



EA-IRMS: Tracing origin of explosives using carbon, hydrogen and oxygen isotope fingerprints

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Goal

Illustrate how isotope fingerprints can help identify origin of explosives through analysis of carbon, hydrogen and oxygen isotopes.

Introduction

The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) states that “tracing is the systematic tracking of explosives from manufacturer to purchaser (and/or possessor) for the purpose of aiding law enforcement officials in identifying suspects involved in criminal violations, establishing stolen status, and proving ownership”. Over the years, stable isotope analysis, or isotope fingerprinting, has shown to be a valuable technique to provide unique information on the origin of sample material, though their application in the investigations requiring the provision of evidence to a Court is very limited in criminal cases. However, identifying and tracking explosives to support counter-terrorism efforts is critical for national and international security.

Benson et al.¹ (2009) employed isotope fingerprints in their study on organic peroxide explosives, with a particular focus on triacetone triperoxide (TATP) and pentaerythritoltetranitrate (PETN). The objective was to assess whether isotope fingerprints could differentiate samples of TATP that had been manufactured utilizing different starting materials and/or manufacturing processes and, with respect to the use of PETN in detonators, detonating cord, and boosters, to differentiate PETN samples from different sources.

Organic explosives, such as TATP, are increasingly used because of: regulation of constituents for traditional inorganic explosives, such as ammonium nitrate; availability and low cost nature of peroxide precursors, such as hydrogen peroxide and acetone; ease of manufacturing of organic explosives; and finally high sensitivity of the organic explosive material, which means that no detonator is required¹.

This application note is a summary of the work by Benson et al. on the studies on origin of explosives. Specifically, it focuses on carbon, hydrogen and oxygen isotope fingerprint data. Further data and data analysis, alongside the full analytical procedures used are presented by the authors in detail in their publication¹.

Sample collection and analytical configuration

Samples were analyzed for their carbon, hydrogen and oxygen isotope fingerprints. A High Temperature Conversion Elemental Analyzer (TC/EA) was utilized for the measurement of the hydrogen and oxygen isotope values. The reactor consisted of a crucible furnace containing a glassy carbon reactor filled with glassy carbon granules. In addition, an Elemental Analyzer connected to an IRMS instrument was used for carbon isotope analysis. Silvered cobaltous/cobaltic oxide and copper oxide packing in the combustion reactor and reduced copper in the reduction reactor were used for conversion. A magnesium perchlorate trap was utilized to remove any water¹.

Isotope fingerprints of explosives

TATP can be derived from household chemicals – acetone, hydrogen peroxide, and strong acids – all of which are easily obtained at hardware and beauty supply stores. Its use in improvised explosive devices, alongside other peroxide-based explosives such as hexamethylene triperoxide diamine (HMTD), is becoming more prevalent, as seen in recent high-profile incidents². As the use of homemade explosives, such as TATP, in improvised explosive devices becomes more prevalent, the ability of law enforcement to link a precursor, such as acetone, to a clandestine lab or possibly to the explosive itself is of forensic interest. The carbon and hydrogen isotope fingerprints in TATP are closely linked to the carbon and hydrogen isotope fingerprints in the precursor acetone, indicating that acetone may well be a good proxy for generating a background dataset for TATP². Further, the oxygen isotope fingerprints derive from the hydrogen peroxide precursor.

Tracing origin of explosives

The analyses undertaken by Benson et al on TATP samples plot in three distinct groups; however, these do not correlate specifically with the type of acid, source of reagent, reaction temperature, cooling temperature, filtering process utilized during the synthesis.

The samples analyzed could be differentiated based on the isotope fingerprints of carbon, oxygen and hydrogen. In addition, the carbon and nitrogen isotope fingerprints of 15 PETN samples coming from different sources can be readily discriminated.

Carbon isotope values were successfully measured in 14 TATP samples, with clearly defined groups appearing in the initial sample set based on the carbon isotope data alone. Four additional TATP samples in a second set of samples were distinguishable utilizing the carbon and hydrogen isotope values individually, and in combination with the oxygen isotope values. The 3D plot of the carbon, oxygen and hydrogen isotopic data demonstrated the discrimination of TATP samples from different sources.

Summary

Benson et al. have demonstrated that isotope fingerprints can be used to differentiate samples of TATP that had been manufactured utilizing different starting materials and/or manufacturing processes. The preliminary study states also the valuable contribution of IRMS technique to the analysis of explosives for forensic interest.

This, by extension, has implications for contributing further evidence to criminal forensic cases, where samples need to be discriminated from different sources.

The data presented are based on bulk measurements of carbon, hydrogen and oxygen using Elemental Analysis Isotope Ratio Mass Spectrometry, such as the Thermo Scientific™ EA IsoLink™ IRMS System (a former model was used in this study).

References

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This application report is a summary of the work published by Benson et al. in Science and Justice as cited in this article. No new data or data interpretations have been added to the summary in this application note by the authors.

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