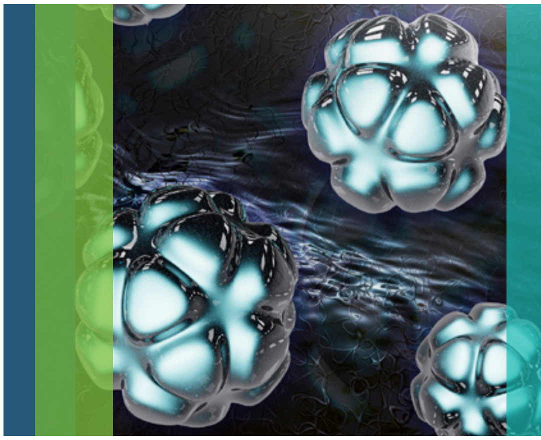
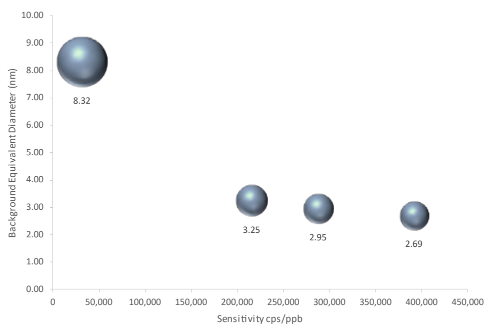


Nanoparticle Analysis by ICP-MS

Why sensitivity is key

Instrument sensitivity determines the smallest nanoparticle you can measure



The relationship between calculated background equivalent diameter and instrument sensitivity (cps/ppb) for the analyte element.

The single MOST important ICP-MS performance characteristic for the determination of nanoparticles using single particle (sp) ICP-MS is SENSITIVITY. This is expressed as counts per second per unit concentration (e.g. cps/ppb). Other instrumental parameters such as low background, short minimum dwell time, and zero settling time between measurements are important in optimizing the analysis. But without sufficient sensitivity, small particles cannot be detected at all, so the other parameters are irrelevant.

How sensitivity impacts precision

Absolute sensitivity (cps/ppb) is critical in detecting and quantifying the mass of very small particles. Sensitivity also affects precision, and precision limits the minimum dwell time that can be used. For example, with a dwell time of 0.1 ms (common for single nanoparticle analysis by ICP-MS), 1 raw count is equivalent to 10,000 cps; zero counts is of course equivalent to 0 cps. Since the ICP-MS detector can only measure whole numbers of counts, the minimum signal change that can be measured (1 raw count) is equivalent to 10,000 cps. So, a signal of 5 counts (50,000 cps) ±1 count (10,000 cps) would result in precision of more than 14% RSD. By comparison, a 10x more sensitive instrument would generate 50 counts (500,000 cps) for the same sample measurement. Assuming the same signal variation of ±1 count, the more sensitive instrument would yield precision of <1.5% RSD.

What is the smallest particle that can be detected?

Absolute sensitivity, coupled with background precision, defines the mass of the smallest particle that can be measured by SP-ICP-MS. This is called the background equivalent mass (BEM). From the BEM, assuming a particle of spherical shape and known composition, the corresponding background equivalent diameter (BED) can be determined.

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Comparing ICP-MS instruments

You can use a simple calculation to compare the BEM and BED that different instruments can achieve for any given nanoparticle element. The calculation is based on instrument sensitivity (response factor in cps/ppb), dwell time and background precision. The results allow you to compare instruments of different sensitivities. Table 1 compares the BEM and BED values for gold nanoparticles using the published sensitivity specifications for four different ICP-MS instruments.

Table 1. Comparison of minimum detectable mass (BEM) and particle diameter (BED) for gold nanoparticles measured using a competitor's ICP-MS and three Agilent ICP-MS models, based on published sensitivity and background specifications.

	Competitor A	Agilent 7800	Agilent 7900	Agilent 8900
Response Factor for Au (cps/ppb)	32000	216000	288000	392000
Dwell time (sec)	0.00005	0.0001	0.0001	0.0001
BEM (fg)	0.00583	0.00035	0.00026	0.00020
BED (nm)	8.32	3.25	2.95	2.69

As shown in Table 1, to improve the minimum detectable particle diameter requires a significant increase in sensitivity. This is because the diameter of a spherical particle is a function of the cube root of the mass, so mass (and therefore signal) decreases a lot with a small reduction in particle diameter. In this case, competitor A's instrument is seven to twelve times less sensitive than the Agilent instruments. The competitor's instrument can achieve a minimum BED that is about two to three times poorer than that achieved by the Agilent instruments. This difference in detection capability may mean the difference between achieving your application requirements and your particle signals being lost in the noise.

Detection of small particles by spICP-MS needs sensitivity, and lots of it. Without it, other instrument parameters don't really matter.

For more information:

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