Chemical I.D. and the Marathon Bombings

Adapted by from articles found in the Boston Globe and the Los Angeles Times

The Boston Marathon bombing was a terrorist attack that occurred when two pressure cooker bombs exploded during the Boston Marathon on April 15, 2013. The bombs exploded about 12 seconds and 190 meters apart, near the marathon's finish line on Boylston Street at 2:49 p.m. They killed 3 people and injured an estimated 264 others.

The Federal Bureau of Investigation (FBI) took over the investigation and, on April 18, released photographs and a surveillance video of two suspects. The suspects were identified later that day as Dzhokhar Tsarnaev and Tamerlan Tsarnaev. Shortly after the FBI released the images, the suspects killed an MIT policeman, carjacked an SUV, and initiated an exchange of gunfire with the police in Watertown, Massachusetts. Tamerlan Tsarnaev was shot several times in the firefight and his brother subsequently ran him over with the stolen SUV in his escape. Tamerlan was pronounced dead at the scene.

An unprecedented manhunt for Dzhokhar Tsarnaev ensued on April 19, with thousands of law enforcement officers searching a 20-block area of Watertown. During the manhunt, authorities asked residents of Boston to stay indoors. The public transportation system and most businesses and public institutions were shut down and around 7:00 p.m. Shortly after the "shelter-in-place" advisory was rescinded, a Watertown resident discovered Dzhokhar hiding in a boat in his back yard. Located within the boat by thermal imaging, he was shot while in the boat, arrested, and then taken to a local hospital.

During an initial interrogation in the hospital, Dzhokhar said that they learned to build explosive devices from an online magazine of the al-Qaeda affiliate in Yemen. He said that he and his brother had decided after the Boston bombing to travel to New York City to bomb Times Square. Dzhokhar was indicted on April 22, while still in the hospital, on 30 charges relating to homegrown terrorism, including use of a weapon of mass destruction and malicious destruction of property resulting in death.

The FBI and Chemical ID:

But how did they catch the Tsarnaev brothers? How did they go from a scary bomb site, blasted by explosives, to knowing exactly what components the two brothers use to make the bombs? The answer lies in the FBI's Forensic Chemistry Department and a process known as "Chemical I.D."

The field of Chemical I.D. is complex, but most often boils down to four different methods of identification:

(1) Observation – Substances are identified based on appearance.

(2) Measurement – Substances are identified based on mass, density, etc.

(3) Reaction Tests – Substances are mixed with other agents to test for a chemical reaction.

(4) Chromatography – Mixtures are separated and identified in parts.

(1) Observation:

At the site of the explosion, investigators found shrapnel that included bits of metal, nails, and ball bearings, as well as black nylon pieces. A metal lid was also found on a nearby rooftop. Investigators also discovered the remains of an electronic circuit board and wiring. Within the debris, scientists observed traces of char, ash, and various powders. All evidence was sent to the FBI Laboratory for analysis.

(2) Measurement:

After observing the debris and measuring the density of the materials, scientists were able to determine that the "lid" was made of aluminum, of the type and style commonly used in pressure cookers. The black nylon pieces were also examined and found to be similar to the type often used in bags and backpacks.

(3) Reaction Tests:

After examining the rest of the debris (including any trace chemicals, such as ashes or powder), scientists were able to conclude that both pressure cooker bombs used a low explosive mixture that incorporated nitrate and perchlorate-based oxidizers. The exact details of the tests that were used were not released to the public, but a test to identify nitrate can be as simple as mixing a substance with iron sulfate and sulfuric acid; any brown rings that form in the liquid will indicate the presence of nitrate.

(4) Chromatography:

Eventually the FBI learned that the Tsarnaev brothers had used $200 cash to purchase two "Lock and Load" kits, each with 24 shells, from the Phantom Fireworks store in Seabrook, New Hampshire. So the FBI began working to determine if any fireworks ingredients had been used in the actual bombs. By separating the store-bought fireworks into their component parts (a mix of clay, one powder to deliver color and noise, and two explosive powders), the FBI determined that those specific store-bought fireworks had *not* been used to build the real bombs. William Weimer said, "My guess is, they purchased these products in early February, experimented with them and probably came to the conclusion that they couldn't harvest enough powder to do what they wanted to do with them."

Conclusions:

The FBI now believes that the Tsarnaev brothers used black powder to build the two bombs. Each bomb was contained inside a pressure cooker filled with nails and BBs. The bombs were ignited using the wireless system from a remote-control toy car along with electrical fuses taken from Christmas lights. The bombs were carried to the scene inside black nylon backpacks, and detonated by the brothers from a safe distance. Evidence from the FBI's investigation was used in the trial of Dzhokhar Tsarnaev this past year to prove that he did indeed help build and detonate the bombs. He was found guilty on all charges on April 8, 2015, and the following month was sentenced to death.

***** Tonight's Homework *****

Imagine the year is 2025. You have graduated college and you now work for the FBI Forensic Chemistry Dept. On October 5th, you are called in to investigate an explosion at a local school. On a separate piece of paper, write a paragraph explaining how you could use the process of "Chemical I.D." at the crime scene. Be sure to mention any of the "four methods" you wish to use. This homework is due tomorrow.