Application of single particle ICP-MS for silver nanoparticles characterization

Chiu-Hun Su[1]*, Chia-Chin (Donna) Hsu[2], Chun-Hua Chen[1], Meng-Tzu Lai[1], Yen-Ying (Brian) Laio[2], Ching-Heng (Jones) Hsu[3]

1. Industrial Technology Research Institute, Hsinchu, 31040, Taiwan
2. Agilent Technologies Taiwan Ltd., Taoyuan City 32450, Taiwan
3. BASF, Taoyuan City, 32853, Taiwan.

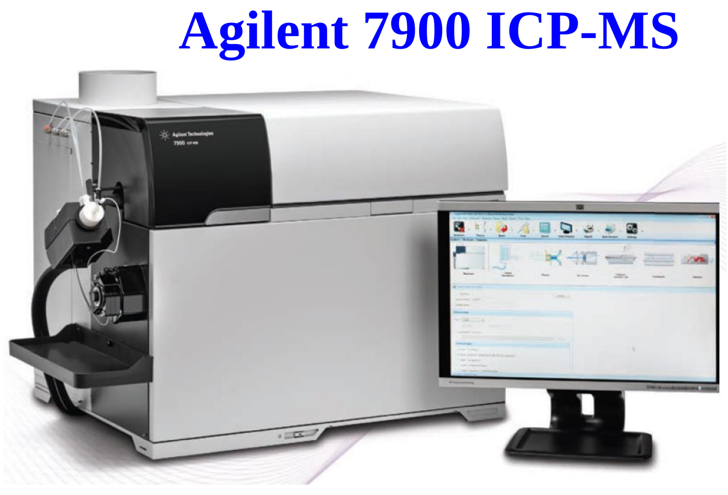
Corresponding author email: ch.su@itri.org.tw; donna.hsu@agilent.com

ABSTRACT

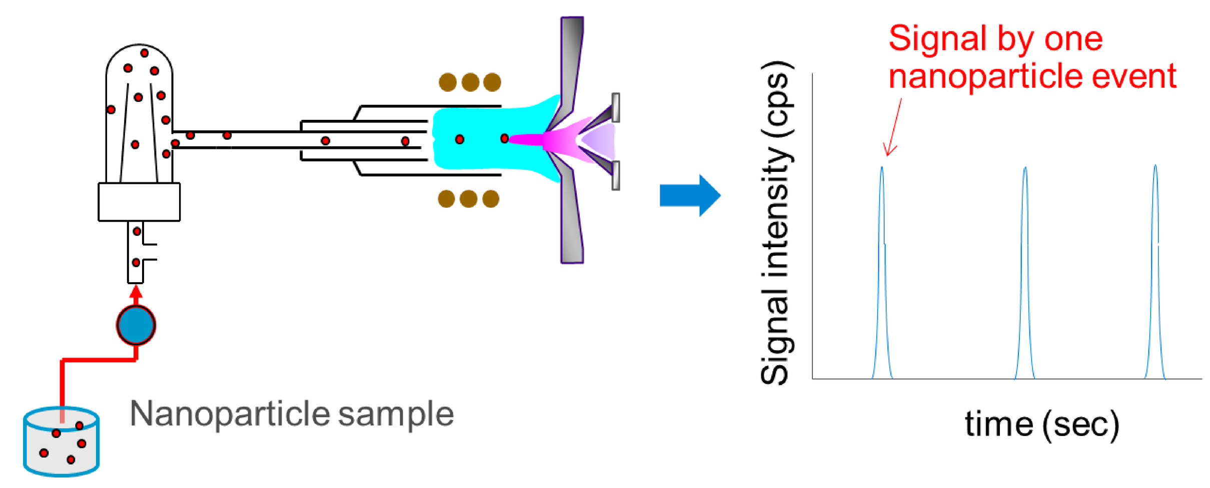
The nanomaterials are widely used in various products of human life such as water purification equipment, anti-bacteria clothes and wearing. In this work, to understanding the behavior and fate of nanoparticles in environmental, we investigated the particle size distribution and particle concentration of silver nanoparticles (Ag NPs) in four kinds of acidic matrix and environmental waters via spICP-MS. Comparison of the particle size stability of Ag NPs that spiked in HCl, CH_3COOH, HNO_3 and H_2SO_4 solutions (the pH value is about 5) for 72 hrs, the relative standard deviation (RSD) of particle size are 6.3%、9.2%、9.6% and 15.4%, respectively. It indicates that Ag NPs stored in H_2SO_4 matrix are the most unstable, followed by HNO_3 matrix. And the disintegration rate of Ag NPs increase when pH value decreases. Furthermore, we spiked Ag NPs in industrial waste water, rain water (pH value is 5.29), artificial acid rain water (mixture of H_2SO_4, HNO_3 and NH_4OH and pH value is 5.24), tap water and ultrapure water. In short- and long-term stability tests, we found that Ag NPs spiked in industrial waste water are the most unstable, and the short-term (16~18 hrs) stability of Ag NPs is good in ultrapure water and tap water. In conclusion, with the present study we have demonstrated that Ag NPs in environmental waters cannot exist for a long-time, they might collapse into Ag ions or transformed in different types of particles, namely Ag_2S and AgCl.

Single Nanoparticle Analysis

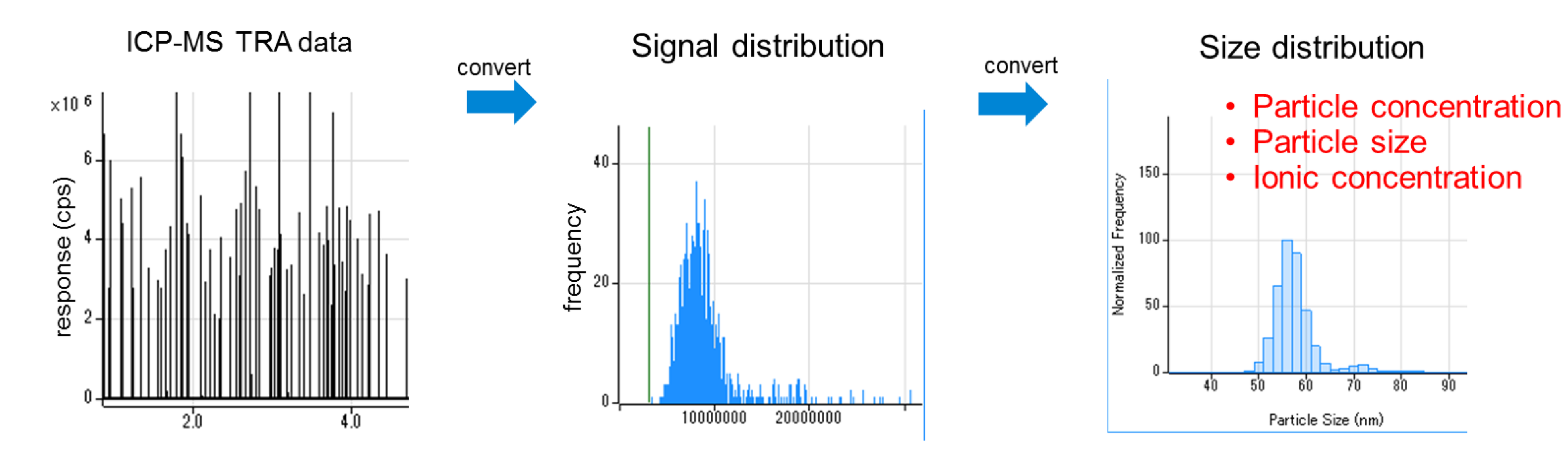
Agilent 7900 ICP-MS



Principle of spICP-MS



Workflow of spICP-MS



Experimental

Chemicals and Nanomaterials

Silver nanoparticles of 40 and 100 nm (Sigma-Aldrich) were acquired in stock suspensions at a nominal concentration of 20 mg Ag/L. Nano-Ag suspensions were made by diluting the stock solutions with 18.2 M-ohm Nanopure water (Millipore to final concentrations, ranging from 1.25 to 100 ppt. Aqueous Ag standards (High-Purity Standards), used for calibration, were diluted in 1% nitric acid to concentrations 1 ppb. Nitric acid (HNO_3) and Hydrochloric acid (HCl) (36%) from BASF, as well as Sulfuric acid (H_2SO_4) (98%) and Acetic acid (CH_3COOH) (99.8%) from J.T. Barker were used to prepare the sample.

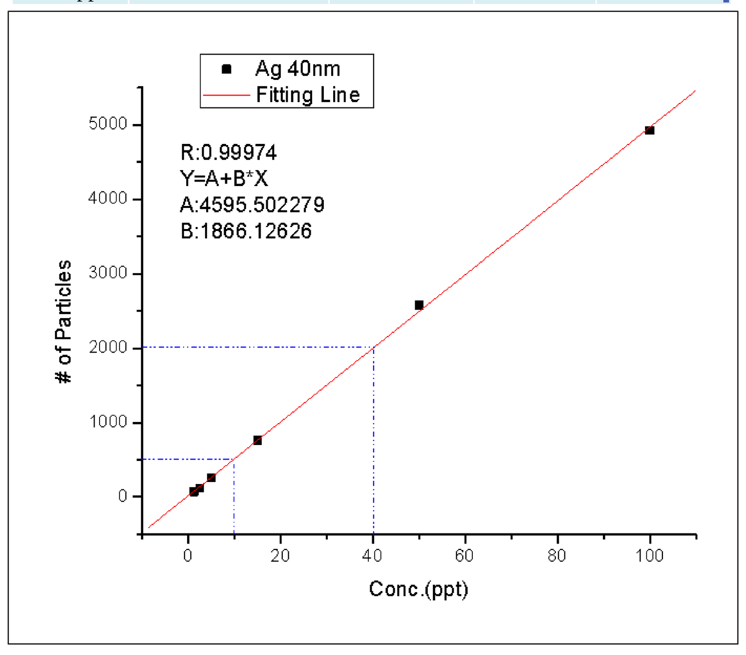
Instrumentation

An Agilent 7900 with Micromist nebulizer was used for single particle (SP) analysis, run at 1550 W RF power.

Dilution of AgNPs

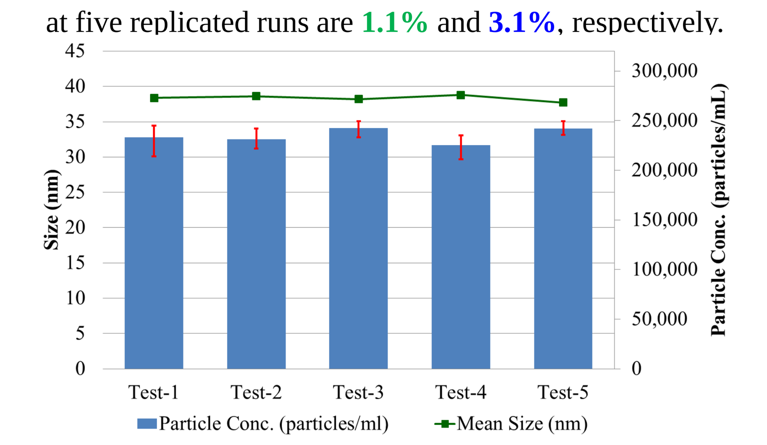
NP samples should give 500 ~ 2000 peaks/min

Conc.	Particle Conc. (particles/mL)	# of Particles	Mean Size (nm)	Mean Size RSD(%)
1.25 ppt	2503	68	39	0.6%
2.5 ppt	4483	122	40	0.6%
5 ppt	9479	259	39	0.6%
15 ppt	27970	763	38	1.0%
50 ppt	94609	2580	39	1.7%
100 ppt	180692	4928	40	0.3%



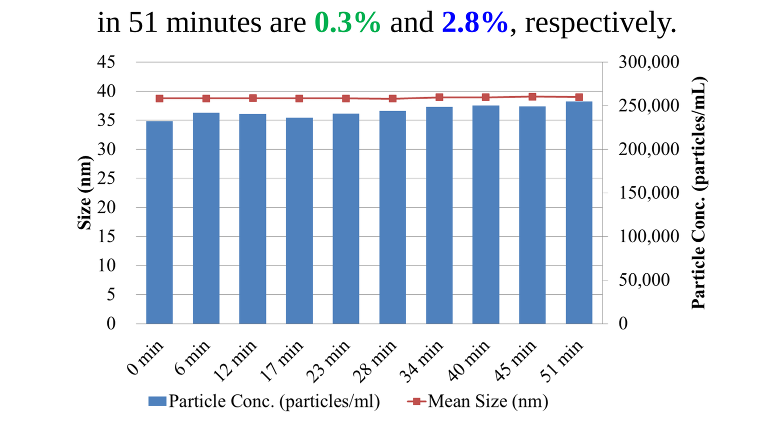
Repeatability test of AgNPs

The RSD of the **Mean Size** and the **Particle Concentration** at five replicated runs are **1.1%** and **3.1%**, respectively.



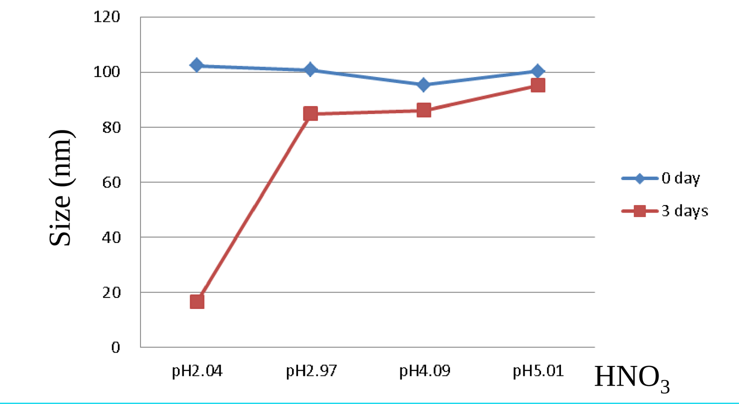
Short-term stability test of AgNPs

The RSD of the **Mean Size** and the **Particle Concentration** in 51 minutes are **0.3%** and **2.8%**, respectively.



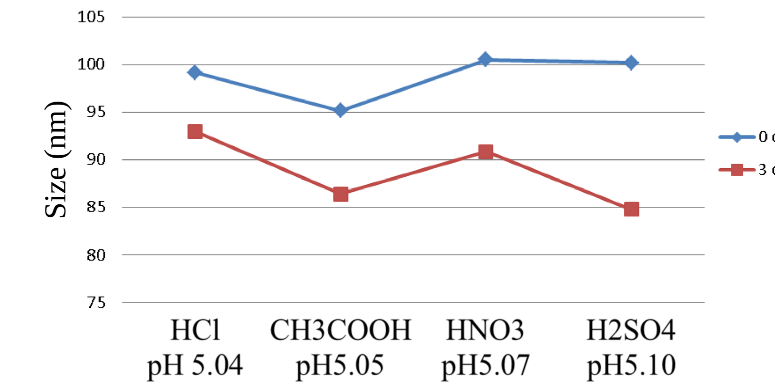
Stability testing of AgNPs (pH effects)

The disintegration rate of Ag NPs increase when pH value decreases.

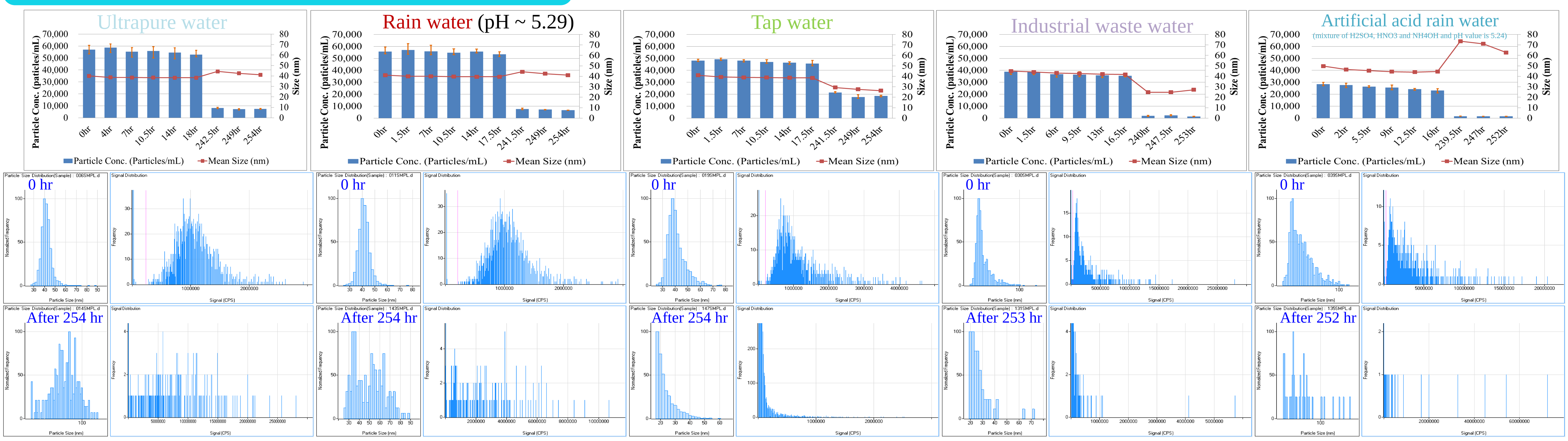


Stability testing of AgNPs (Matrix effects)

Ag NPs stored in H_2SO_4 matrix are the most unstable, followed by HNO_3 matrix.

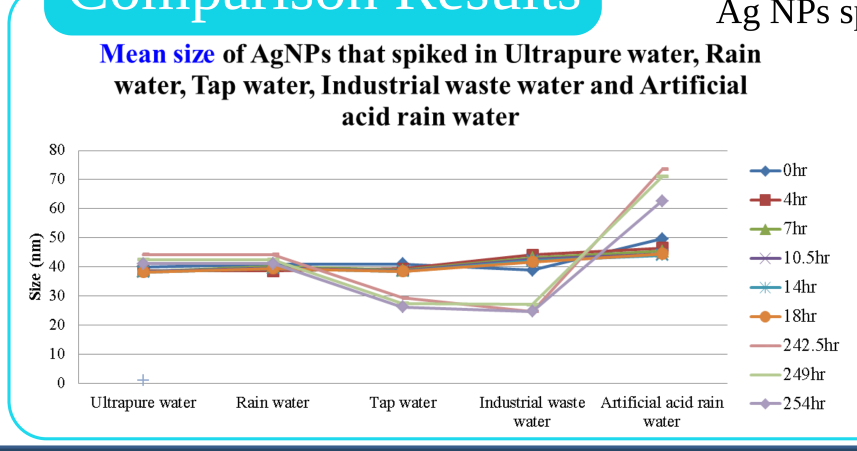


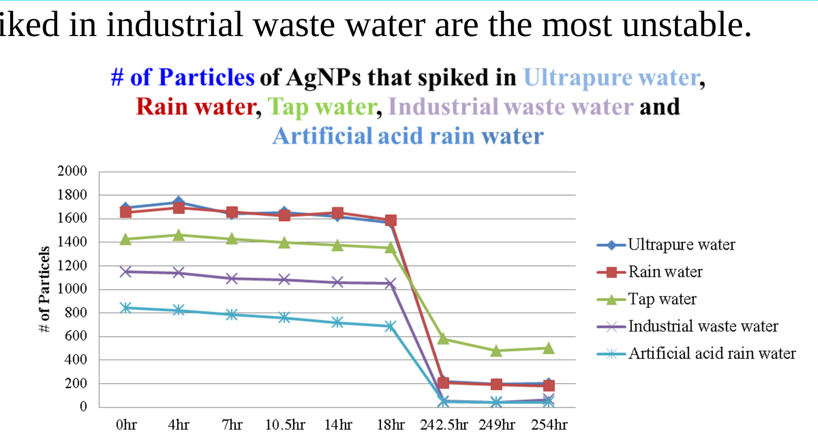
Stability testing of AgNPs in environmental waters



Comparison Results

Ag NPs spiked in industrial waste water are the most unstable.





Reference

1. S. Wilbur, M. Yamanaka and S. Sannac, *Agilent publication*, **2015**, 5991-5516EN.

2. Ariel R. Donovan, Craig D. Adams, Yinfa Ma, Chady Stephan, Todd Eichholz, Honglan Shi, *Chemosphere*, **2016**, 144, 148–153.

3. Vera V. Pinto, Maria José Ferreira, Ricardo Silva, Hélder A. Santos, F. Silva, Carlos M. Pereira, *Colloids and Surfaces A: Physicochem. Eng. Aspects*, **2010**, 364, 19–25.