# SOURCE OF THE PROBLEM

**Mike Seed** *examines the best way to trace drug trafficking routes back to their original location*

**Drug trafficking affects many countries around the world, undermines political and economic stability, damages communities and ruins the lives of individuals, with some 35-million people suffering from drug use disorders. It is also a major source of revenue for organised crime groups, bringing in a fifth of all profits from organised crime, according to Europol.**

As international borders become more penetrable and more regions in the world become new manufacturing grounds for illicit drugs such as cocaine, heroin and marijuana, accessibility to drugs has become increasingly widespread. Tim Morris, executive director for police services at Interpol, describes the current state of the drugs trade as: "More abundant, more sophisticated and more diverse than it has ever been before".

This, as well as criminals devising ever more creative ways of disguising illegal drugs for transport, makes it harder for officials to detect and adequately respond to the trade. Therefore, criminal justice organisations are increasingly turning to science to help combat trafficking with a technique called stable isotope analysis.

Materials that cannot be chemically distinguished by other analytical techniques can be identified using stable isotope ratio analysis. Conducted by using isotope ratio mass spectrometers (IRMS), this method provides an additional signature to the chemical signature of a sample and generates characterising information for use in forensic investigations. The technique provides unique capabilities to the modern-day crime laboratory by making it possible to determine similarities and differences between drug seizures to follow trafficking routes back to their original clandestine source.

By tracing drug trafficking routes back to their original location and putting a stop to production, law enforcement can make a bigger impact on criminal activities. Drug trafficking is often related to other serious criminal activities, such as money laundering, firearms, modern slavery and terrorism.

Stable isotope analysis can be utilised in many different applications, but the underlying question is always 'where do things come from?' Isotopes are atoms of the same elements that have the same number of protons and electrons but a different amount of neutrons, giving them slightly different weights. They can be divided into two categories – radioactive and stable.

Radioactive isotopes decay over time, while stable isotopes remain unchanged over geological time scales. The varying abundance of different stable isotopes of a particular element allows scientists to use IRMS to distinguish between chemically identical compounds. These differences arise as a result of biological, manufacturing and physical processes and can therefore distinguish between identical chemical compounds that originated from different locations. The IRMS analyses samples and produces an isotopic ratio, which can be used to tell scientists about the sample and its possible origins.

Isotope ratios cannot be used to pinpoint a specific location; however, they can be used to distinguish geographic regions and so help to determine the origin of biological and non-biological materials, including the origins of animals, such as migrating birds, plants, valuable gems and ivory, as well as the history of the human diet.

## SEIZED SHIPMENTS ARE SENT TO SCIENTISTS TO DETERMINE THE SOURCE THROUGH ANALYSIS

Anything, anywhere in the world, is made up of isotopes; however, the variation between isotopes of the same elements depends on the substance and conditions of a sample. For instance, the oxygen and hydrogen isotope ratios found in the water and soil where a plant is growing will reflect the local hydrological conditions. As the plant grows, the isotopic ratio of oxygen and hydrogen incorporated into the plant's physiology will thus also reflect the local hydrological conditions. Measuring the isotopic ratio of the plant therefore allows the plant to be related back to its source.

The variation of isotopes in rainwater across the globe is predictable and has been used to form databases known as 'isoscapes'. Comparing unknown samples against these isotopes makes it possible to determine where these samples may have originated.

Scientists undertaking stable isotope analysis are interested in the isotopes of carbon, hydrogen, oxygen, sulphur and nitrogen. Depending on the elements analysed, different stories can be told. In relation to drug trafficking, determining the geographic origin of cocaine and heroin – the most widely used narcotics, with use spanning all economic and social classes – has been the focal point of forensic scientists for some time.

Earlier studies used trace residues or trace alkaloids to derive a region of origin. However, this method was only useful in determining processing methods used in different regions, which has limited applicability if a drug is transported to another region. It is this reason that forensics rely on analysing the stable isotopic composition of a drug.


**Heroin stamps, used to brand a specific batch of the drug, are displayed before a press conference following a major bust**

Most of the world's supply of cocaine comes from Columbia, Peru and Bolivia in South America and is trafficked into the United States and Europe. Shipments seized before they reach their intended destination are sent to scientists to help determine the source through stable isotopic analysis.

By analysing the chemical composition of the coca plant from which cocaine is derived, a 'fingerprint' is revealed. Stable isotope ratio mass spectrometers distinguish very small differences in isotope compositions of an element, with the natural differences between compounds being indicative of different regions. This means that even though a sample of cocaine might be processed in Columbia, it would be possible to determine if that was where it originated from, or whether it was from somewhere else.

Ratios of isotopes found in water vary from North to South due to temperature differences. For instance, when condensation is formed during low temperatures (ie: higher latitudes and elevations), it contains lighter isotopes. Differences between the East and West are mainly caused by the movement of clouds that form over the oceans.

Carbon isotopes can offer insights into whether a plant was grown indoors or outdoors by showing that it grew in a wet and shady climate or a dry and sunny one. Nitrogen isotopes can identify qualities unique to the soil it was grown in, and whether fertiliser was used and what type.

The same technique can be applied to heroin, where isotopic abundances are different in morphine grown from poppies in South-East Asia versus South-West Asia. This is because once morphine is formed,

Picture credit: Getty

it retains its natural stable isotope abundance until it is decomposed. This means if there are naturally occurring differences in stable isotopes in morphine produced by poppies grown in South-East Asia compared with South-West Asia, these can be used to determine where it originated.

Typically, ratios of carbon ($^{13}C$) depend on the way in which the plant photosynthesises, ratios of oxygen ($^{18}O$) and hydrogen ($^{2}H$) differ based on precipitation and altitude, while ratio of nitrogen ($^{15}N$) vary based on soil conditions and the way in which the plant fixes nitrogen. Sulphur isotopes ($^{34}S$) are found to be highly dependent on local bedrock types as well as distance from the ocean, due to the influence of marine sulphate aerosols raining out over coastal regions.

Therefore, through stable isotopic analysis it is possible to identify whether a sample of a drug seized in one place was produced in that area or in another region. However, the application of isotopic analysis in determining the origins of illicit drugs is hampered by a lack of sufficient authentic samples of known origin that can be used to determine a geographical location.

Also, due to the chemical composition of drugs being very similar, stable isotopic analysis can additionally be used to determine if two independent seizures could have come from a single clandestine laboratory, which helps to elucidate trafficking routes.

Stable isotope ratio mass spectrometry is a technique that covers a broad array of applications and sample types. As well as the isotope ratio mass spectrometer, the system usually comprises a peripheral inlet system. In the case of illicit drug analysis, these inlets may be an elemental analyser (EA) or a gas chromatograph (GC).

These systems are responsible for the conversion and separation of the original sample to a form that the IRMS can analyse namely pure gases, such as $CO_2$, $N_2$, $SO_2$, $H_2$ and CO. The isotopic ratio of the original sample is transferred into one or several of these gases so when analysed at the IRMS, the original isotope ratio of the sample can be determined.

## KEEPING IT SIMPLE

Modern stable isotope ratio mass spectrometry systems make use of powerful software that is able to control and optimise the systems for the highest performance, while also making it simple for relatively in-experienced operators to successfully use the instrument. Unknown samples are then queried against a database of known samples through integrated database management software.

Clearly, the issue of drug trafficking is not one that is likely to go away on its own, which is why it is so vital that developments continue to be made in helping identify the origin of illicit drugs. With the types of drugs trafficked and the routes used constantly changing, it is essential that countries work together to counter illicit production, trafficking and abuse of drugs.

In an industry where precision is vital, isotope ratio mass spectrometry allows forensic scientists to assess the oxygen, hydrogen, carbon and nitrogen isotopic content of their drug samples to gain a more complete picture of where a drug originates.

What's more, the most modern elemental analysers allow for multiple elements to be accurately measured in a single sample with minimal maintenance, resulting in the kind of rapid, efficient and reliable sample throughput required for the sector. By investing in the right technology for tracing the origins of illicit drugs, law enforcement will be more resilient to the pressures it is facing ●

**Mike Seed**, Sales and Product Manager at Elementar, has been working with stable isotope instrumentation for the past 20 years as an engineer, applications specialist and product manager.

**Chinese police officers destroy 57kg of illicit drugs in Neijiang**

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