PerkinElmer 高分辨单细胞-ICP-MS技术与应用

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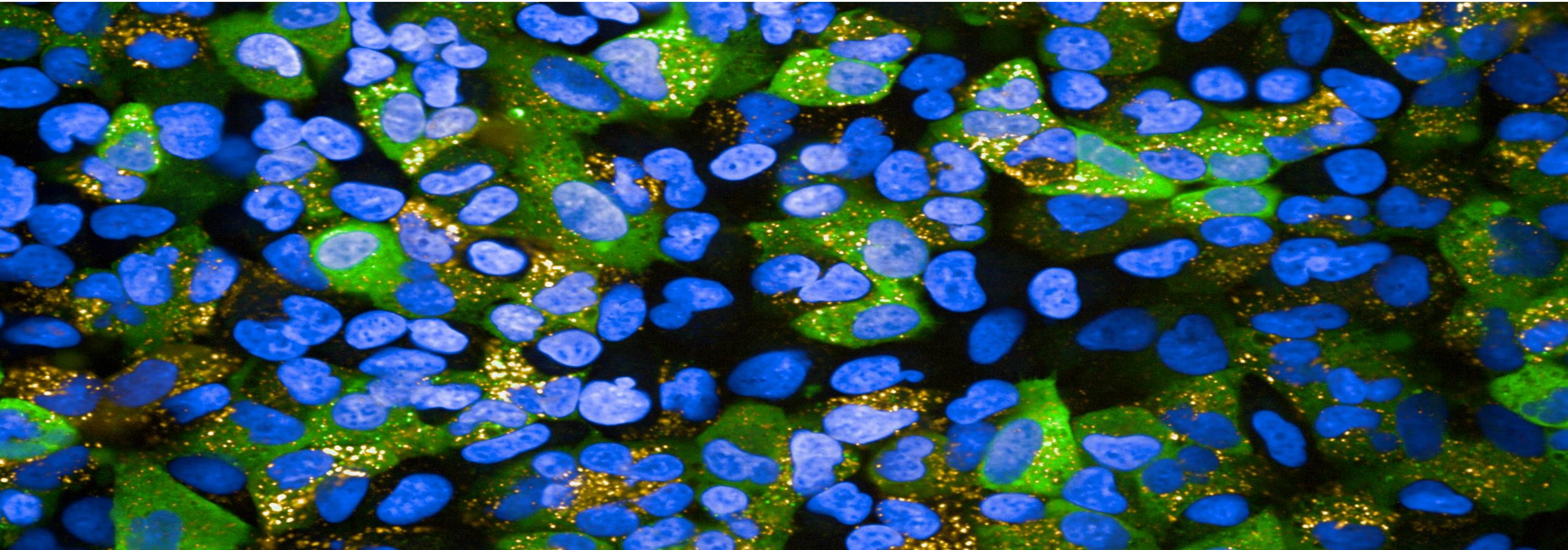
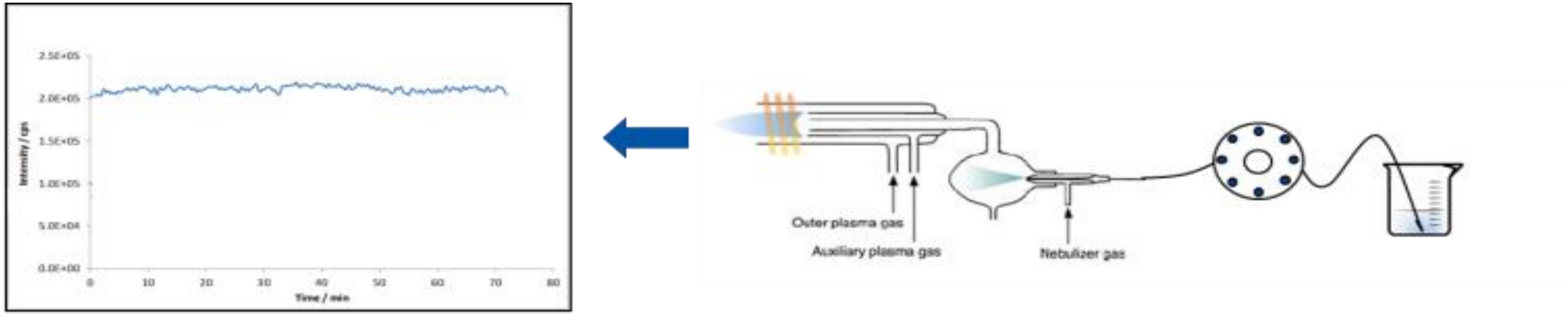
- 21th, Sep, 2018



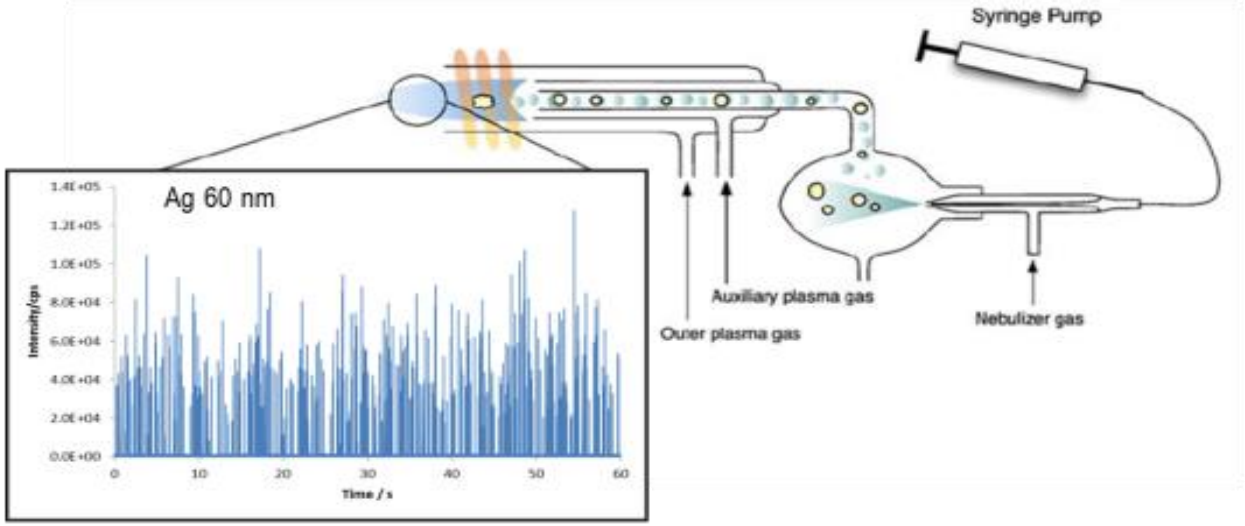
单颗粒、单细胞 SP-ICP-MS分析技术

- PerkinElmer 公司极力倡导的单颗粒、单细胞ICP-MS(single particle-ICPMS)技术被公认为一种定性和定量测定含有特定元素的低浓度的单颗粒最有前途的方法。
- 单颗粒目标可以是纳米粒子，也可以是PM2.5/PM10等大气粉尘颗粒物，或者合成的超细颗粒物及包合物等，更可以是生命科学研究前沿的细胞，藻类，病毒等活体小颗粒型目标物。
- 相对传统的元素监测方法，SP-ICP-MS技术可快速有效并提供更多的信息：它能够测定颗粒尺寸分布、颗粒个数，颗粒内部元素的浓度、颗粒外部溶解出来的元素浓度等。而且，它能够区分含有不同元素的特定粒子。

常规ICP-MS测定与SP-ICP-MS单颗粒测定的区别

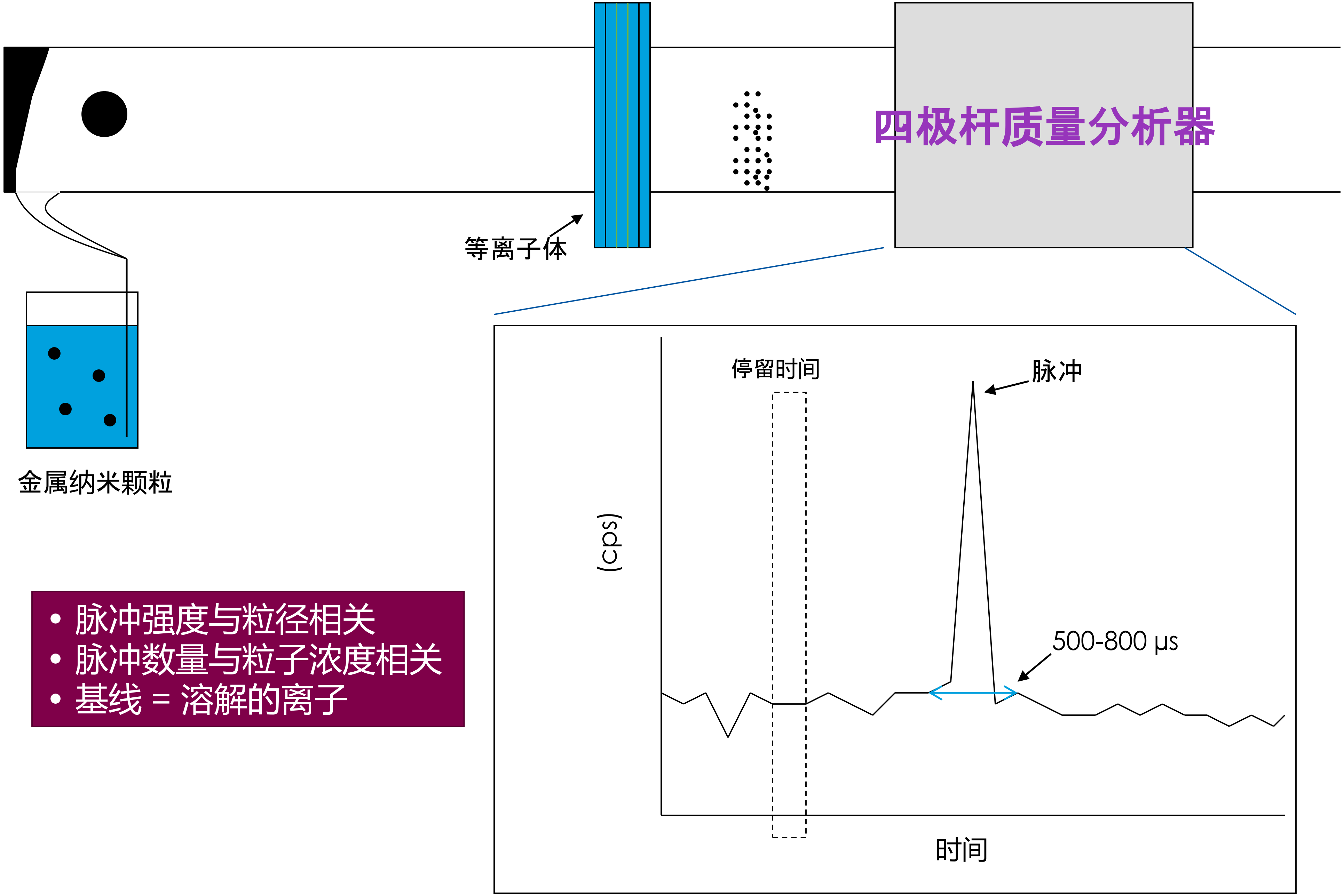


连续稳定的信号（溶液）



单独的信号（纳米粒子）

SP-ICP-MS 单颗粒测定原理



- 脉冲强度与粒径相关
- 脉冲数量与粒子浓度相关
- 基线 = 溶解的离子

单颗粒-ICP-MS技术对仪器的要求

analytical chemistry
Feature
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dx.doi.org/10.1021/ac402980q | Anal. Chem. 2014, 86, 2270−2278

Single Particle Inductively Coupled Plasma Mass Spectrometry: A Powerful Tool for Nanoanalysis

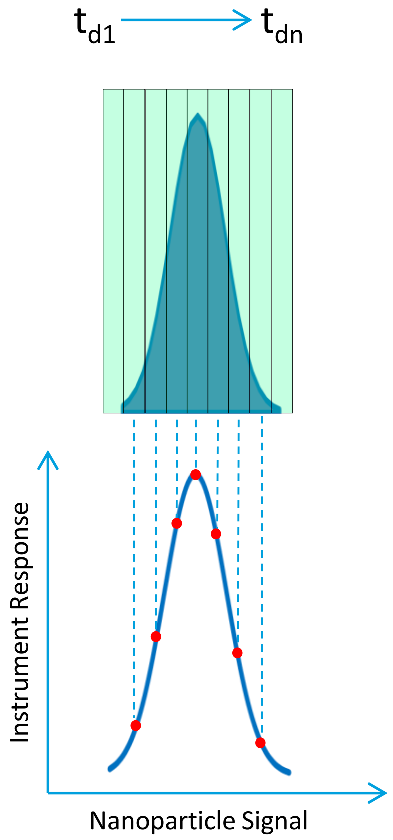
Table 1. Size and Element Mass Detection Limits Reported for Selected Nanoparticles Determined by SP-ICPMS

nanoparticle	LOD_{size}	LOD_{mass}	ref
Ag	18 nm	32 ag	15
	<20 nm	<44 ag	20
	20 nm	44 ag	34,28
	33 nm	200 ag	21
	30 nm	535 ag	22
Au	21 nm	94 ag	21
	25 nm	158 ag	13
	17 nm	331 ag	22
U	10 nm	106 ag	22
Al_2O_3	30 nm	30 ag	9
ZrO_2	70 nm	755 ag	10
ThO_2	80 nm	2.4 fg	11
TiO_2	100 nm	1.3 fg	9
FeOOH (goethite)	200 nm	10 fg	9

At present, SP-ICPMS is particularly suitable for NPs consisting of one element only and sizes higher than ~20 nm. In order to enhance size detection limits and implement multielement capabilities for heterogeneous NPs, improved commercially available ICPMS instruments are needed.

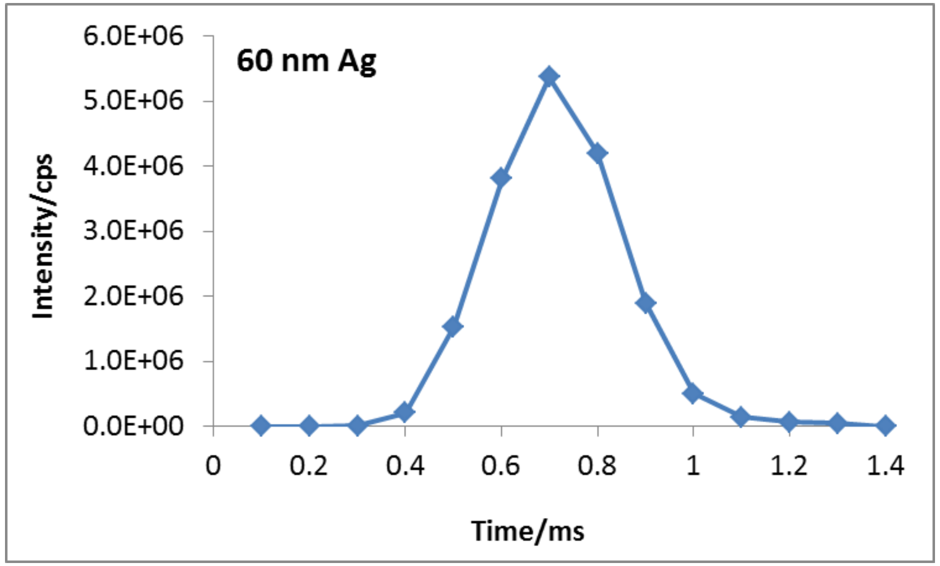
Because the duration of the transient signal generated by an individual NP is in the range of hundreds of microseconds, the multielement detection of transient signal generated by individual NPs involves the use of simultaneous or fast scanning instruments, able of recording full spectra of a mass range of interest at frequencies around 10^5 Hz.[45] Apart from

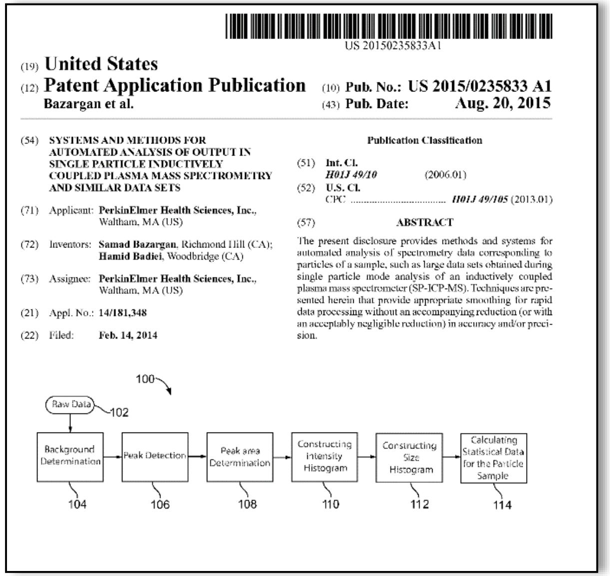
NexION高分辨单颗粒ICP-MS的快速数据采集能力



NexION 系列ICP-MS:

- **最短驻留时间可达10 μs，**单质量数据采集能力可达100000点每秒
- 专利的数据处理算法获得实时信号分析与背景信号校正





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(12) **Patent Application Publication**
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(10) **Pub. No.: US 2015/0235833 A1**
(43) **Pub. Date: Aug. 20, 2015**

(54) **SYSTEMS AND METHODS FOR AUTOMATED ANALYSIS OF OUTPUT IN SINGLE PARTICLE INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY AND SIMILAR DATA SETS**

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(72) Inventors: **Samad Bazargan**, Richmond Hill (CA); **Hamid Badiei**, Woodbridge (CA)

(73) Assignee: **PerkinElmer Health Sciences, Inc.**, Waltham, MA (US)

(21) Appl. No.: **14/181,348**

(22) Filed: **Feb. 14, 2014**

Publication Classification

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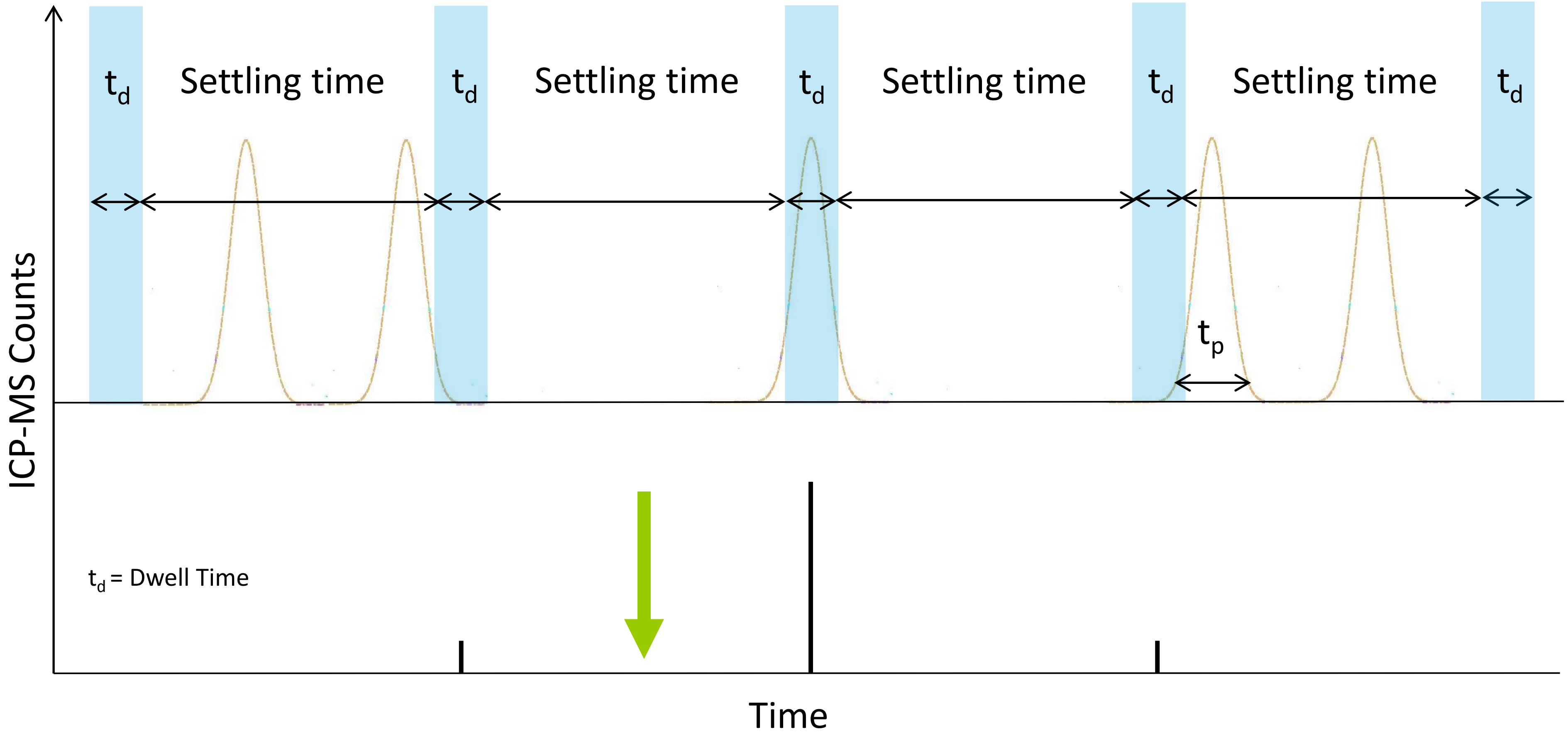
H01J 49/10 (2006.01)

(52) **U.S. Cl.**
CPC *H01J 49/105* (2013.01)

(57) **ABSTRACT**

The present disclosure provides methods and systems for automated analysis of spectrometry data corresponding to particles of a sample, such as large data sets obtained during single particle mode analysis of an inductively coupled plasma mass spectrometer (SP-ICP-MS). Techniques are presented herein that provide appropriate smoothing for rapid data processing without an accompanying reduction (or with an acceptably negligible reduction) in accuracy and/or precision.

单颗粒-ICP-MS技术对仪器的要求

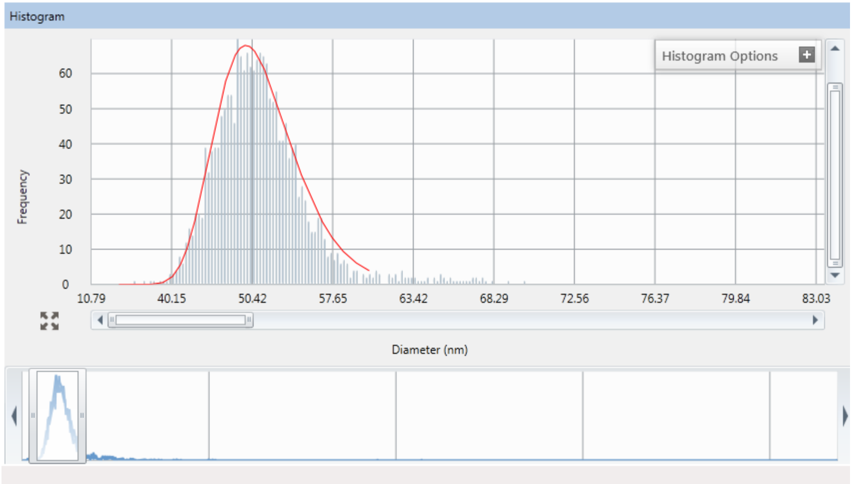


1、不准确的信号

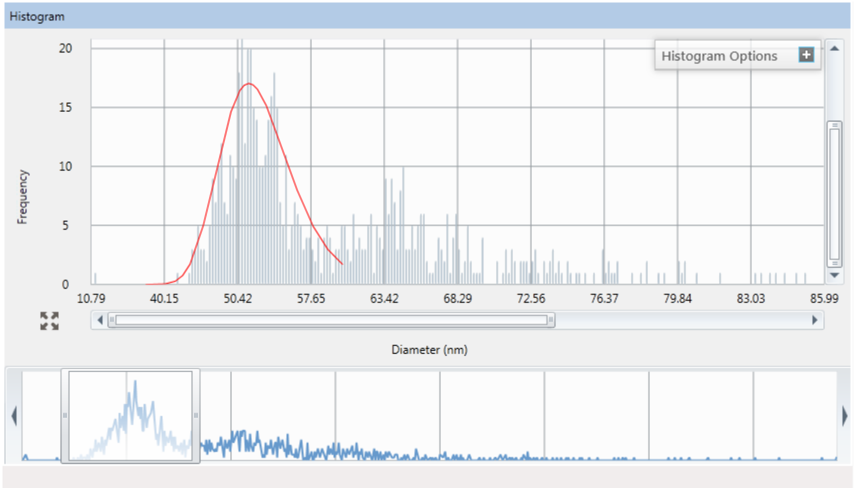
2、不准确的尺寸、颗粒浓度、线性、样品适应性等

驻留时间对单颗粒 -ICP-MS分析技术的影响

200 000 part/mL dwell time (50 µs)



200 000 part/mL dwell time (3000 µs)



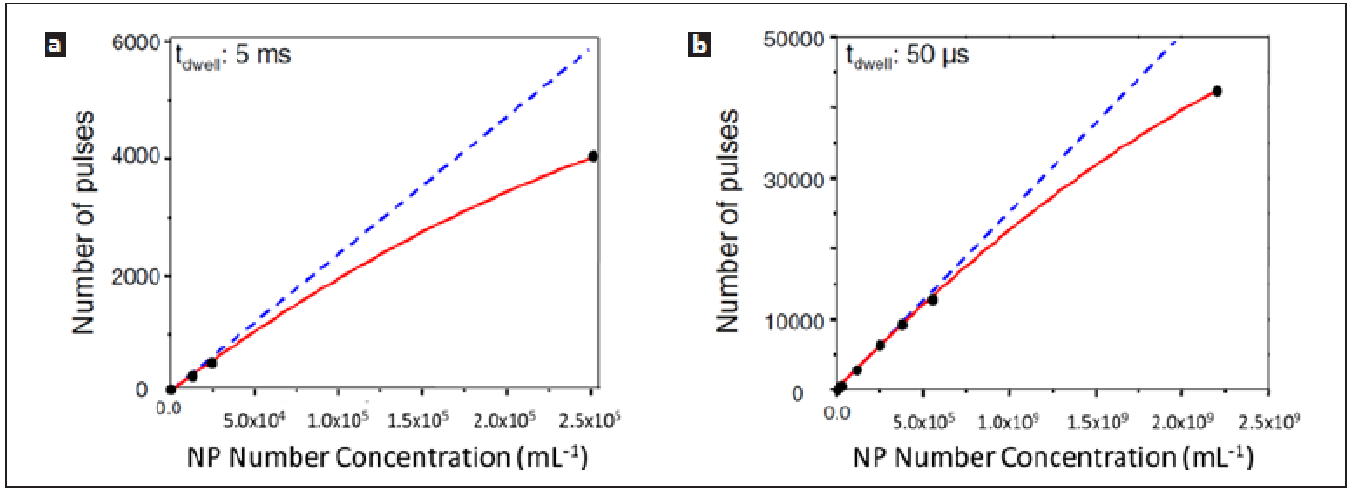


Figure 2. Number concentrations at dwell times of 5 ms (b) and 50 µs (b). Blue line = theoretical calculations; red line = experimental results (60 nm Au NPs, acquisition time = 60 sec).

Hineman, A., Stephan, C. *JAAS*, 2014, 29, 1252

驻留时间对单颗粒-ICP-MS分析技术的影响

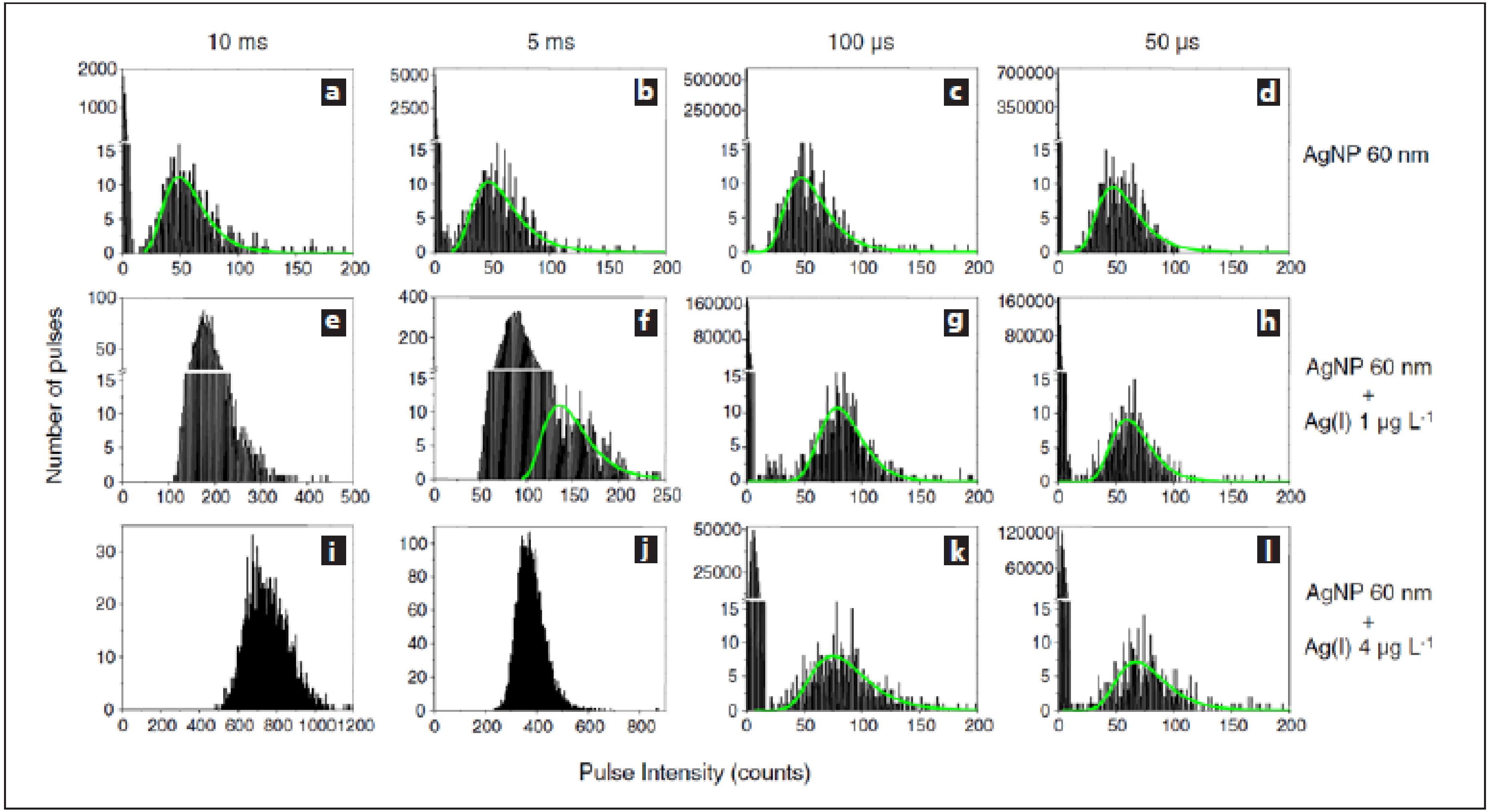
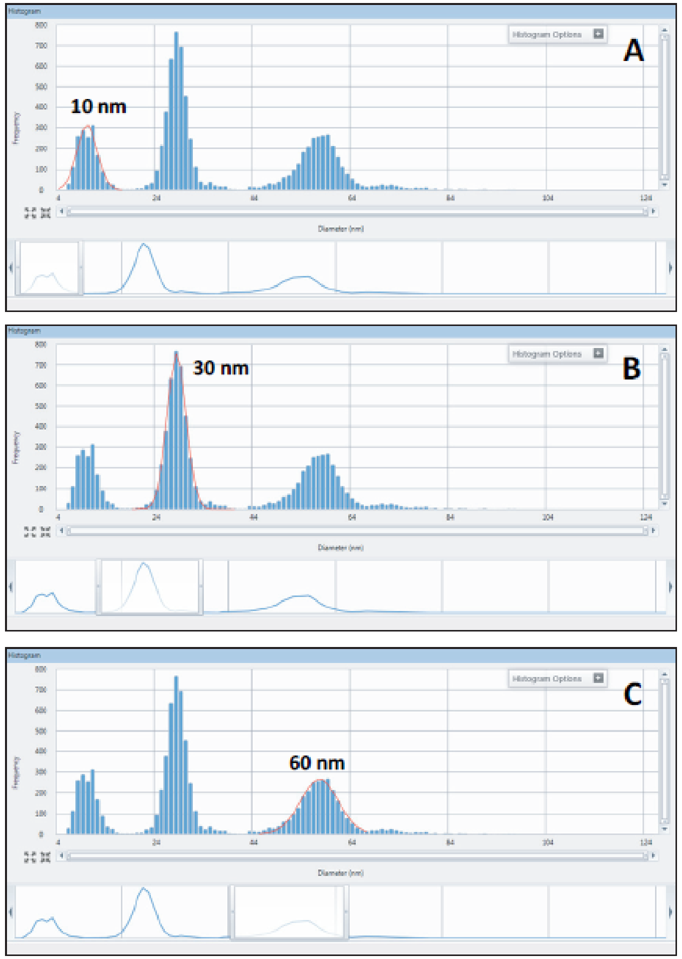


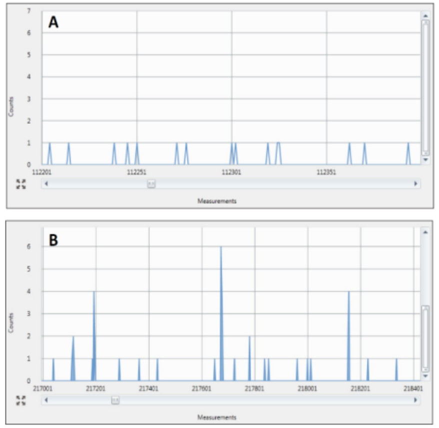
Figure 3. Size distribution histograms for: 60 nm Ag NPs (a-d); 60 nm Ag NPs + 1 µg/L dissolved Ag (e-h); and 60 nm Ag NPs + 4 µg/L dissolved Ag (i-l). All solutions contained Ag NPs at a concentration of 25,000 part/mL and were analyzed with dwell times of 10 ms (a, e, i), 5 ms (b, f, j), 100 µs (c, g, k), and 50 µs (d, h, l).

精确测定10 nm Au 纳米颗粒的粒径和数量

表 6. 不同粒径纳米颗粒混合物的分析。

	NIST 8011 - 10 nm			NIST 8012 – 30 nm			NIST 8013 – 60 nm		
同样的样品	标称粒径 (nm)	平均粒径 (nm)	颗粒浓度 (PART/mL)	标称粒径 (nm)	平均粒径 (nm)	颗粒浓度 (PART/mL)	标称粒径 (nm)	平均粒径 (nm)	颗粒浓度 (PART/mL)
1	9	8.9	20,058	28	28.3	49,411	57	56.6	31,295
2	9	8.9	20,622	28	28.3	49,391	57	56.7	31,007
3	9	8.7	21,327	28	28.2	49,763	57	57.0	31,585
均值	9	8.8	20,669	28	28.3	49,522	57	56.8	31,296
% RSD	0.0	1.3	3.1	0.0	0.2	0.4	0.0	0.4	0.9





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10 nm Au

Table 4. Particle Size Results Determined with Particle and Dissolved Calibrations.

Sample	Certificate Value (by TEM; nm)	Particle Calibrations (nm)	Dissolved Calibrations (nm)
NIST 8011	8.9 ± 0.1	8.8 ± 0.03	8.8 ± 0.03
NIST 8012	27.6 ± 0.1	27.8 ± 0.06	27.9 ± 0.03
NIST 8013	56 ± 0.51	56.1 ± 0.37	56.2 ± 0.30

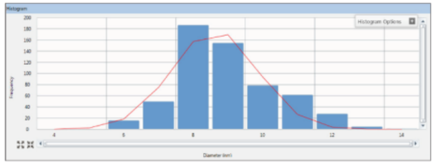

Figure 4. Particle size distribution for NIST 8011 10 nm Au NPs, fitted with a Gaussian distribution.

高分辨单颗粒ICP-MS实现金纳米棒表征

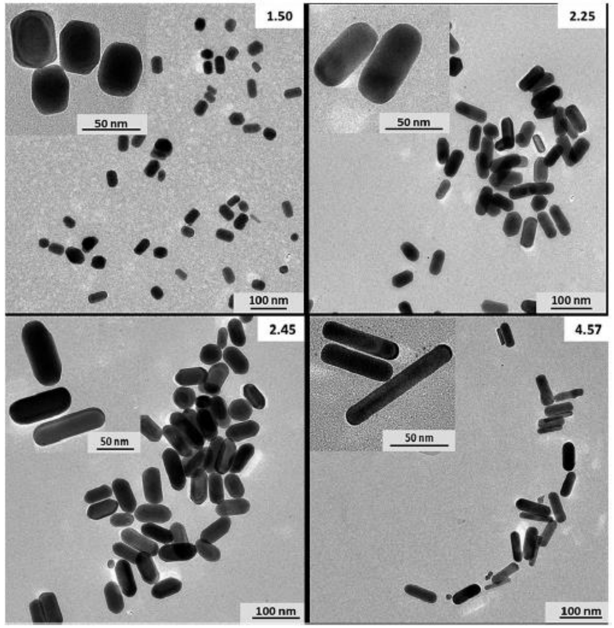

Table 1 ICP-MS instrumental settings and

Parameter/device	NexION 350
RF power	1400 W
Plasma gas flow rate	20.0 L min^{-1}
Carrier gas flow rate	1.05 L min^{-1}
Plasma sampling depth	4 mm
Measurement mode	TRA
Dwell time	20 µs
Acquisition time	60 s
Nebulizer	MicroMist
Spray chamber	Cyclonic

Table 3 Calculated width and length data for nanorods as determined by high resolution spICP-MS measurements. The relative error is calculated with respect to the data shown in Table 2

Width (nm)	Length (nm)	Rel. error for the width (%)	Rel. error for the length (%)
30.9	47.5	1.4	1.0
32.9	66.7	2.3	1.6
30.3	63.7	4.3	2.7
29.9	67.8	4.9	3.0
17.2	46.3	1.7	1.1
28.9	85.2	5.4	3.1
15.9	55.7	4.8	2.7
15.9	74.7	1.6	1.9

JAAS

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Dimensional characterization of gold nanorods by combining millisecond and microsecond temporal resolution single particle ICP-MS measurements†

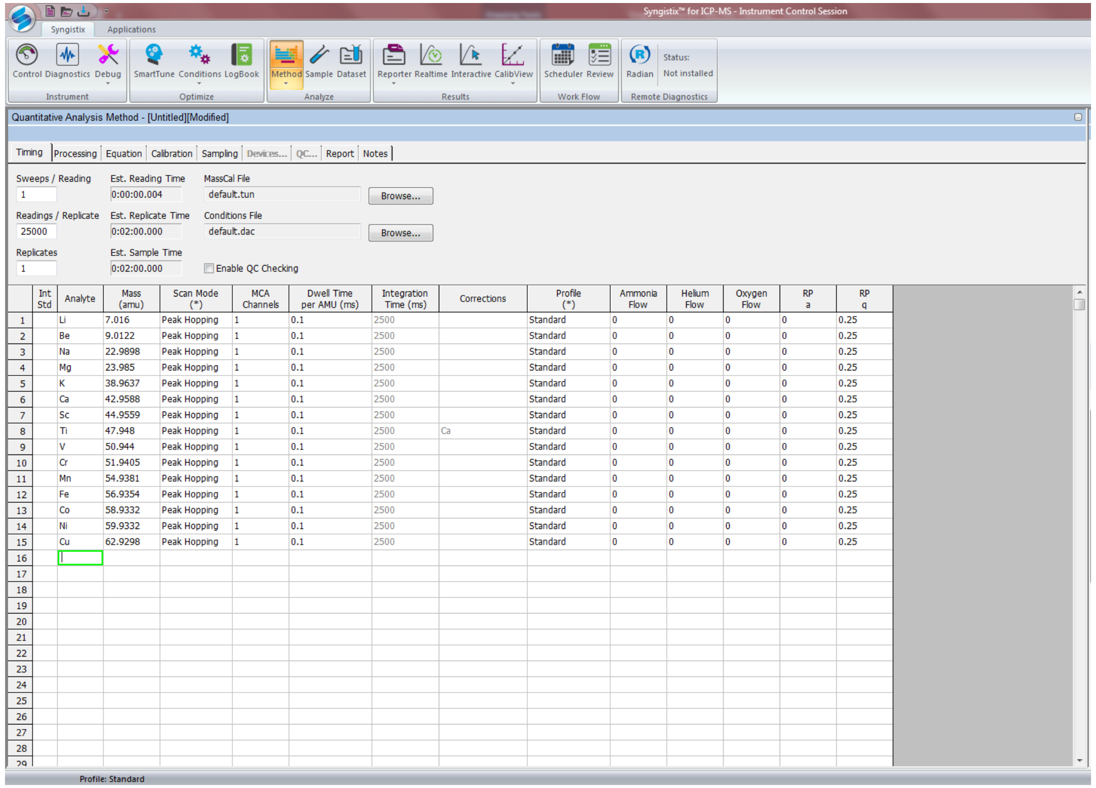
Ildikó Kálomista,[a] Albert Kéri,[a] Ditta Ungor,[b] Edit Csapó,[bc] Imre Dékány,[b] Thomas Prohaska[d] and Gábor Galbács*[a]

A systematic investigation of single particle inductively coupled plasma mass spectrometry (spICP-MS) signal profiles recorded with normal (ms-range) and high (µs-range) temporal resolution for spherical and rod-shaped gold nanoparticles was performed. The experiments with nanorods were carried out on hemispherically capped cylindrical particles synthesized in the aspect ratio range from 1.5 to 4.5. A comparison of NP signals and time profiles for spherical and rod-shaped NPs revealed that (i) the volume of the particles can be assessed by conventional spICP-MS measurements using a joint, linear calibration

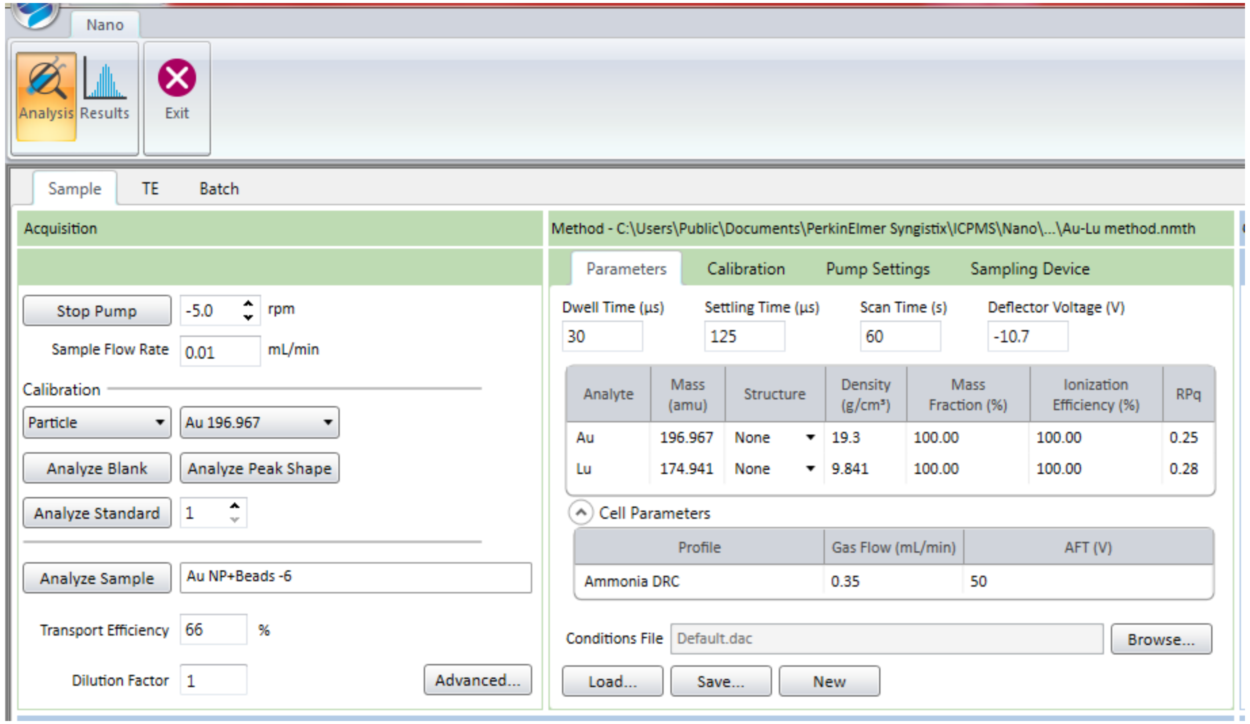
DOI: 10.1039/c7ja00306d

高分辨单颗粒ICP-MS实现单颗粒的双元素检测能力

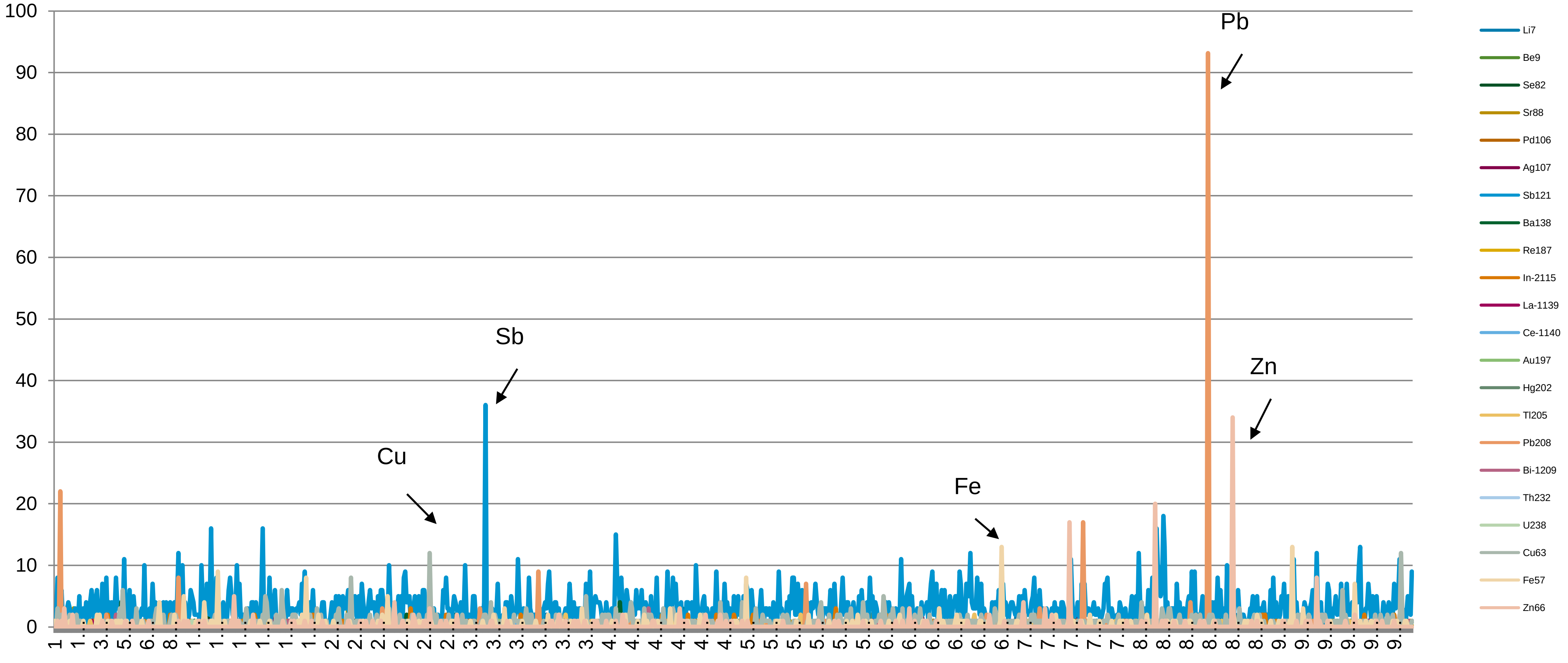
颗粒的多元素扫描



单颗粒的双元素同时分析



颗粒的多元素扫描



100
90
80
70
60
50
40
30
20
10
0
Pb
Sb
Zn
Cu
Fe
Li7
Be9
Se82
Sr88
Pd106
Ag107
Sb121
Ba138
Re187
In-2115
La-1139
Ce-1140
Au197
Hg202
Tl205
Pb208
Bi-1209
Th232
U238
Cu63
Fe57
Zn66

颗粒的多元素扫描-污水处理厂淤泥中发现大量纳米颗粒

DOI: 10.1021/acs.est.6b05931

7. Occurrence of Ti-, Fe- and Zn- NPs and dissolved elements in sludge samples

Table S6. Occurrence of Ti-, Fe- and Zn- NPs and dissolved elements in sludge samples

Sample Sites	Chemical Fractions	Ti Most Freq. Size (nm) TiO_2	Ti Part. Conc. (Parts/g)	Ti Diss. Conc. (μg/g)	Fe Most Freq. Size (nm) Fe_2O_3	Fe Most Freq. Size (nm) Fe_3O_4	Fe Most Freq. Size (nm) FeS/FeOOH	Fe Most Freq. Size (nm) FeS_2	Fe Most Freq. Size (nm) Fe_7S_8	Fe Part. Conc. (Parts/g)	Fe Diss. Conc. (μg/g)	Zn Most Freq. Size (nm) ZnO	Zn Most Freq. Size (nm) ZnS	Zn Part. Conc. (Parts/g)	Zn Diss. Conc. (μg/g)
S4	Acid-exchangeable fraction	64	1.96E+09	10.00	57	56	60	66	62	3.83E+09	1311.25	45	53	9.86E+10	718.75
	Acid-exchangeable fraction duplicate	64	1.91E+09	9.89	58	58	62	68	64	4.17E+09	1406.25	45	53	9.64E+10	717.50
S5	Acid-exchangeable fraction	64	6.20E+09	51.50	47	46	50	54	51	2.65E+10	2095.00	45	53	2.41E+10	1280.00
	Acid-exchangeable fraction duplicate	64	6.70E+09	52.25	47	46	50	54	51	2.50E+10	2080.00	45	53	2.15E+10	1253.75
S10	Acid-exchangeable fraction	71	6.46E+08	21.93	47	46	50	54	51	4.09E+10	4497.46	45	53	1.92E+10	1230.00
	Acid-exchangeable fraction duplicate	71	7.67E+08	22.60	47	46	50	54	51	3.34E+10	4379.60	45	53	2.22E+10	1247.50
S11	Acid-exchangeable fraction	29	1.92E+08	2.61	56	56	57	57	58	7.20E+10	176.50	--	--	--	267.50
	Acid-exchangeable fraction duplicate	29	2.07E+08	2.74	59	59	60	60	61	7.47E+10	184.50	--	--	--	270.00
S12	Acid-exchangeable fraction	35	2.85E+07	4.89	49	49	50	50	51	2.40E+10	129.50	--	--	--	527.50
	Acid-exchangeable fraction duplicate	36	2.84E+07	5.55	51	51	52	52	53	2.20E+10	125.50	--	--	--	526.00
S14	Acid-exchangeable fraction	81	1.06E+09	25.00	57	56	60	66	62	9.78E+08	2096.62	45	53	2.07E+10	303.13
	Acid-exchangeable fraction duplicate	81	1.11E+09	25.10	54	53	57	62	59	7.53E+08	2126.10	45	53	2.16E+10	303.75
S15	Acid-exchangeable fraction	76	1.00E+09	68.40	52	52	56	61	58	1.46E+10	1051.10	45	53	8.70E+10	705.00
	Acid-exchangeable fraction duplicate	76	8.77E+08	65.70	54	53	57	62	59	1.33E+10	1049.99	45	53	9.06E+10	702.50
S17	Acid-exchangeable fraction	71	3.67E+09	30.75	55	54	58	63	60	9.02E+09	2475.44	45	53	7.03E+10	668.75
	Acid-exchangeable fraction duplicate	71	3.99E+09	31.35	56	55	59	64	61	7.51E+09	2467.86	45	53	6.87E+10	662.50
S18	Acid-exchangeable fraction	76	1.20E+09	11.04	51	51	55	60	57	2.93E+09	2705.41	48	57	2.77E+10	1303.75
	Acid-exchangeable fraction duplicate	76	1.17E+09	10.95	57	57	60	66	63	2.18E+09	2719.47	48	57	3.17E+10	1306.25
S19	Acid-exchangeable fraction	71	1.96E+09	15.88	55	54	58	63	60	3.13E+10	5598.12	45	53	5.51E+09	993.75
	Acid-exchangeable fraction duplicate	71	1.88E+09	15.70	54	53	57	62	59	3.58E+10	5630.98	45	53	5.23E+09	991.25
S20	Acid-exchangeable fraction	71	5.20E+08	12.08	51	51	55	60	57	2.88E+10	17302.01	41	48	1.20E+11	2140.00
	Acid-exchangeable fraction duplicate	71	5.25E+08	13.05	51	51	55	60	57	3.43E+10	17606.29	41	48	9.40E+10	2007.50
S21	Acid-exchangeable fraction	71	1.01E+09	12.70	56	55	59	64	61	3.25E+10	17885.81	45	53	6.27E+11	5340.00
	Acid-exchangeable fraction duplicate	71	1.02E+09	12.75	57	57	60	66	63	3.79E+10	18137.15	45	53	5.94E+11	5400.00
S23	Acid-exchangeable fraction	76	1.21E+09	34.85	50	50	53	59	55	1.35E+09	2271.79	45	53	4.15E+10	585.00
	Acid-exchangeable fraction duplicate	76	1.22E+09	35.13	50	50	53	59	55	1.13E+09	2274.63	45	53	3.45E+10	573.75
S26	Acid-exchangeable fraction	71	1.77E+08	34.00	58	58	62	68	64	1.77E+10	6712.06	41	48	4.88E+10	140.00
	Acid-exchangeable fraction duplicate	71	1.83E+08	33.80	58	58	62	68	64	1.62E+10	6742.84	41	48	5.00E+10	143.13
	Reducible fraction	97	5.02E+07	21.74	--	--	--	--	--	--	--	--	--	--	--
	Reducible fraction duplicate	96	5.08E+07	21.92	--	--	--	--	--	--	--	--	--	--	--
	Oxidizable fraction	98	1.95E+08	39.61	--	--	--	--	--	--	--	--	--	--	--
	Oxidizable fraction duplicate	97	1.92E+08	37.73	--	--	--	--	--	--	--	--	--	--	--

--: Not Tested

Environmental Science & Technology
Article
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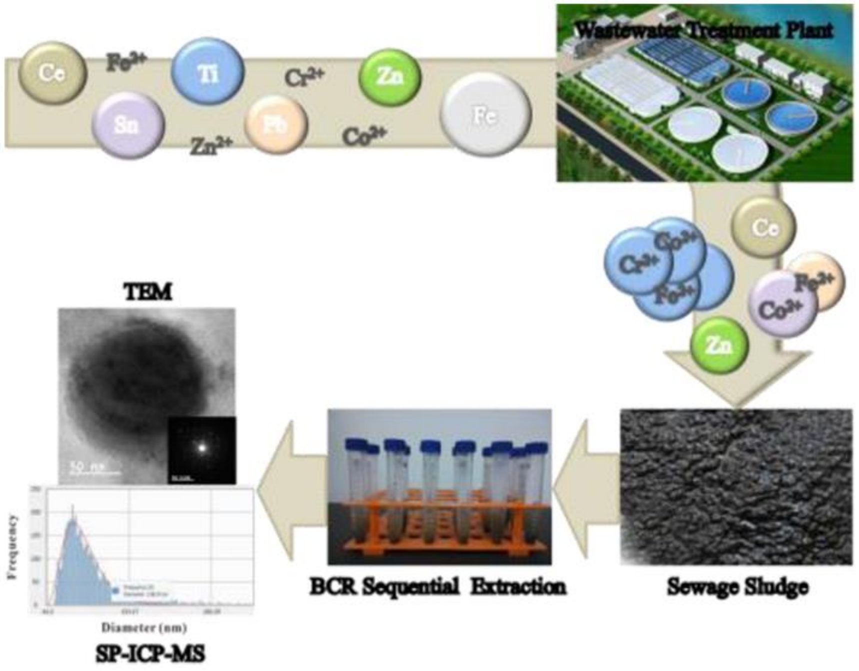
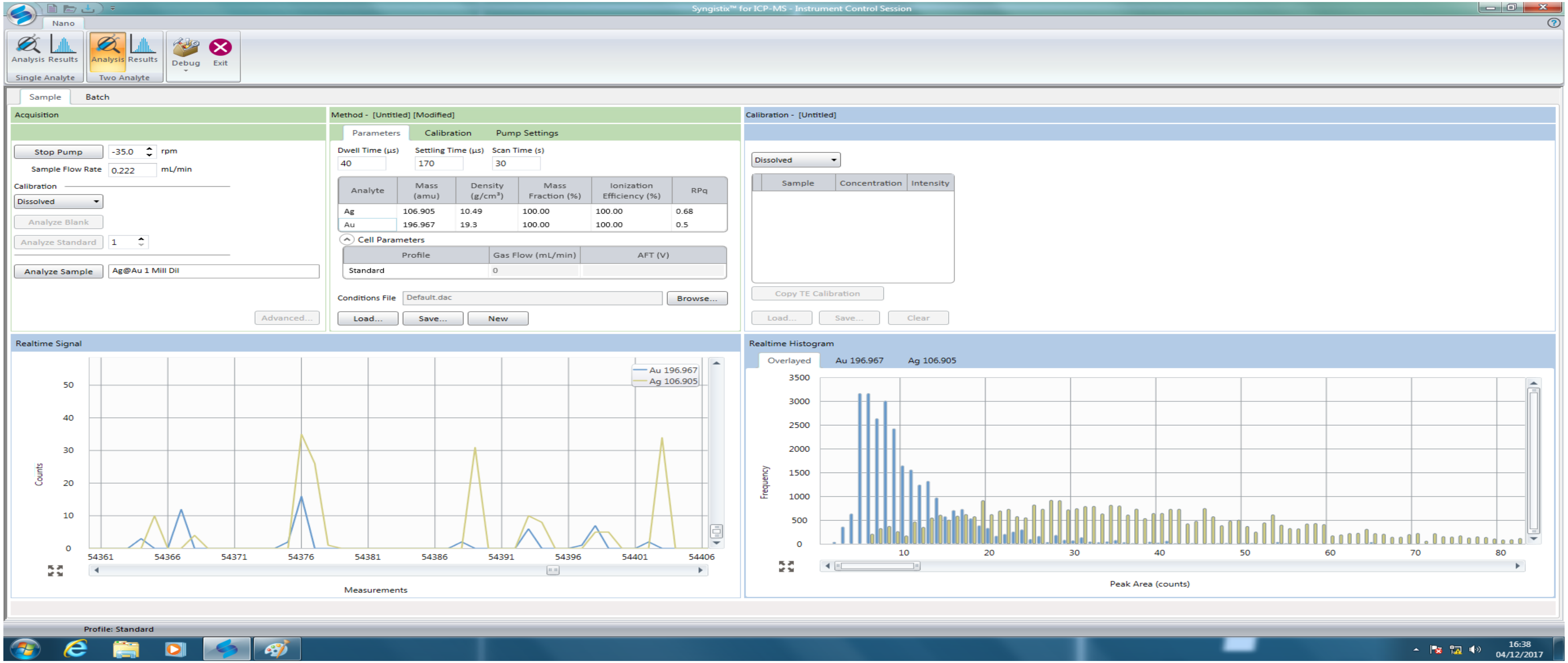
Environmental Risk Implications of Metals in Sludges from Waste Water Treatment Plants: The Discovery of Vast Stores of Metal-Containing Nanoparticles

Feiyun Tou,[†] Yi Yang,[*,†,‡] Jingnan Feng,[†] Zuoshun Niu,[†] Hui Pan,[†] Yukun Qin,[†] Xingpan Guo,[†] Xiangzhou Meng,[§] Min Liu,[†] and Michael F. Hochella[∥,⊥]



单颗粒双元素同时分析（ Au@Ag ）



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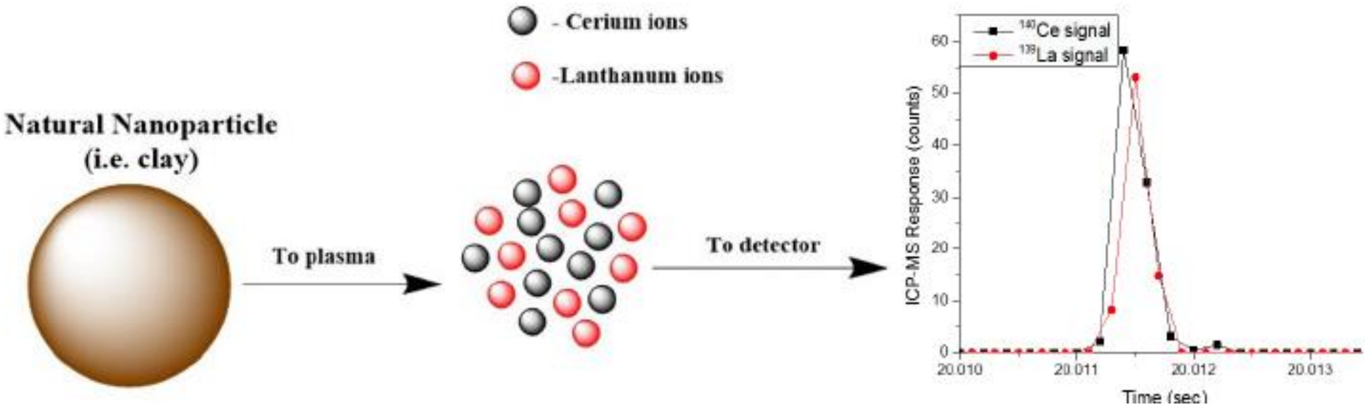
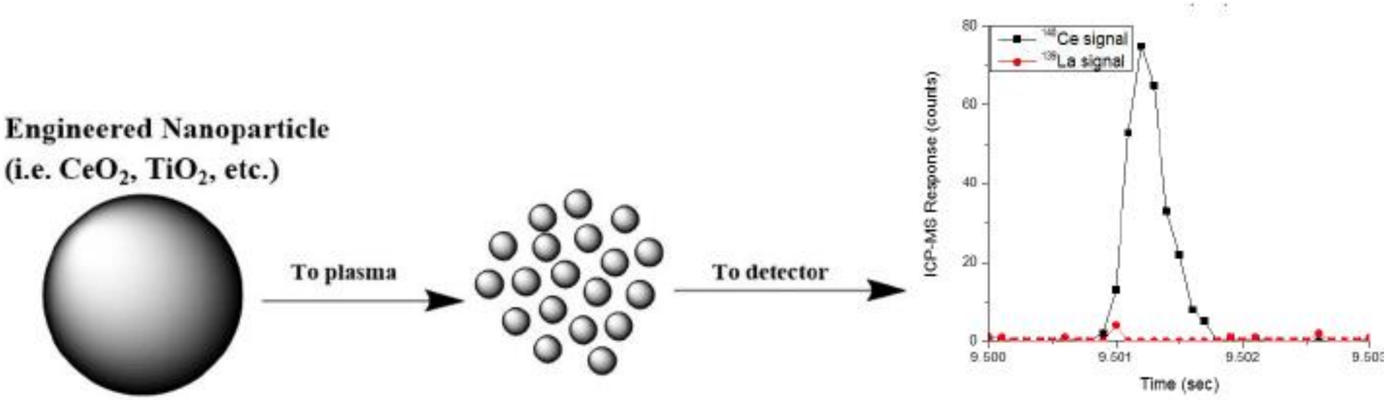
单颗粒双元素同时分析

- Natural clay is composed of a 2:1 ratio of Ce:La



- Engineered CeO NP is composed of Ce



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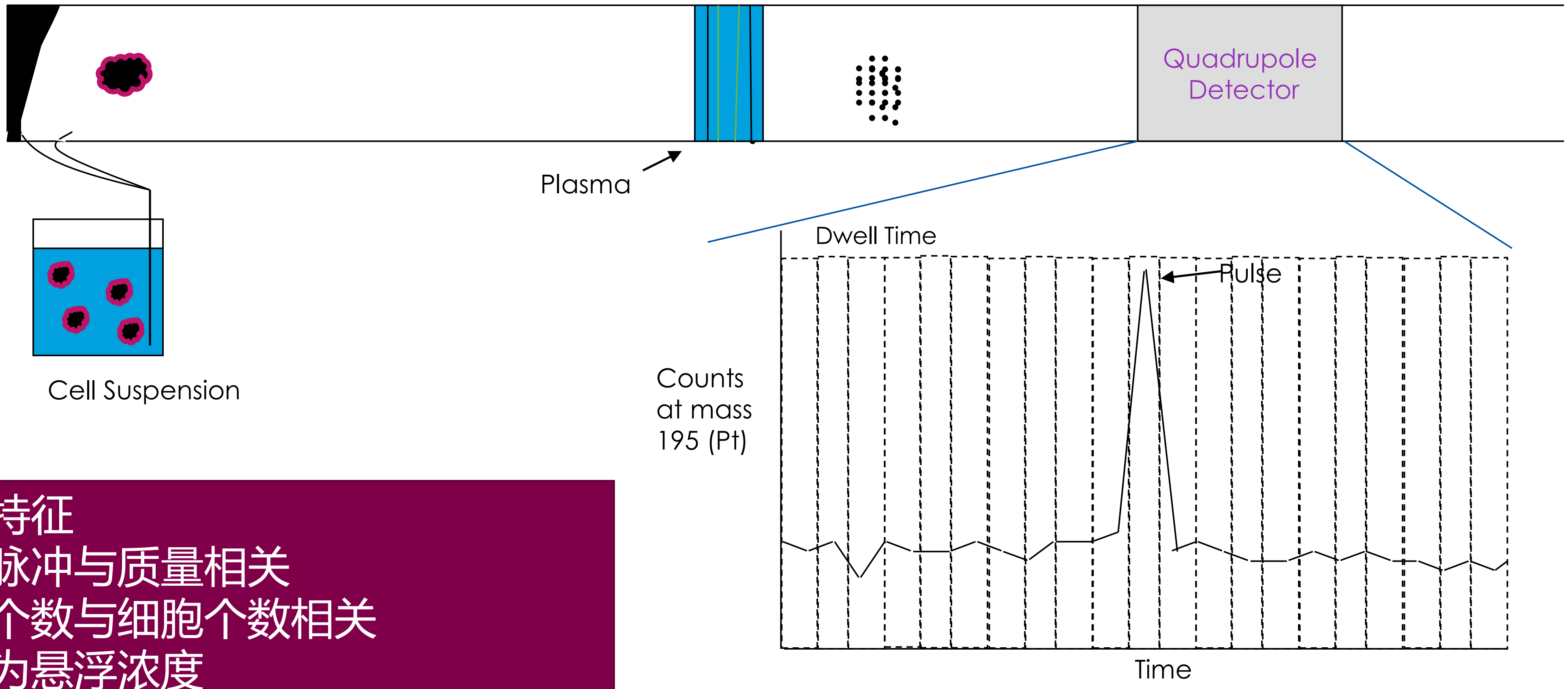
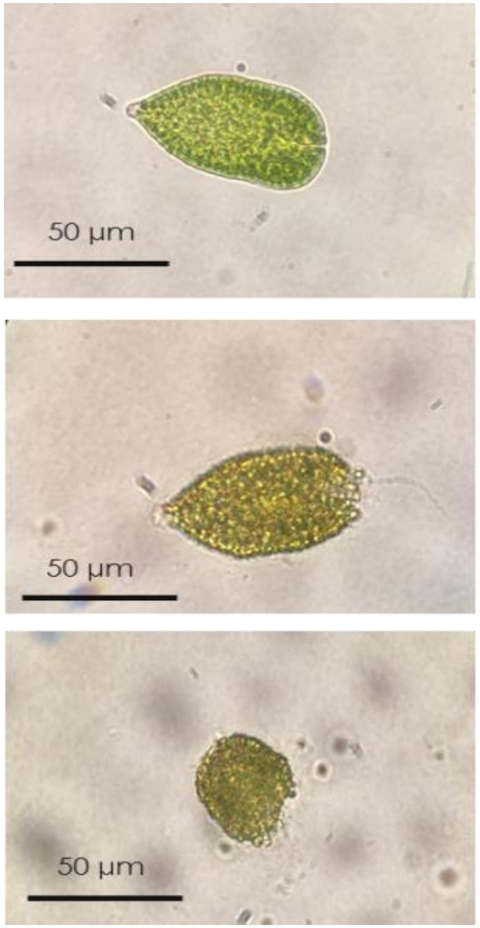
Single Cell ICP-MS 工作原理



- 元素特征
- 信号脉冲与质量相关
- 脉冲个数与细胞个数相关
- 基线为悬浮浓度

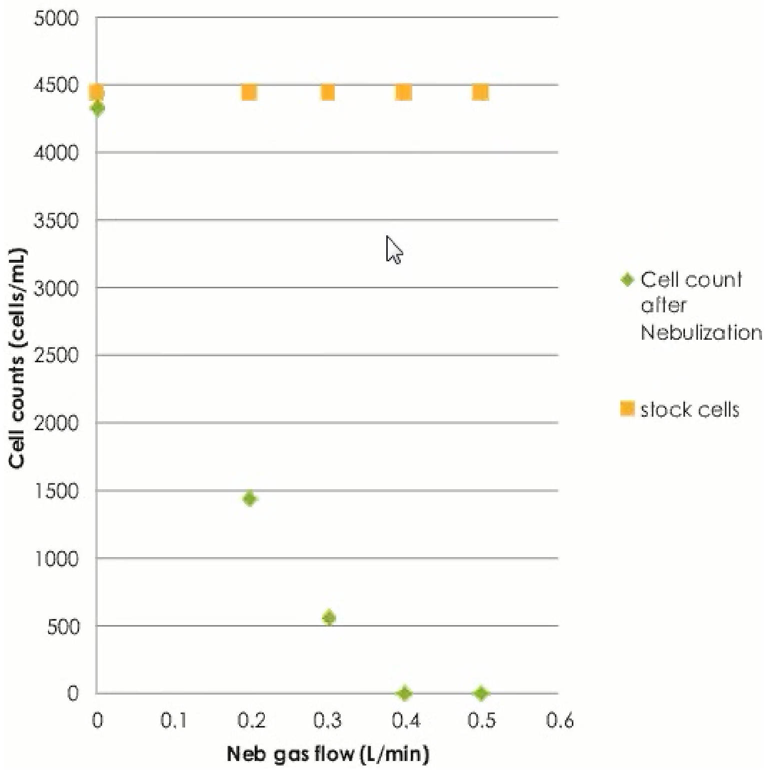
SP-ICP-MS单颗粒用于细胞、藻类、细菌等生物分析

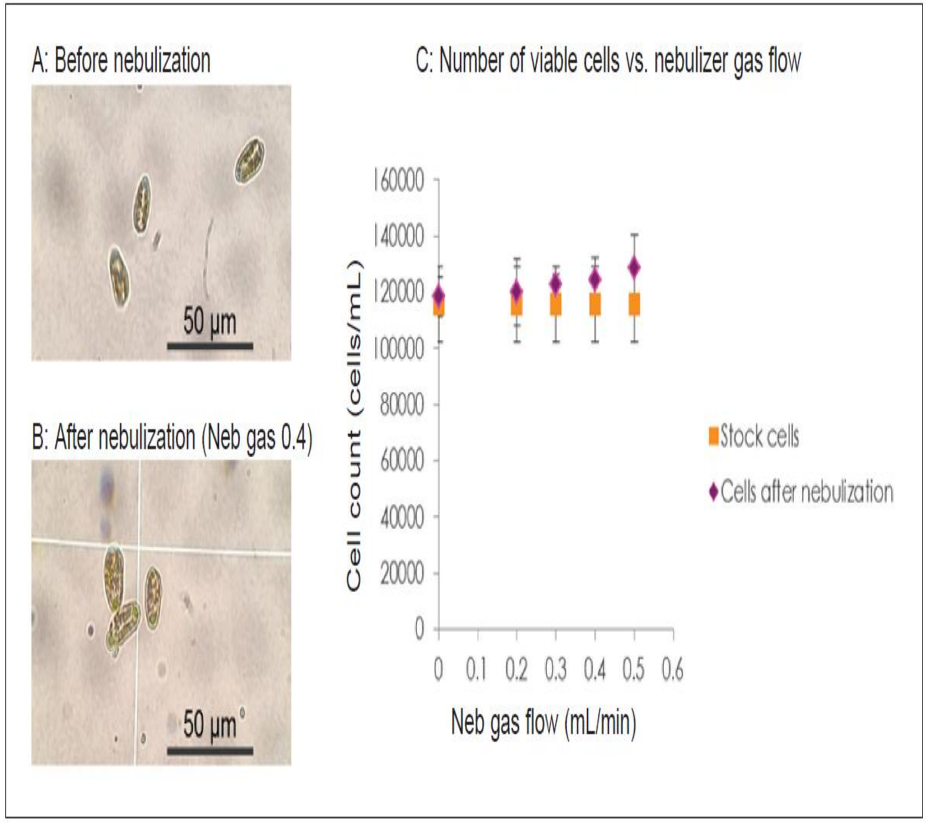


Stock
Before Nebulization

After Nebulization
Neb gas 0.3

After Nebulization
Neb gas 0.4



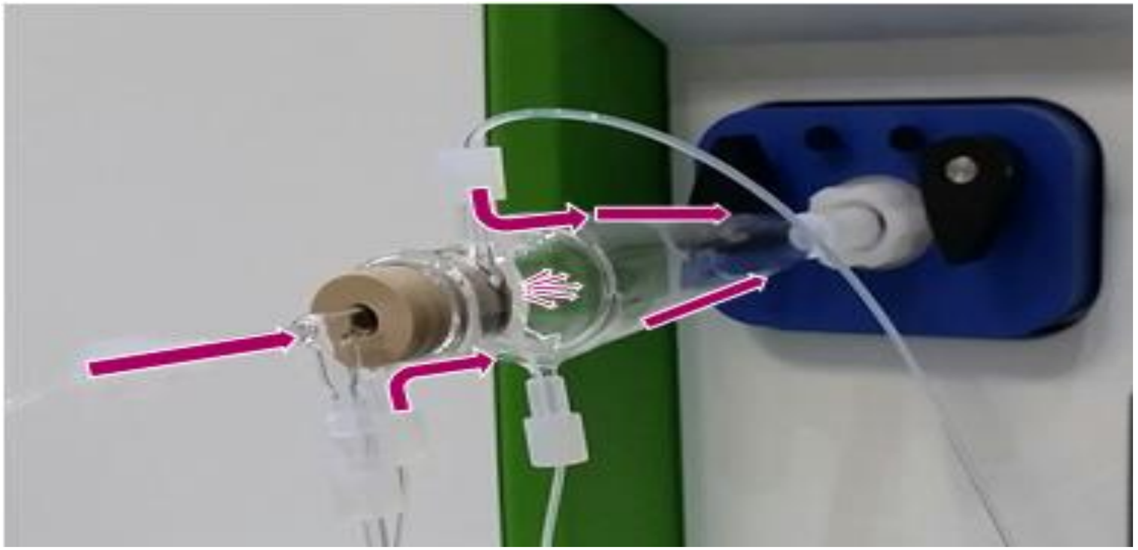


PerkinElmer

SP-ICP-MS单颗粒用于细胞、藻类、细菌等生物分析

- Nanoparticles < 0,1 µm
- **Aerosol-droplets ~ 4 µm**
- Yeast cells 2 - 10 µm
- Algae cells 1 - 100 µm

- 传统ICP-MS雾化器不适合细胞、藻类、细菌等生物分析



Asperon™ Linear Path

旋流雾室

Scott 双通道雾室

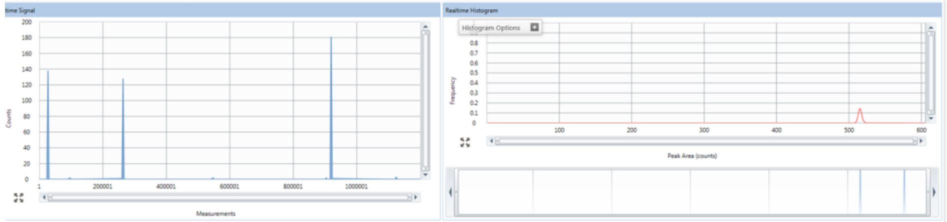
Asperon™ 单细胞雾室与传统旋流对比

Spray chamber	Baffled Cyclonic	Asperon™
Neb gas flow (mL/min)	0.92	0.32
Make up gas (mL/min)	0	0.7
Sample flow rate (mL/min)	0.283	0.015
TE 2.5 um beads (%)	0.04	30.84
TE 60 nm NIST (%)	5.42	31.33

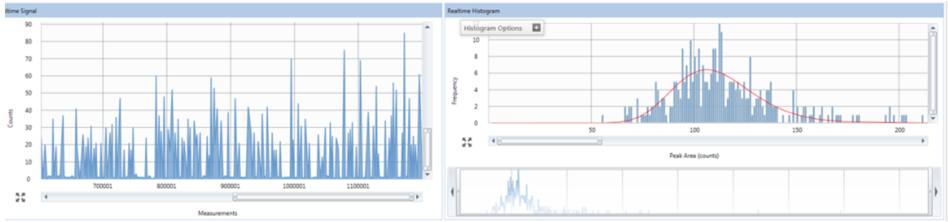
Asperon™ Linear Path

Baffled Cyclonic

2.5 µm Beads

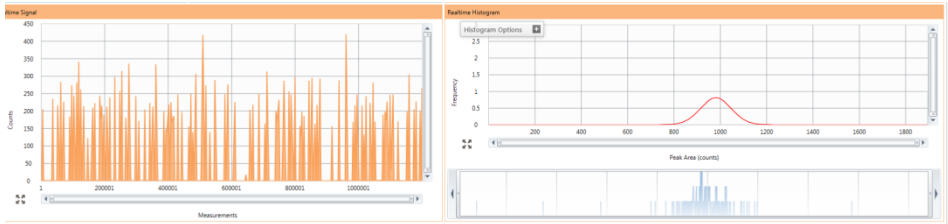


60 nm Au NIST



Asperon™

2.5 µm Beads



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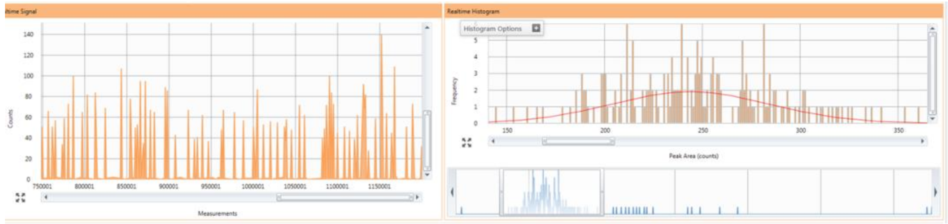

Single cell 软件– 在 attogram (ag) 水平上的分析

Prefix		10^n	Decimal	English Word		Platinum Atoms
		10^0	1	one		
deci	d	10^{-1}	0.1	tenth		
centi	c	10^{-2}	0.01	hundredth		
milli	m	10^{-3}	0.001	thousandth	mg Pt	
micro	μ	10^{-6}	0.000001	millionth	μg Pt	
nano	n	10^{-9}	0.000000001	billionth	ng Pt	
pico	p	10^{-12}	0.000000000001	trillionth	pg Pt	3,000,000,000
femto	**f**	10^{-15}	**0.000000000000001**	**quadrillionth**	**fg Pt**	**3,000,000**
atto	**a**	10^{-18}	**0.000000000000000001**	**quintillionth**	**ag Pt**	**3,000**
zepto	z	10^{-21}	0.000000000000000000001	sextillionth	zg Pt	3

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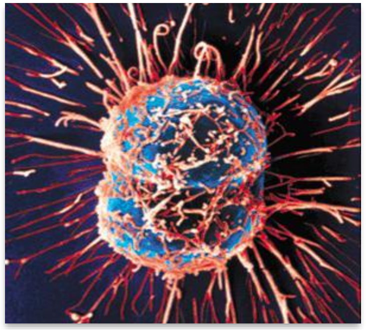
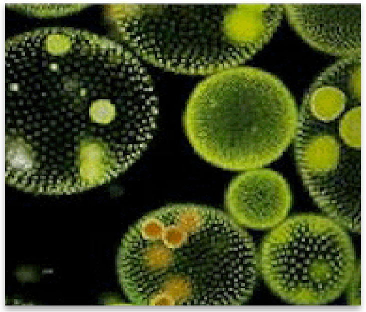
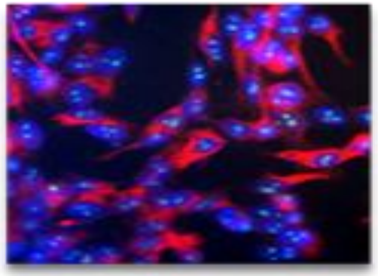
单细胞ICP-MS准确分析镧系金属标记的聚苯乙烯珠

- 含有镧系金属的聚苯乙烯珠
- 尺寸：2.5 μm
- 进样 33,000 part./mL

From supplier				Measured using ionic calibrations in SC-ICP-MS (ag)					
Element	Atoms per bead (±15%)	Mass (ag)	Size (nm)	1	2	3	4	Average	STDEV
Ce 140	19.9E6	4626.26	109.7	4519.76	4560.64	4749.98	4698.90	4632.32	94.98
Eu 151	11.3E6	2833.38	101.1	2960.52	3011.75	3122.76	3075.32	3042.59	61.61
Eu 153	12.0E6	3048.75	103.6	2903.66	3239.50	3113.54	3061.42	3079.53	120.42
Ho 165	7.6E6	2082.32	76.8	2157.37	2227.98	2576.47	2354.24	2329.02	159.33
Lu 175	9.8E6	2847.82	82.1	2920.82	2779.02	2965.16	2892.10	2889.28	68.77
Number particles				34323	33145	34696	34821	34246	661.67

单细胞-ICP-MS应用

- 癌症研究
- 药物设计
- 环境毒理学
- 生物技术和细胞科学
- 。。。

基于单细胞-ICP-MS 的卵巢癌细胞对顺铂吸收研究新方法

APPLICATION NOTE

ICP - Mass Spectrometry

Authors:
Lauren Amable
National Institute on Minority Health and Health Disparities, National Institutes of Health
Bethesda, MD

Stan Smith
Chady Stephan
PerkinElmer, Inc.
Shelton, CT

New Research Evaluating Cisplatin Uptake in Ovarian Cancer Cells by Single Cell ICP-MS

Introduction

Cisplatin, carboplatin, and oxaliplatin are the most widely used of platinum-based cancer chemotherapy drugs in the Western world. Cisplatin's effectiveness is due to its ability to bind to the DNA, resulting in DNA-platinum (Pt) adducts, which bend the DNA. The cells must then repair the DNA damage, otherwise DNA replication is blocked resulting in cell death[1].

Many cancers are initially sensitive to platinum-based treatment, but patients frequently relapse with tumors displaying resistance to further cisplatin therapy[1]. Cisplatin drug resistance is due to three major molecular mechanisms: increased DNA repair, increased cytosolic inactivation, and altered cellular accumulation. Decreased cellular uptake or increased cellular export of cisplatin constitutes the mechanisms involved in altered cellular accumulation[1].

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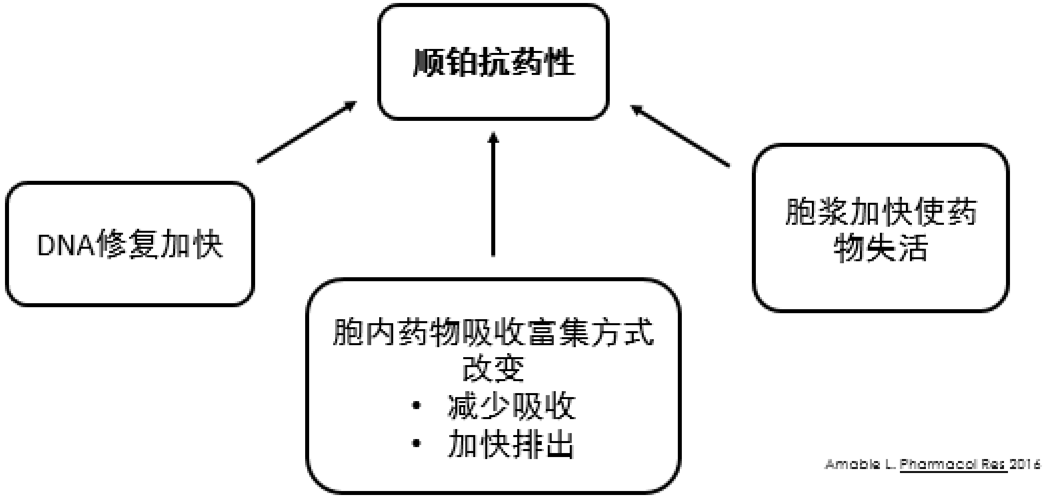
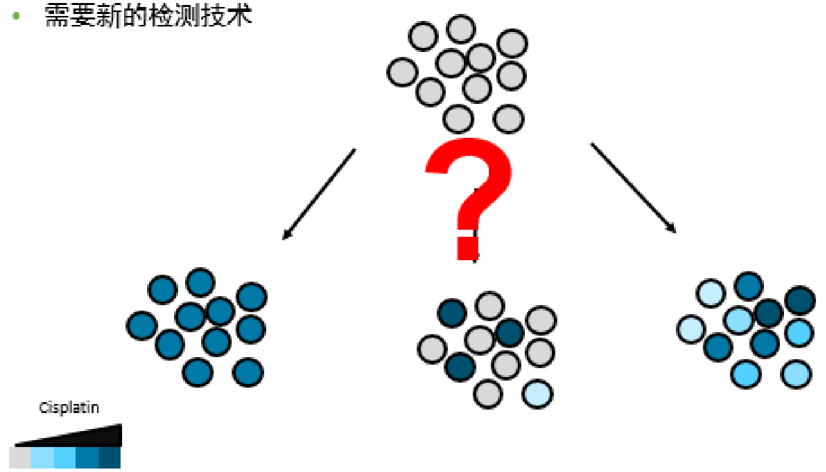
For the Better



Amable L. Pharmacol Res 2016

- 传统AA，ICP，MAS技术只能测定吸收平均值，无法区分细胞间差异
- 顺铂以及其他药物的吸收存在特异性，即吸收/不吸收；吸收多与少的差异
- 需要新的检测技术



基于单细胞-ICP-MS 的卵巢癌细胞对顺铂吸收研究新方法

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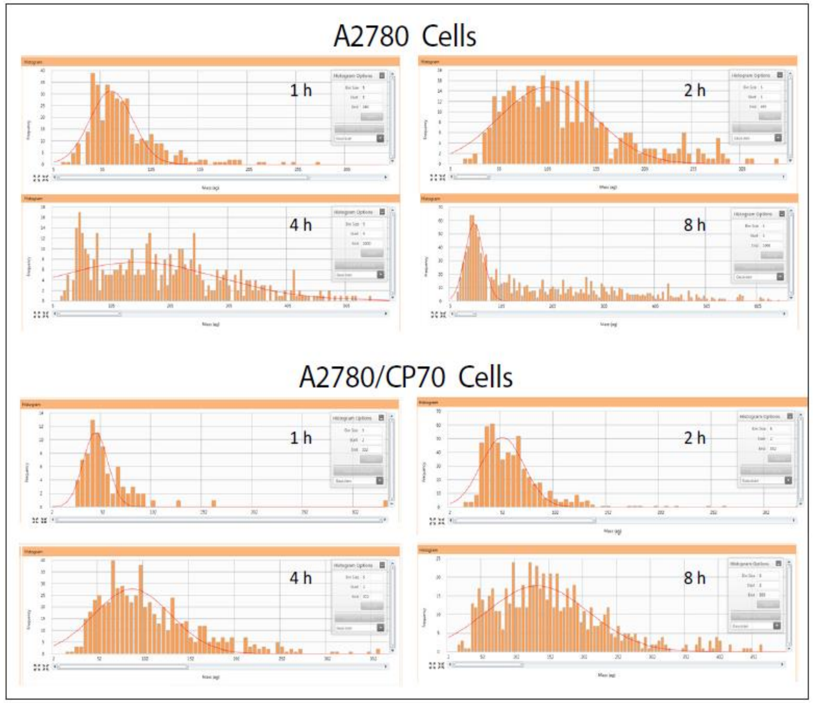

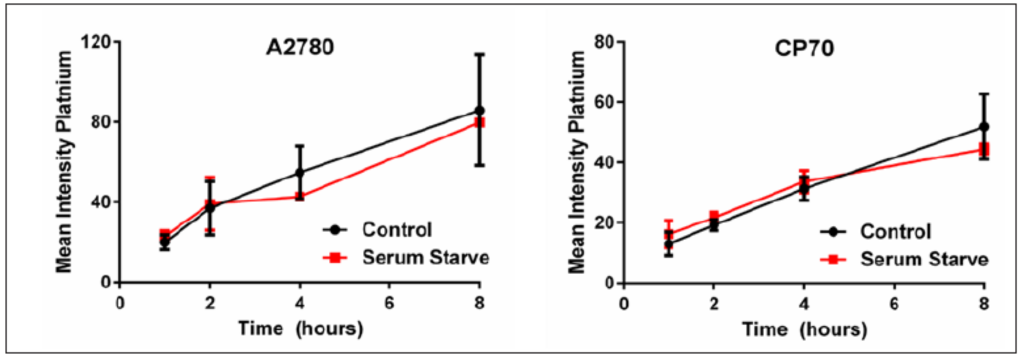

PerkinElmer Application Note: New Research Evaluating Cisplatin Uptake in Ovarian Cancer Cells by Single Cell ICP-MS

基于单细胞-ICP-MS 对金纳米颗粒吸收

APPLICATION NOTE

ICP - Mass Spectrometry

Authors:

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Norman, Oklahoma

Ryan C. Benson, Naga Rama Kothapalli,
Anthony W. G. Burgett

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University of Oklahoma
Norman, Oklahoma

Ruth Merrifield, Chady Stephan

PerkinElmer, Inc.
Woodbridge, Canada

Quantification of Gold Nanoparticle Uptake into Cancer Cells using Single Cell ICP-MS

Introduction

Cancer is a disease that is characterized by the uncontrolled growth and spread of abnormal cells. According to the American Cancer Society, cancer is the second most common cause of death in the US.[1] Current treatments for various cancers include surgery, radiation, immunotherapy, and chemotherapy. Although these conventional therapies may improve patients' overall survival and quality of life, they also have several limitations. For example, in conventional cancer chemotherapy, small-molecule-based cancer therapeutics distribute non-specifically throughout the entire human body. The consequence is that these drugs do not only kill cancer cells but also destroy healthy cells in the body causing severe side effects for cancer patients,[2] leading to a need for new therapies that can target diseased cells.

Nanoparticles (NPs) have been of significant interest over the last two decades as they offer attractive benefits for drug delivery to overcome limitations in conventional chemotherapy.[3] Nanoparticles can be engineered to carry both drugs and imaging probes to simultaneously detect and treat cancer. They may also be designed to specifically target diseased tissues and cells in the body. A number of nanoparticle-based cancer therapeutics have been approved for clinical use and/or are currently under development.[4,5] Advantages that rationally engineered nanoparticles may offer over conventional small-molecule drugs include: (i) prolonged circulation time in the body; (ii) reduction of nonspecific cellular uptake and undesirable off-target and side effects; and (iii) improvement in cellular interactions through specific cancer cell targeting moieties.

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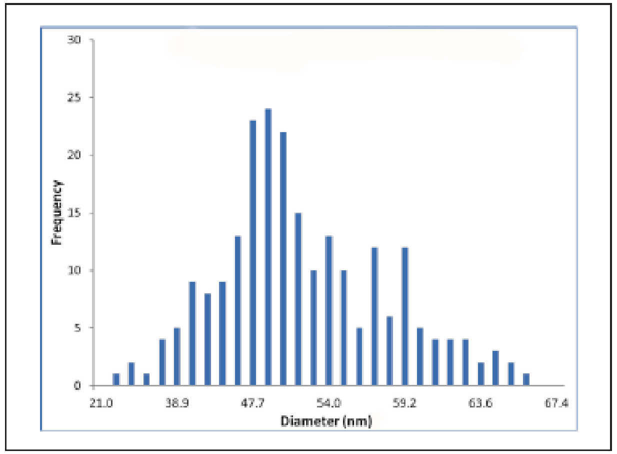
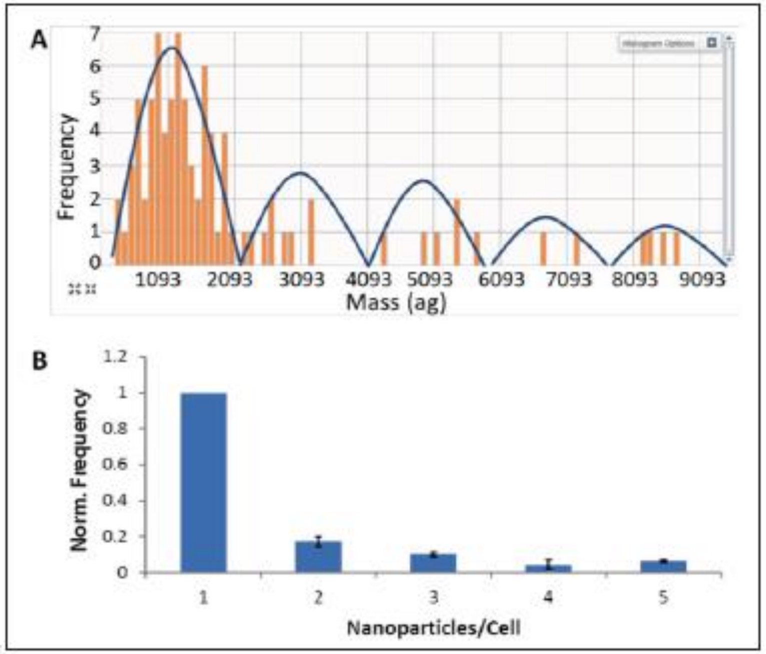
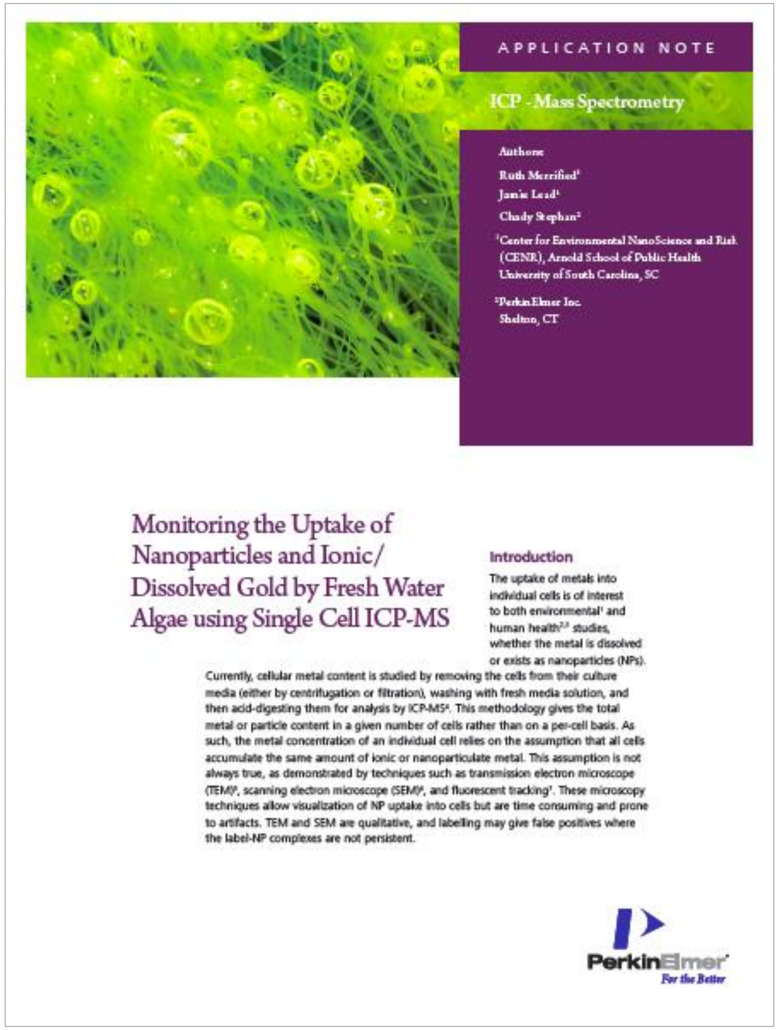




基于单细胞-ICP-MS的淡水藻类对金纳米颗粒和金离子的摄入行为研究



APPLICATION NOTE

ICP - Mass Spectrometry

Authors:

Ruth Merrifield[1]
Jamie Lead[1]
Chady Stephan[2]

[1]Center for Environmental NanoScience and Risk (CENR), Arnold School of Public Health University of South Carolina, SC

[2]PerkinElmer Inc. Shelton, CT

Monitoring the Uptake of Nanoparticles and Ionic/ Dissolved Gold by Fresh Water Algae using Single Cell ICP-MS

Introduction

The uptake of metals into individual cells is of interest to both environmental[1] and human health[2,3] studies, whether the metal is dissolved or exists as nanoparticles (NPs). Currently, cellular metal content is studied by removing the cells from their culture media (either by centrifugation or filtration), washing with fresh media solution, and then acid-digesting them for analysis by ICP-MS[4]. This methodology gives the total metal or particle content in a given number of cells rather than on a per-cell basis. As such, the metal concentration of an individual cell relies on the assumption that all cells accumulate the same amount of ionic or nanoparticulate metal. This assumption is not always true, as demonstrated by techniques such as transmission electron microscope (TEM)[5], scanning electron microscope (SEM)[6], and fluorescent tracking[7]. These microscopy techniques allow visualization of NP uptake into cells but are time consuming and prone to artifacts. TEM and SEM are qualitative, and labelling may give false positives where the label-NP complexes are not persistent.

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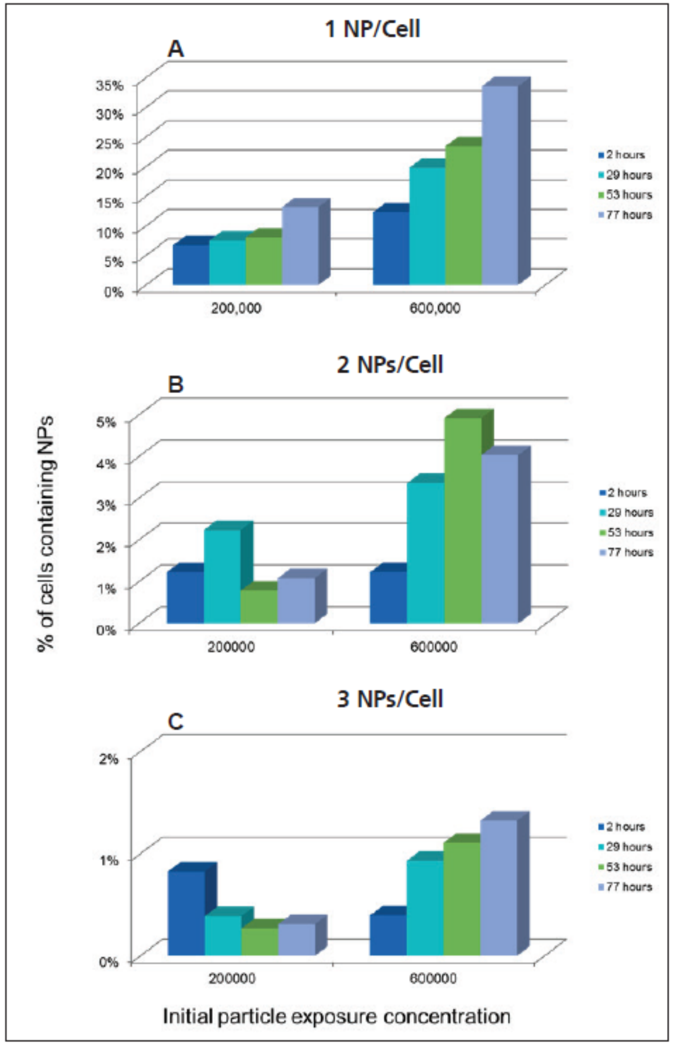

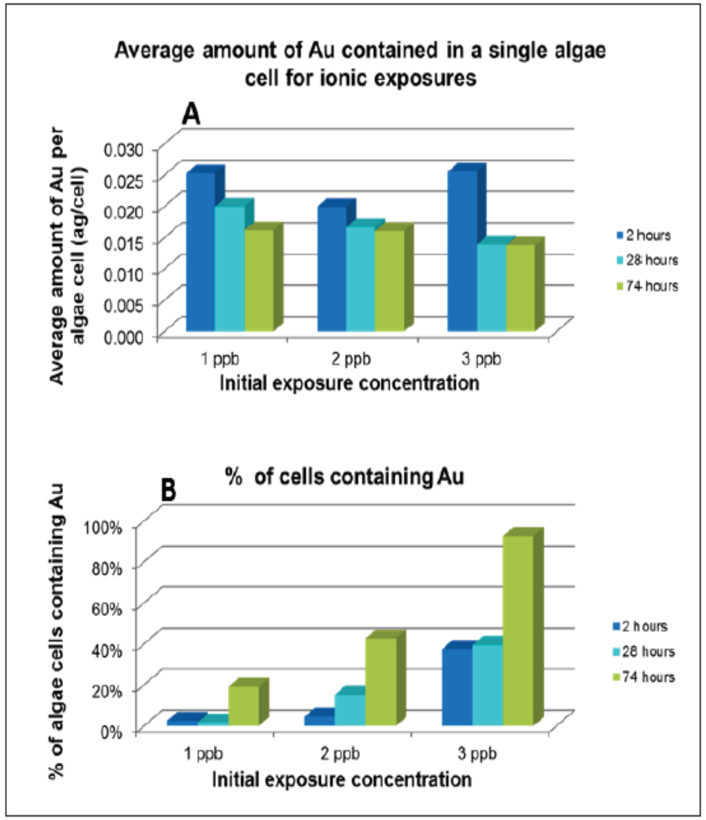

PerkinElmer Application Note: 利用单细胞ICP-MS 监测淡水藻类对金纳米颗粒和金离子的摄入行为

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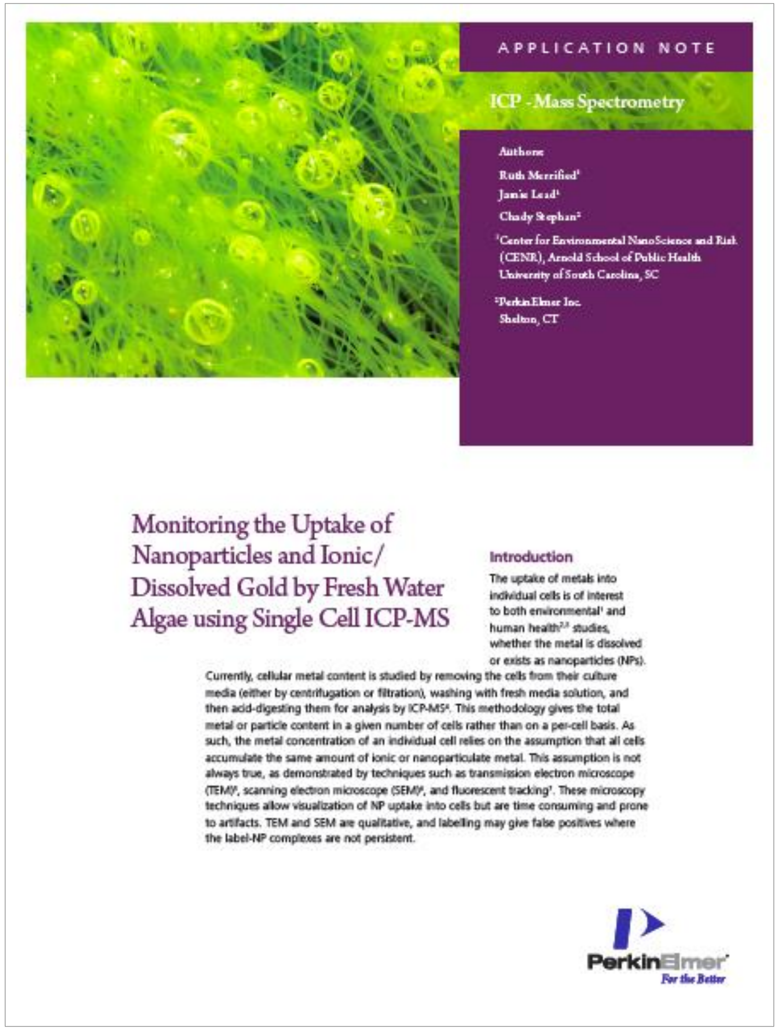
基于单细胞-ICP-MS的淡水藻类对金纳米颗粒和金离子的摄入行为研究



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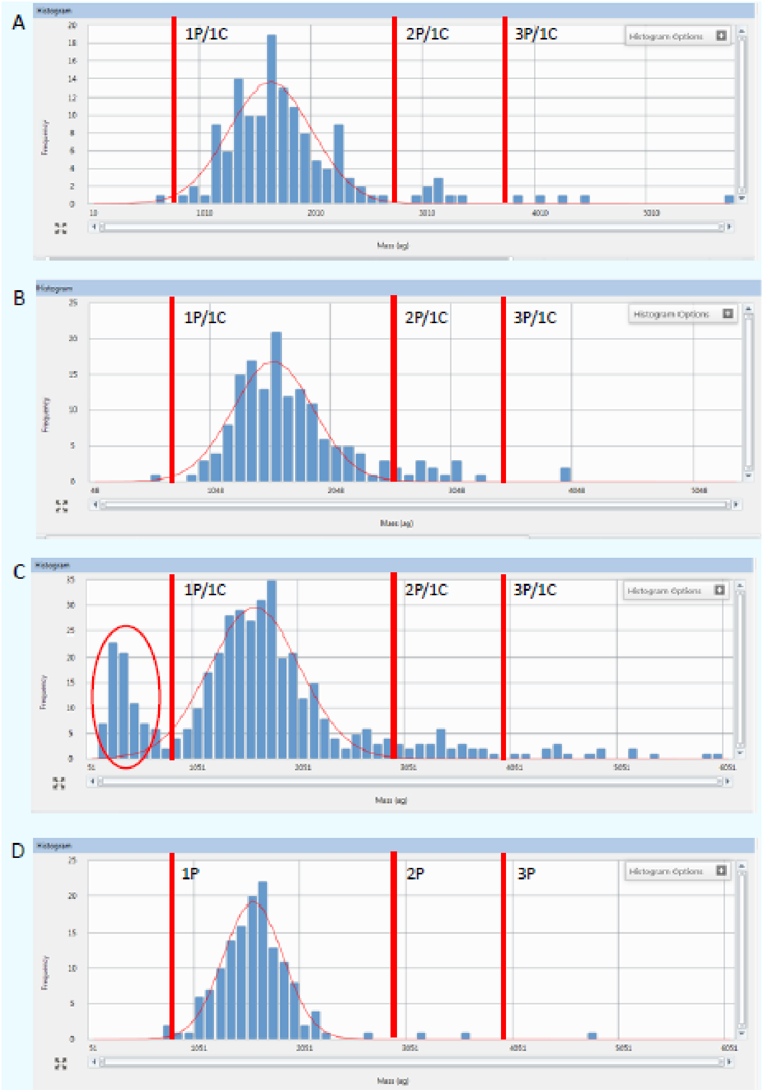

单个细菌中铁含量的测定

APPLICATION NOTE

ICP - Mass Spectrometry

Authors:

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Michael E. P. Murphy

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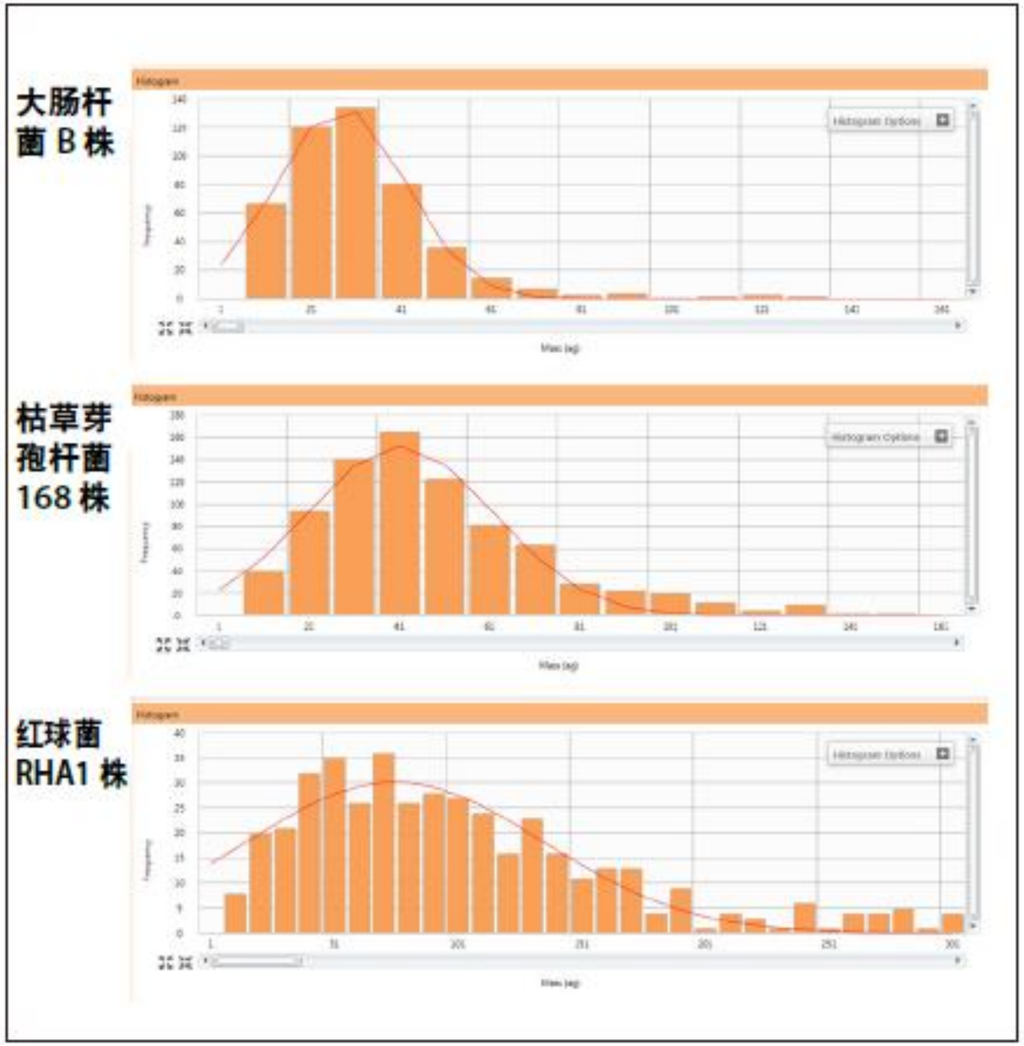
Ruth Merrifield
Chady Stephan

PerkinElmer, Inc.
Woodbridge, ON Canada

Iron Content Measurement in Individual Bacterial Cells Using SC-ICP-MS

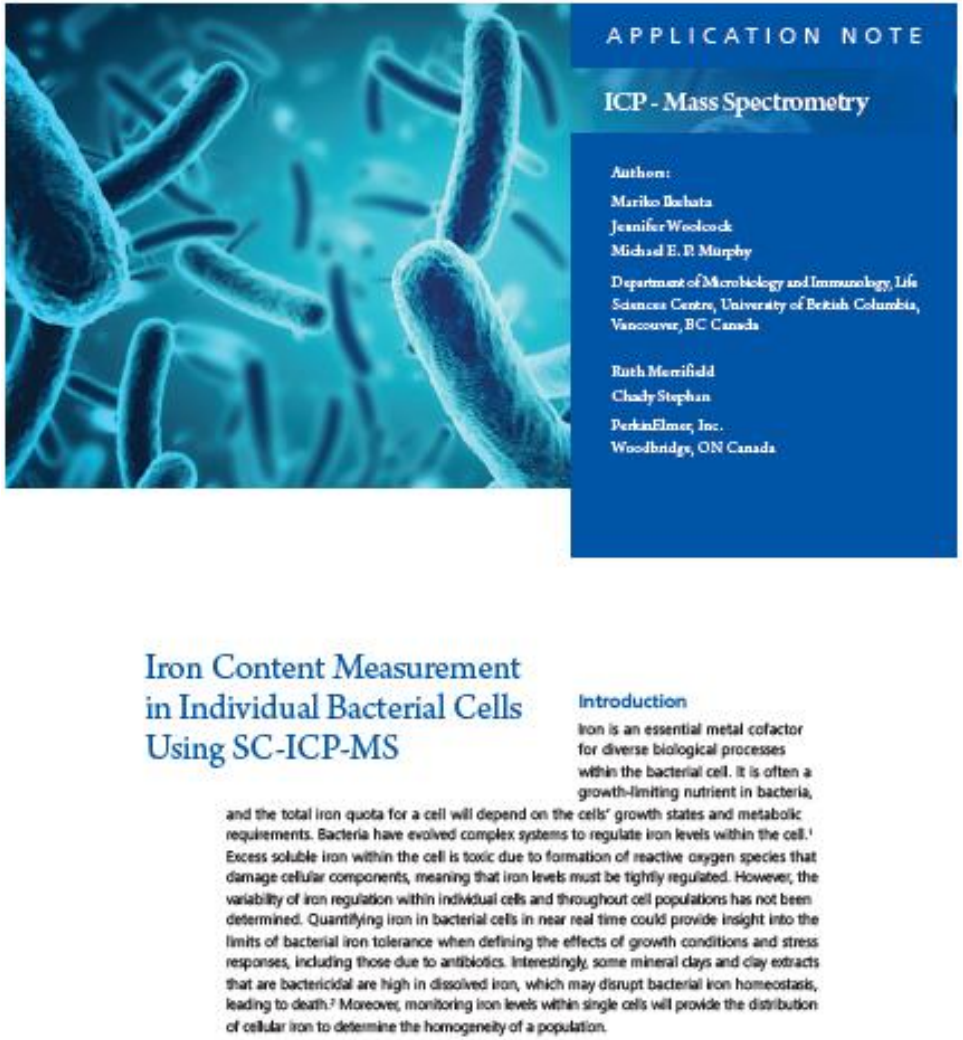
Introduction

Iron is an essential metal cofactor for diverse biological processes within the bacterial cell. It is often a growth-limiting nutrient in bacteria, and the total iron quota for a cell will depend on the cells' growth states and metabolic requirements. Bacteria have evolved complex systems to regulate iron levels within the cell.[1] Excess soluble iron within the cell is toxic due to formation of reactive oxygen species that damage cellular components, meaning that iron levels must be tightly regulated. However, the variability of iron regulation within individual cells and throughout cell populations has not been determined. Quantifying iron in bacterial cells in near real time could provide insight into the limits of bacterial iron tolerance when defining the effects of growth conditions and stress responses, including those due to antibiotics. Interestingly, some mineral clays and clay extracts that are bactericidal are high in dissolved iron, which may disrupt bacterial iron homeostasis, leading to death.[2] Moreover, monitoring iron levels within single cells will provide the distribution of cellular iron to determine the homogeneity of a population.



PerkinElmer Application Note: Quantification of Gold Nanoparticle Uptake into Cancer Cells using Single Cell ICP-MS

单个细菌中铁含量的测定



APPLICATION NOTE

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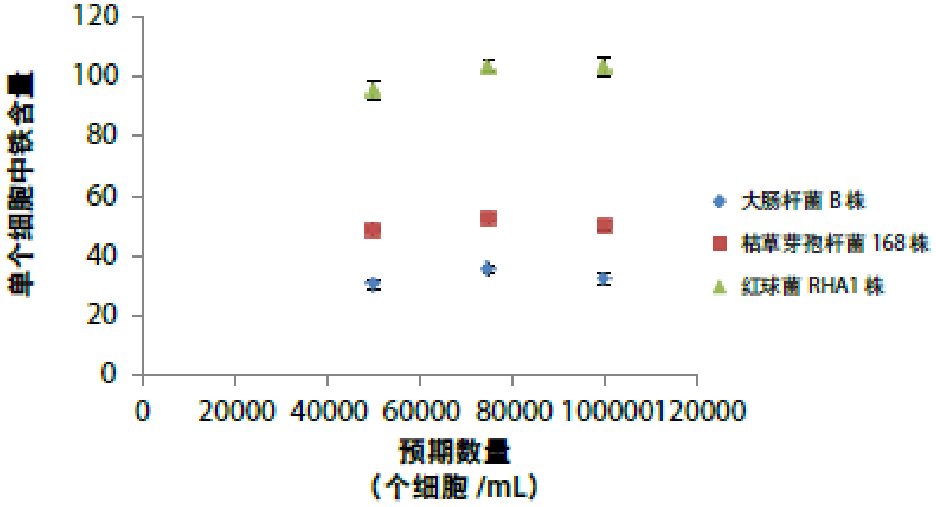
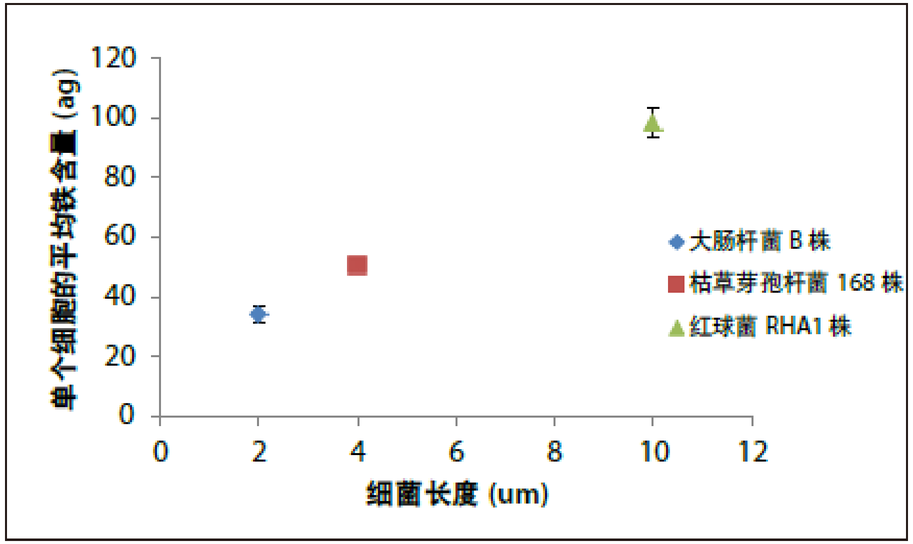
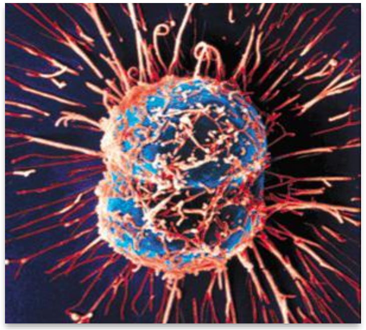
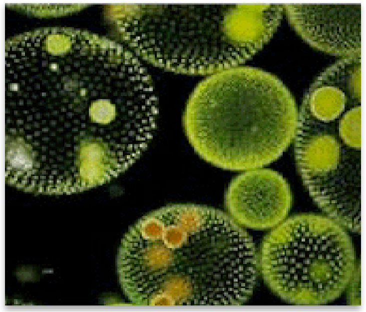
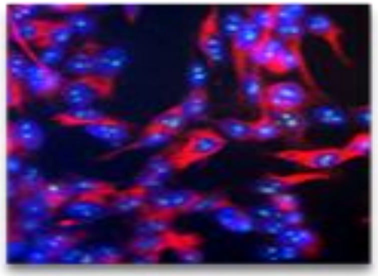




单细胞-ICP-MS应用







- 癌症研究
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谢　　谢！