Trace Element Analysis of Environmental and Biological Samples

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For trace element analysis, inductively coupled plasma mass spectrometry (ICP-MS) excels with extremely low limits of detection for most elements (down to ppt-level (ng L⁻¹)), outstanding accuracy, an extremely wide linear dynamic range of up to 12 orders of magnitude and a very high multi-element coverage. ICP-MS has become increasingly applied to environmental¹ and biological samples.²

In the field of air analysis, coupling air sampling units to ICP-MS is of interest to those wishing to determine elemental species in near-real time. Ohata et al. wrote a review paper titled on “Research Progress on Gas to Particle Conversion – Gas to Aerosols by ICP-MS. Air was sampled through a cyclone at 30 L min⁻¹ with a 50% cutoff @ ~250 nm, and the particles deposited into a cup. Nitric acid was then added downstream and the resultant suspension passed through a quartz photo-reactor for digestion. Further work was required to minimize system blanks and so take advantage of the inherent ICP-MS sensitivity.³

In the area of water analysis, solid-phase extraction (SPE) is useful for on-site separation. Yabutani et al. reported on “Copper Speciation for Natural Water by On-site Sample Treatment/Solid-phase Extraction/Inductively Coupled Plasma Mass Spectrometry”, describing the speciation of Cu(I), Cu(II), and hydrophobic Cu in natural water.⁶ Three SPE runs with/without bathocuproin disulfonate (BCS) and ascorbic acid (AA) were performed to determine the concentration of total Cu and those of individual Cu fractions. The developed method was applied to natural water collected in Tokushima prefecture. Furukawa et al. reported on “Ultrasonic Mist Generation Assist Argon-Nitrogen Mix Gas Effect on Radioactive Strontium Quantification by Online Solid-Phase Extraction with Inductively Coupled Plasma Mass Spectrometry”, describing a radioactive strontium quantification.⁷ They found that the sensitivity of online SPE with ICP-MS was enhanced by introducing Ar–N₂ mixed gases as nebulizing gas, and measured environmental paddle water in Fukushima Nuclear Power Plant.

The speciation of As,⁸ Cr,⁹ and Hg¹⁰ species continued to be reported. Narukawa et al. reported on “A Method for Methylmercury and Inorganic Mercury in Biological Samples Using High Performance Liquid Chromatography Inductively Coupled Plasma Mass Spectrometry”, describing the measurement of MeHg and Hg²⁺ in biological CRMs using HPLC-ICP-MS following alkaline extraction.¹⁰ Mercury spices were extracted with 10% (w/v) tetramethylammonium hydroxide (TMAH). All results were in good statistical agreement with spike recoveries, 95% or greater. Wei et al. reported on “Chromatographic Separation of Cd from Plants via Anion Exchange Resin for an Isotope Determination by Multiple Collector ICP-MS”, describing the high-precision analysis of Cd isotopes by multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS). Analytical methods including digestion, purification, and determination of Cd isotopes in plants were optimized. Lastly, researchers started taking advantage of the ICP-MS/MS instrumentation to determine elements, such as F previously undetectable. Zhu et al. reported on “Analysis of Fluorine in Drinking Water by ICP-QMS/QMS with an Octupole Reaction Cell”, describing the analysis of fluorine by measuring the BaF⁺ ions with ICP-tandem quadrupole mass spectrometer (ICP-QMS/QMS).¹¹

As described above, ICP-MS analysis of environmental and biological samples revealed a broad range of metals and other elements. Furthermore, the types of target elements will increase even more, and the standard values have become lower because the number of notifications of new chemicals has been increasing up to around 600/y in Japan,¹² and also because the environmental laws and regulations are stricter now. It is necessary to develop the analytical method and improve the equipment itself.

Keywords ICP-MS, air, water, speciation
References