Agilent Case Study: Ghent University

Measuring Engineered Nanoparticles And Microplastics Using ICP-MS

Using single-cell ICP-MS to characterize carbon-based microplastics, nanoparticles, and the elemental content of single biological cells.

Agilent spoke to Dr. Eduardo Bolea Fernandez, a postdoctoral research fellow in the Atomic and Mass Spectrometry (A&MS) research group within the Chemistry Department at Ghent University in Belgium.

"We can obtain semi-quantitative information of up to 78 elements in a few seconds"

Dr. Eduardo Bolea Fernandez
Postdoctoral research fellow
Ghent University

Q. Please tell us about your research

At A&MS, our research includes using single-event ICP-mass spectrometry to measure different types of engineered nanoparticles (NPs). This includes not only the classic NPs like gold or silver nanoparticles, but also silicon dioxide, titanium dioxide, or iron oxide nanoparticles. These are much more challenging to measure using ICP-MS, but they are of interest because they are often used as food additives and in consumer products, and also in biomedicine.

We have explored the possibility of using ICP-MS for microplastics and nanoplastics characterization, which is interesting because carbon has traditionally been considered as one of the elements that cannot be measured using ICP-MS.

And we use single-cell ICP-mass spectrometry for biological applications, with recent developments in instrumentation enabling us to move in that direction.

Q. Why do you use ICP-MS and why an Agilent ICP-MS?

ICP-mass spectrometry is one of the most powerful techniques for ultratrace elemental and isotopic analysis. The technique has a large number of advantages compared to other analytical techniques, but it also has some disadvantages. One of the disadvantages is the occurrence of spectral interferences, some of which can be very intense and limit the ability to detect some critical analytes. 10 years ago, in 2012, Agilent developed a novel type of ICP-MS instrument with a tandem MS configuration to overcome these spectral interferences. The current ICP-MS/MS we use, the Agilent 8900, is equipped with two quadrupole mass analyzers and a collision reaction cell located in-between them. This tandem mass spectrometer offers high sensitivity and much better control of spectral overlaps, which gives outstanding detection capabilities down to the part per trillion level or even lower.

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Q. What advantages does the Agilent ICP-MS offer?

Agilent ICP-MS instrumentation combines high sensitivity and good precision with fast detection capabilities so that we can select very short integration times. Short integration time means can detect very fast transient signals with a duration of only half of a millisecond. This new mode of operation is called single-event ICP-mass spectrometry. We use this method for characterizing engineered nanoparticles. But we've also been exploring the possibilities of using this single-event mode for the characterization of nano- and microplastics in collaboration with colleagues with expertise in environmental science.

ICP-mass spectrometry is often seen as a relatively complicated technique. People think that it requires an expert operator for method development, method validation, data treatment, and data interpretation. However, methods on the Agilent ICP-MS/MS are actually more consistent for different sample matrices, so in some ways, MS/MS makes ICP-MS simpler to use. Also, modern ICP-MS instrumentation is equipped with powerful software tools and predefined methods to make method development easier.

The IntelliQuant option available within the Agilent ICP-MS MassHunter software allows us to get a panoramic view of the elements that are present in the sample—so a full elemental screen. We can obtain semi-quantitative information of up to 78 elements in a few seconds. This is something that we can use to identify the elements that are present in a sample of biological cells before we select which elements we want to study further in the individual cells.

Q. What has the technique allowed you to achieve?

We were actually the first, in 2020, to demonstrate that ICP-mass spectrometry can characterize microplastics. Microplastics are based on carbon, and carbon is typically an element that cannot be measured with ICP-mass spectrometry. But thanks to the fast detection capabilities of the Agilent ICP-MS, we can detect small microplastics of 1 micrometer in diameter.

The single-event mode is also useful for the analysis of individual cells. As cells are the basic units of life, getting information about the metal content within individual cells is an extremely important area of research. We use this sort of measurement both to understand the natural role of metals and other elements in cells, but also to investigate interactions of cells with metal-based drugs or environmental contaminants.

Q. How does single-cell ICP-MS work?

Single-cell ICP-mass spectrometry is based on the one-by-one introduction of individual cells into the ICP. The cells are vaporized and the elemental content is ionized, and we get a very fast, transient signal that can be detected thanks to the fast detection capabilities of our ICP-MS instrumentation. We can use single-cell ICP-mass spectrometry for the measurement of elements that are intrinsically present in the cells because they play a role in a biological function. We can also measure exogenous elements that are present in the cells because of, for example, a chemotherapeutic treatment. We have developed a method for the analysis of individual human cells that can be used for cancer research.

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