 a man decided to blow up another man he suspected of being too friendly with his wife. He bought two sticks of tagged explosives. The victim was killed, and another man was injured; the identification tags were recovered by members of the ATF Forensic Science Branch, and they worked just as planned. The explosives were identified and traced to the suspect. In December 1979 the suspect was found guilty. More importantly, however, the court admitted identification tags as scientific evidence.

Legislation

Currently Senate Bill S.333, the Omnibus Antiterrorism Act of 1979, includes a section requiring the tagging of commercially produced cap-sensitive explosives. It is difficult to assess the chances of enactment since the bill has encountered opposition from groups such as the National Rifle Association (NRA) and the Institute of Makers of Explosives (IME). They claimed tagging was unsafe, would cost over $700 million per year, and would not be useful to law enforcement personnel in the reduction in deaths, injuries, and property damage.

Because the members of Congress did not know whether to believe the Aerospace-AFT team or the opposition, Senators Ribicoff, Javits, and Stevens requested the Congressional Office of Technology Assessment (OTA) to evaluate the technology of the program; OTA found that from the testing thus far tagging could be presumed safe, but more research was needed. Specifically, the tests conducted to date create a presumption that there are no incompatibilities between the 3M identification tag and dynamites, slurries, gels, emulsions, or black powder.

The OTA found the objectives of the Explosives Tagging Program reasonable and the selection and direction of the research projects acceptable.

Explosives tagging research is not yet complete. ATF believes the technology has been mastered for identification tagging. In detection tagging there still are unresolved areas that further research must clarify.

Conclusion

The most critical problem now is not science at all—it is the will of Congress. If it does not pass a law requiring tagging, the opponents of tagging could find new ways to oppose and delay the implementation. On the other hand, should a law be passed requiring tagging, it is likely that the more enterprising makers of explosives will immediately find out how to add tags efficiently to stay ahead of competition.

This program is designed to help suppress one of the most vicious types of crime. It is not a panacea, but most law enforcement people believe it will help.

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