Inductively Coupled Plasma-Mass Spectrometry

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Inductively coupled plasma-mass spectrometry (ICP-MS) is widely used in various fields, such as environmental, geological, and clinical sciences. Laser-ablation (LA) sample introduction is an effective tool to elucidate elemental compositions in solid materials with ICP-MS.¹ Nakazawa *et al.* reported on “Acceleration of Vaporization, Atomization, and Ionization Efficiencies in Inductively Coupled Plasma by Merging Laser-Ablated Particles with Hydrochloric Acid Gas”. They improved vaporization, atomization, and ionization efficiencies of elements in a glass material by merging ablated particles with HCl gas.² Quantitative analysis in LA-ICP-MS is more complex than that in solution nebulization ICP-MS. Zhu reported on “Quantitative Analysis of Trace Elements in Silicate Glass Sample by LA-ICP-QMS/QMS with an ORC: Silicon as the Matrix of Calibrating Solutions and the Internal Standard for Measurement”, describing a calibration strategy for the quantitative analysis of trace elements.³ Silicon in the glass was used as the internal standard as well as the matrix for making the calibrating solutions. Machida *et al.* reported on “Temporal Changes of Fractionation Index Caused by Changes in the Large Size of Ablated Particles in Laser Ablation-Inductively Coupled Plasma Mass Spectrometry”, describing the fractionation index variation of elements.⁴ Based on the analytical results, the measured elements were classified into two groups. The laser ablation can be utilized for isotope ratio determination. Ohata *et al.* reported on “Comparison of 265 nm Femtosecond and 213 nm Nanosecond Laser Ablation Inductively Coupled Plasma Mass Spectrometry for Pb Isotope Ratio Measurements”.⁵ They revealed the similar analytical performance of 265 nm femtosecond laser and 213 nm nanosecond laser ablation systems for Pb isotope ratio measurements of solder. They also reported on “Studies on Isotope Ratio Measurement of Cl by Inductively Coupled Plasma Triple-quad Mass Spectrometry”, describing an isotope ratio measurement of Cl using ICP-MS/MS.⁶ Similar sensitivities as those obtained by ICP-SFMS and the precisions of 0.2–0.5% of RSD at the concentration range of 1–10 mg kg⁻¹ were obtained. Speciation analysis is another

important subject for ICP-MS applications.⁷ Terol *et al.* reported on “Fast Determination of Toxic Arsenic Species in Food Samples Using Narrow-bore High-Performance Liquid-Chromatography Inductively Coupled Plasma Mass Spectrometry”, describing the analysis of arsenic species in food samples using small-bore columns.⁸ The use of the columns led to higher sensitivity, a shorter analysis time, a reduced mobile-phase consumption and minor matrix loading into the plasma source and the interface region of the ICP mass spectrometer. Anan *et al.* reported on “Complementary Use of LC-ICP-MS and LC-ESI-Q-TOF-MS for Selenium Speciation”, describing the analytical performance of these techniques for Se-containing compounds, such as selenate, selenomethionine (SeMet), and trimethylselenonium ion (TMSe).⁹ This study indicated that the sensitivity of LC-ICP-MS was higher than that of LC-ESI-Q-TOF-MS. Iwai *et al.* reported on “Arsenic Speciation and Cadmium Determination in Tobacco Leaves, Ash and Smoke”.¹⁰ Tobacco leaves, ash, and smoke samples were prepared and the concentrations of As and Cd were determined after microwave-assisted digestion. Narukawa *et al.* reported on “Reversed Phase Column HPLC-ICP-MS Conditions for Arsenic Speciation Analysis of Rice Flour”, describing an entirely robust and readily applicable method for the determination of arsenic species in rice flour.¹¹ Eight arsenic species were separated and determined using a HPLC-ICP-MS equipped with a reversed-phase ODS column. A main drawback in ICP-MS is spectral interferences by polyatomic ions. A laborious chemical separation process is often required to overcome this problem. However, the recent development of ICP-MS/MS (Fig. 1) enables us to remove interferences without any special sample preparation.^{6,12} As well as ICP-MS/MS, single particle ICP-MS has been intensively investigated in recent years.¹³ These developments will open up new possibilities for ICP-MS applications in various fields.

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References

1. A. Limbeck, P. Galler, M. Bonta, G. Bauer, W. Nischkauer, and F. Vanhaecke, *Anal. Bioanal. Chem.*, **2015**, 407, 6593.
2. T. Nakazawa, S. Izumo, and N. Furuta, *Anal. Sci.*, **2016**, 32, 1283.
3. Y. Zhu, *Anal. Sci.*, **2016**, 32, 1237.
4. R. Machida, T. Nakazawa, and N. Furuta, *Anal. Sci.*, **2015**, 31, 345.
5. M. Ohata, N. Nonose, L. Dorta, and D. Günther, *Anal. Sci.*, **2015**, 31, 1309.
6. M. Ohata, Y. Zhu, and N. Nonose, *Anal. Sci.*, **2017**, 33, 375.
7. O. T. Butler, W. R. L. Cairns, J. M. Cook, and C. M.

Fig. 1 Schematic drawing of the separation of selenium and argon ions using ICP-MS/MS.

- Davidson, *J. Anal. At. Spectrom.*, **2016**, *31*, 35.
8. A. Terol, M. Marcinkowska, F. Ardini, and M. Grotti, *Anal. Sci.*, **2016**, *32*, 911.
 9. Y. Anan, G. Nakajima, and Y. Ogra, *Anal. Sci.*, **2015**, *31*, 561.
 10. T. Iwai, K. Chiba, and T. Narukawa, *Anal. Sci.*, **2016**, *32*, 957.
 11. T. Narukawa, E. Matsumoto, T. Nishimura, and A. Hioki, *Anal. Sci.*, **2015**, *31*, 521.
 12. L. Balcaen, E. Bolea-Fernandez, M. Resano, and F. Vanhaecke, *Anal. Chim. Acta*, **2015**, *894*, 7.
 13. R. Peters, Z. Herrera-Rivera, A. Undas, M. Lee, H. Marvin, H. Bouwmeester, and S. Weigel, *J. Anal. At. Spectrom.*, **2015**, *30*, 1274.
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