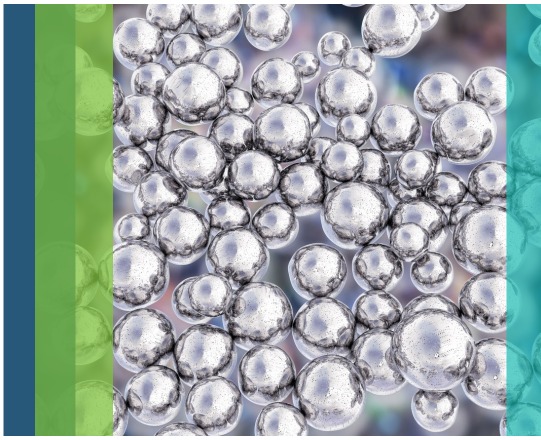

Agilent Case Study: UC, Santa Barbara

Looking Far and Near

Agilent helps researcher examine the short- and long-term effects of nanoparticles

Arturo Keller sees nanoparticles everywhere.

They are, of course, present in nature, in smoke and dust and ocean spray, but more and more of them are manmade. We find them in electronics, medicines, foods, paints, pesticides, fertilizers, cosmetics, toothpastes, sunscreens, and many other personal care products.

Keller has been tracking the engineered variety for more than a decade, and he received an Agilent Thought Leader Award in 2015 in support of his research, which continues today.

“The concentrations that we are finding out there in the environment, so far, are low,” he says. “That’s good news. By and large, the concentrations are in the low parts per million to parts per billion or even in some cases even parts per trillion. Now, that doesn’t mean that they are not causing effects at that level.”

One of Keller’s concerns is that these engineered particles may have adverse effects on small but vital organisms—the microbes used in wastewater treatment plants, for example.

He is also farsighted enough to worry about concentrations increasing as nanoparticles (often composed of metals such as silver and copper) are added to more and more products.

“As they accumulate over time, they could also be affecting decomposers in the soil and other organisms that are important for a healthy agricultural system. That’s concerning because we do see accumulation,” Keller says.

“With these nanoscale formulations, what happens is you have a very condensed amount of material in a very small space, and that can be brought into cells where normally that would not happen. So you could have, locally, a very high dose, and we want to make sure this is well understood when people develop these different materials.”

To understand the effects of nanoparticles in the environment, Keller’s team faces a challenge of first measuring them accurately due to their tiny size and varying metal compositions.

Arturo Keller, PhD

Professor
Bren School of Environmental Science and Management
University of California, Santa Barbara
Santa Barbara, California

“The tools that we have had for the past decade were really not capable of giving us the complete picture,” Keller explains. “Using electron microscopy, for example, we can see them, but it’s difficult to count them. When you’re looking at the field of view of an electron microscope, you could miscount very easily. You also don’t get any information about their composition directly, so it’s difficult to make sure that’s the material you’re looking for.”

He notes that some laser-based technologies are able to count nanoparticles, but they only work at the parts per million level or higher.

“That’s where Agilent comes in,” Keller says. “With the Agilent Thought Leader Award came two instruments. One was an ICP-MS system with single-particle capabilities. The other was a triple quadrupole LC/MS system. We use both of them extensively for this work.”

Keller and his colleagues use the **ICP-MS** to determine how much nanomaterial is present in various environmental samples—down to parts per billion or even trillion. They use the **LC/MS** to look at the effects of nanomaterials.

“If we expose a plant to nanomaterials, for example, we can measure: How does the plant express certain metabolites: sugars, amino acids, antioxidants, carbohydrates, fatty acids, and so on? How does it change?” Keller says. “Since nanoparticles have the effect of oxidation, the plant uses all these antioxidants to try to counteract that effect. Even though we don’t see a visible effect on the plant, we can detect changes early on. That way we can say, ‘Oh, this concentration is likely to begin to cause effects as the plant grows if you keep exposing it to this material.’”

In some cases, the team has discovered unexpected benefits of nanomaterials. For example, a formulation designed to ward off pests was having beneficial effects within the plant’s energy cycle—a discovery that can perhaps be exploited to increase crop production.

“Leading-edge instruments from Agilent are enabling us to answer key questions,” Keller says.

“What’s really cool about the Agilent Thought Leader Award that I received is that Agilent has been right next to us, saying, ‘Hey, guess what? We just came up with this new column that will help you do that analysis much better.’ We tried the column and were able to get a much cleaner analysis on some amino acids, for example. We shared that with Agilent and they said, ‘Wow, that’s even more impressive than we thought.’ So we wrote an application note together.”

He reports that, working with Agilent over the past few years, the software his team uses (a single-particle module within **ICP-MS MassHunter**) has been improving rapidly and dramatically.

“Early on we were able to detect particles at low concentrations, but it wasn’t as accurate as we thought it could be. This improved significantly with the introduction of single-particle software for the ICP-MS. Just recently the software team came back and said, ‘You can now measure several elements at once.’ We said, ‘What? That’s exciting.’ So now we’re working with new software—same instrument but just new software—and that allows us to look at 16 different elements at one time. That is really cool. Getting more information out of the same instrument.”

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