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Inductively Coupled Plasma Mass Spectrometer ICPMS-2050

Application News

Determination of Trace Elements in Whole Blood by ICP-MS with Simple Dilution of Samples

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User Benefits

- Whole blood samples are directly diluted and tested to avoid contamination and losses caused by complex pretreatment processes, while saving labor and time costs.
- Low sample consumption enables simultaneous analysis of trace elements in batch samples for research.

■ Introduction

Elements are crucial substances that sustain normal metabolism and life activities within the human body. They serve as components of certain enzymes, hormones, and so on in the body and are also significant indicators of human nutritional status. Blood is a common biological fluid, a complex liquid mixture mainly composed of water, proteins, glucose, mineral salts, and red and white blood cells. Meanwhile, blood samples for research are characterized by small size yet large in quantity. Therefore, how to rapidly, accurately, and simply detect the content of multiple trace elements in bulk whole blood is an urgent problem that needs to be solved.

This article uses a mixed dilution solution of 0.2% HNO3+0.1 mg/L Au to dilute whole blood samples 20 times, and directly determines the content of 19 elements including Fe, Ca, Mg, Se, Hg, Pb in the samples by ICPMS-2050.

Fig. 1 ICPMS-2050

■ Sample

Bovine whole blood

■ Sample Preparation

Whole blood samples were diluted 20 times with a mixture of 0.2% HNO3+0.1 mg/L Au and directly with ICP-MS. Simultaneously prepare blank samples and spiked samples

■ Standard Samples

- Calibration Standards

Calibration standards were prepared by mixing standard solutions (As, Ba, Cd, Cr, Li, Mn, Ni, Pb, Sb, Sn, Sr, Tl, Se, Cu, Ca, Mg, Fe, Hg) diluted solution of (0.2% HNO3+0.1 mg/L Au). The concentrations in each calibration curve sample are shown in Table 1.

- Internal Standard Solution

A mixed internal standard element solution was prepared with a dilution solution of 10% isopropanol and 0.2% nitric acid. The concentrations of internal standard elements Be, Sc, and Ge are 1000 µg/L, and the concentrations of In, Y, and Bi are 500 µg/L.

Table 1 Calibration Standards

Elements	Concentration(µg/L)						
	STD 0	STD 1	STD 2	STD 3	STD 4	STD 5	STD 6
As/Ba/Cd/Cr/ Li/Mn/Ni/Pb/ Sb/Sn/Sr/Tl	0	0.10	0.50	2.50	5.00	10.0	--
Se	0	0.10	0.50	2.50	5.00	10.0	20.0
Cu	0	--	4.00	20.0	50.0	100	--
Zn	0	--	20.0	100	200	400	--
Ca*/Mg*	0	--	0.20	1.00	2.00	4.00	--
Fe*	0	--	2.0	10.0	20.0	40.0	--
Hg	0	--	0.10	0.50	1.00	2.00	--

Note: * The unit of element concentration is mg/L.

■ Equipment Configuration and Analytical Conditions

The system configuration and analytical conditions used are shown in Table 2 and Table 3.

Table 2 ICP-MS System Configuration

System:	ICPMS-2050
Nebulizer:	Nebulizer, DC04
Chamber:	Cyclone Chamber
Torch:	Mini-Torch
Skimmer Cone:	Nickel
Autosampler:	AS-20
Internal Standard Elements:	Online Internal Standard Kit (sample: internal standard=about 9:1)

Table 3 ICP-MS Analytical Configuration

RF Power:	1.20 kW
Plasma Gas Flowrate:	9.0 L/min
Auxiliary Gas Flowrate:	1.10 L/min
Carrier Gas Flowrate:	0.85 L/min
Dilution Gas Flowrate:	0 L/min
Collision/Reaction Gas:	He/H_2
pump Speed:	10 rpm
Sampling Depth	6 mm

■ Detection Limits

Calibration curves were prepared using the calibration standards shown in Table 1. IDLs were calculated from 3 times the standard deviation (σ) of 11 measurements of the calibration blank (STD0). MDLs were calculated based on the sample dilution factor (dilution 20 times) and IDLs . MDLs are shown in Table 4.

Table 4 Method Detection Limits (MDLs)

Elements	MDLs (μg/L)	Elements	MDLs (μg/L)
^{75}As	0.09	^{55}Mn	0.2
^{138}Ba	0.04	^{60}Ni	0.2
^{44}Ca	110	^{206}Pb	0.04
^{111}Cd	0.09	^{121}Sb	0.03
^{52}Cr	0.3	^{78}Se	0.3
^{63}Cu	0.2	^{78}Se*	0.06
^{56}Fe	37	^{118}Sn	0.07
^{202}Hg	0.2	^{88}Sr	0.2
^{7}Li*	0.07	^{205}Tl	0.03
^{24}Mg	9	^{66}Zn	0.8

Note: ^{7}Li* is in no gas mode; ^{78}Se* is in H_2 mode.

■ Precision Test

The spiked sample with 1 μg/L was measured for 11 times to determine the method precision of each element. The method precision of elements were shown in Table 6.

Table 6 Precision Test

Elements	RSD (%, n=10)	Elements	RSD (%, n=10)
^{75}As	1.51	^{55}Mn	2.47
^{138}Ba	1.46	^{60}Ni	2.33
^{44}Ca	2.62	^{206}Pb	1.19
^{111}Cd	2.70	^{121}Sb	1.89
^{52}Cr	2.06	^{78}Se	2.69
^{63}Cu	1.46	^{78}Se*	2.12
^{56}Fe	2.85	^{118}Sn	2.26
^{202}Hg	1.72	^{88}Sr	1.29
^{7}Li*	2.23	^{205}Tl	0.88
^{24}Mg	2.20	^{66}Zn	1.85

■ Analysis of Sample and Spike Recovery

Unspiked and spiked bovine whole blood were quantitatively measured using calibration curves, and spike recoveries were calculated. The results are shown in Table 5. Spike recoveries of 90.3 to 110 % were obtained for all the measured elements.

Table 5 Analysis of bovine whole blood and Spike Recovery

Element	Unspiked Bovine Whole Blood		Spiked Bovine Whole Blood		
	Measured Values (μg/L)	Concentration in whole blood (μg/L)	Spike Conc. (μg/L)	Measured Values (μg/L)	Recovery (%)
^{75}As	0.06	1.20	1.00	1.16	110
^{138}Ba	0.76	15.1	1.00	1.76	101
^{44}Ca*	3.30	66.0	2.00	5.26	98.3
^{111}Cd	N.D.	N.D.	1.00	0.90	90.3
^{52}Cr	N.D.	N.D.	1.00	1.06	106
^{63}Cu	27.9	557	50.0	75.4	95.1
^{56}Fe*	14.8	296	20.0	34.6	99.0
^{202}Hg	N.D.	N.D.	1.00	1.08	108
^{7}Li	0.23	4.58	1.00	1.26	103
^{24}Mg*	0.92	18.5	2.00	3.11	109
^{55}Mn	0.24	4.82	1.00	1.28	104
^{60}Ni	N.D.	N.D.	1.00	1.01	101
^{206}Pb	0.13	2.68	1.00	1.23	110
^{121}Sb	0.02	0.34	1.00	1.04	102
^{78}Se	7.39	148	5.00	12.3	98.2
^{78}Se	7.27	145	5.00	12.2	98.7
^{118}Sn	N.D.	N.D.	1.00	90.2	90.2
^{88}Sr	2.89	57.8	1.00	3.84	95.5
^{205}Tl	N.D.	N.D.	1.00	1.09	109
^{66}Zn	128	2560	200	311	91.5

Note: * : The unit of element concentration is mg/L;
N.D.=Not Detected

■ Long-Term Stability

Add 15.0 mg/L Fe and 1.00 µg/L Hg standard solution to the diluted bovine whole blood sample. The spiked samples were continuously measured for Fe, Hg and Se concentrations over 4 hours. The average concentrations of these three elements over the 4-hour measurement period were 31.4 mg/L (Fe), 1.08 µg/L (Hg), 7.43 µg/L (Se with He Mode) and 7.59 µg/L (Se with H_2 Mode). Calculate the ratio of each measurement to average values for Fe, Se, and Hg. Long-term stability for 4 hours was shown in Fig. 2. The ratio remains stable between 0.95 and 1.05.

■ Conclusion

The content of trace elements in whole blood was determined with Shimadzu ICPMS-2050. The method was achieved with simple pre-processing, low pollution, low sample consumption, high accuracy, fast analysis speed.

From the analysis result, even ICPMS-2040 with only He collision can meet the elemental analysis in whole blood. In addition, ICPMS-2050 with the H_2 mode can improve the sensitivity of Se.

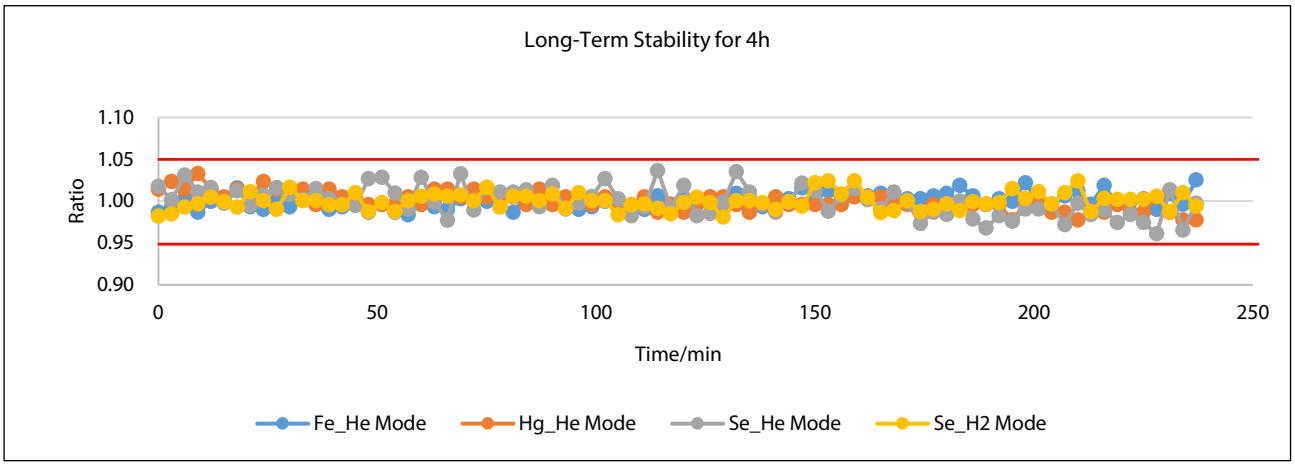

Fig. 2 Stability of bovine whole blood samples for 4 hours

03-ICPMS-230-EN First Edition: Apr. 2025

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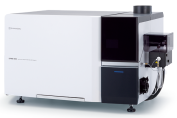

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