Supporting Information for

Bulk nanobubbles or not nanobubbles: that is the question

Ananda J. Jadhav, Mostafa Barigou✉

School of Chemical Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom

Pages: 11

Figures: 7

Tables: 3

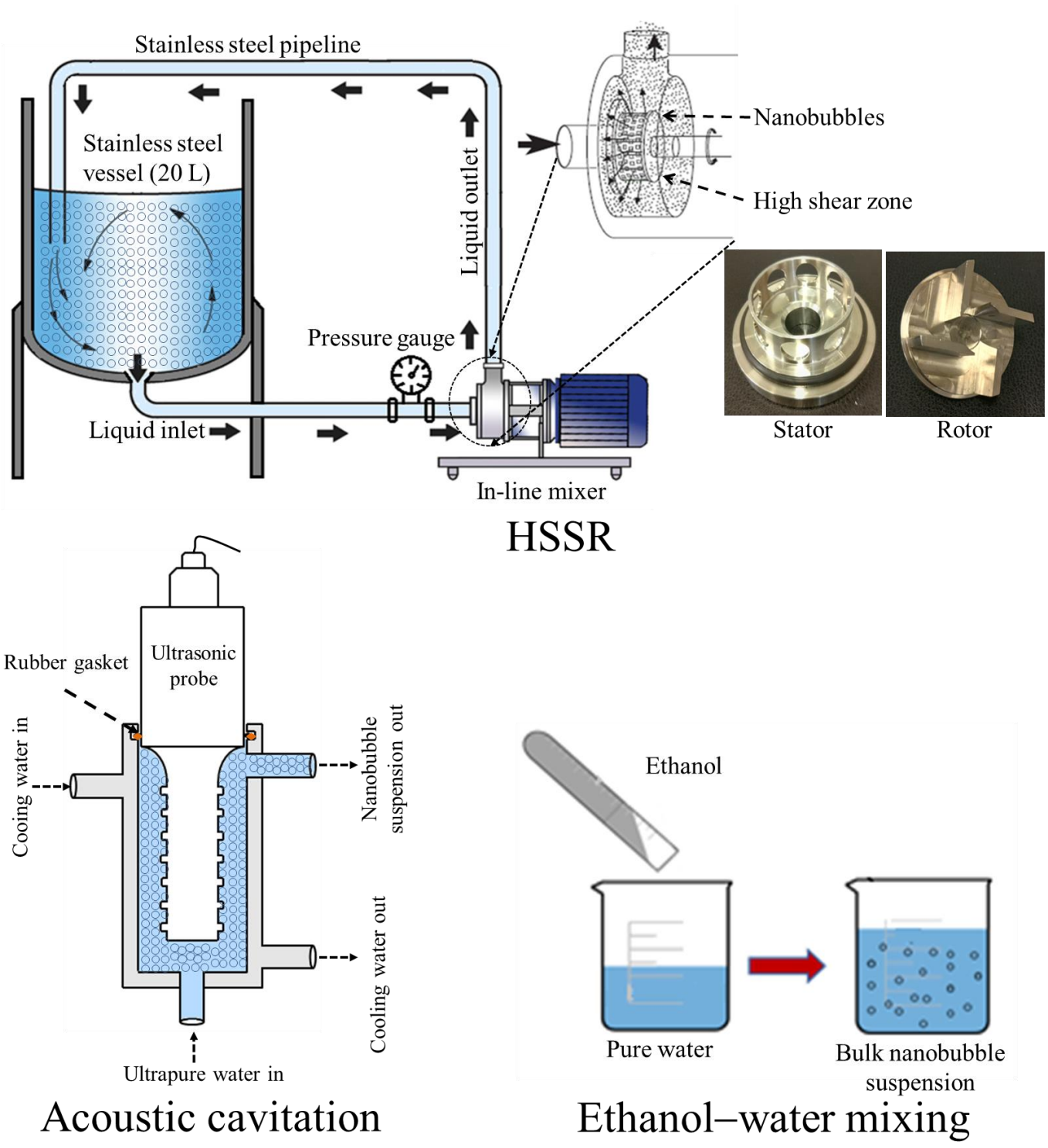

Figure S1. Schematic illustration of the (A) continuous high-shear rotor-stator device; (B) acoustic cavitation setup; (C) water-ethanol mixing process.

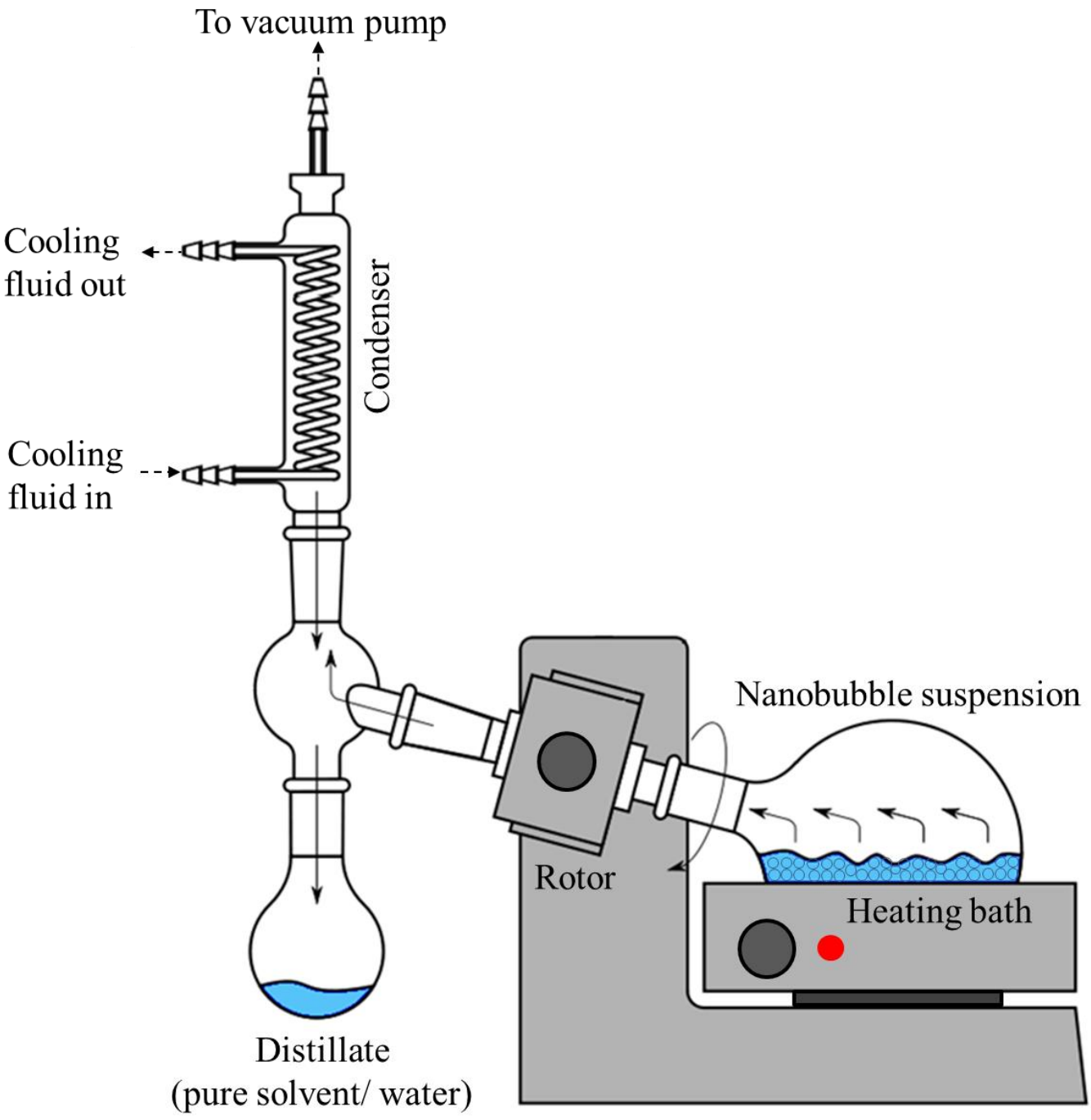

Figure S2. Schematic of vacuum rotary evaporator experiments.

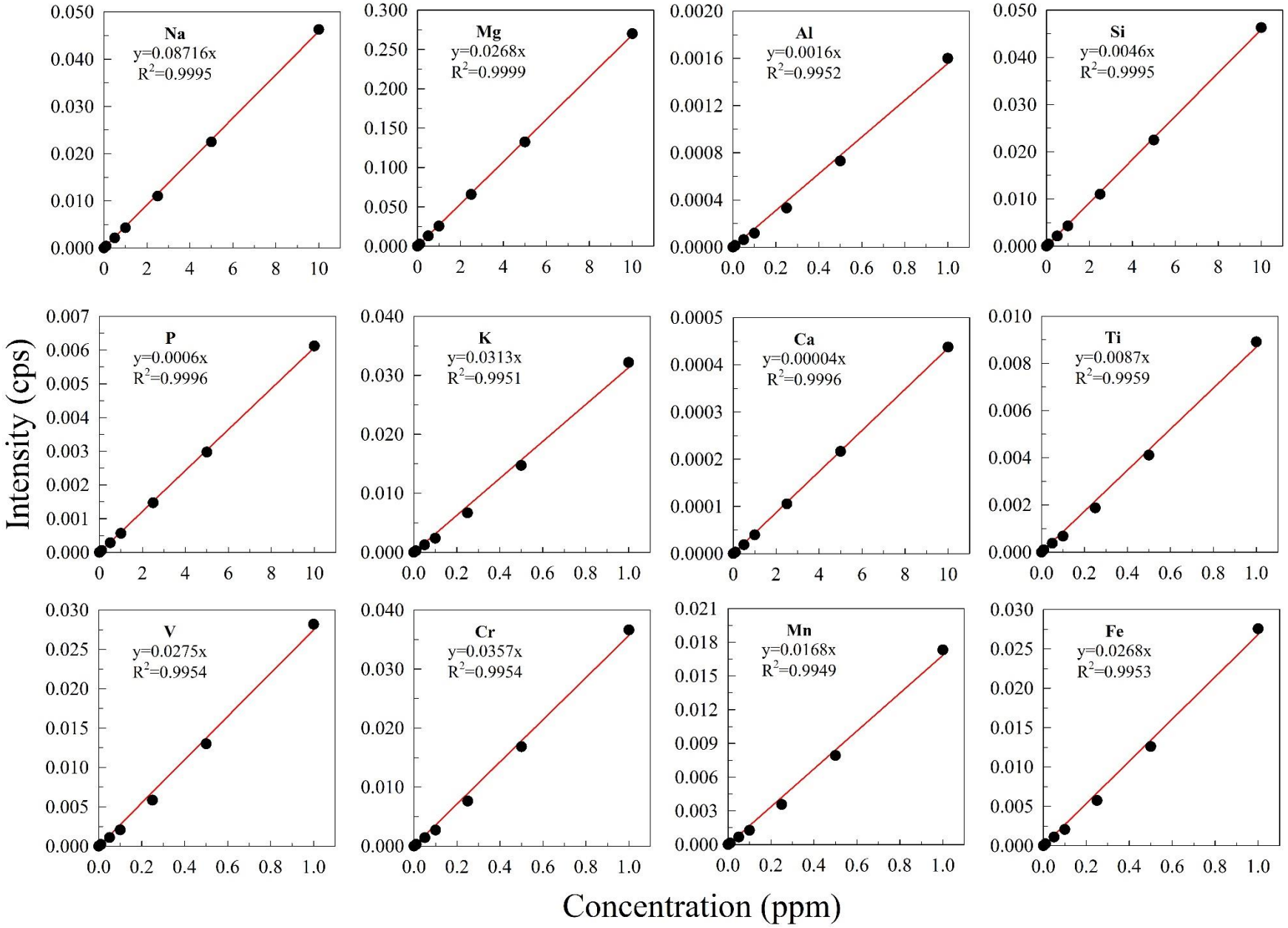

Figure S3. Calibration curves for individual elements (Na, Mg, Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe) measured by ICP-MS with solution-based calibration (standard additions mode).

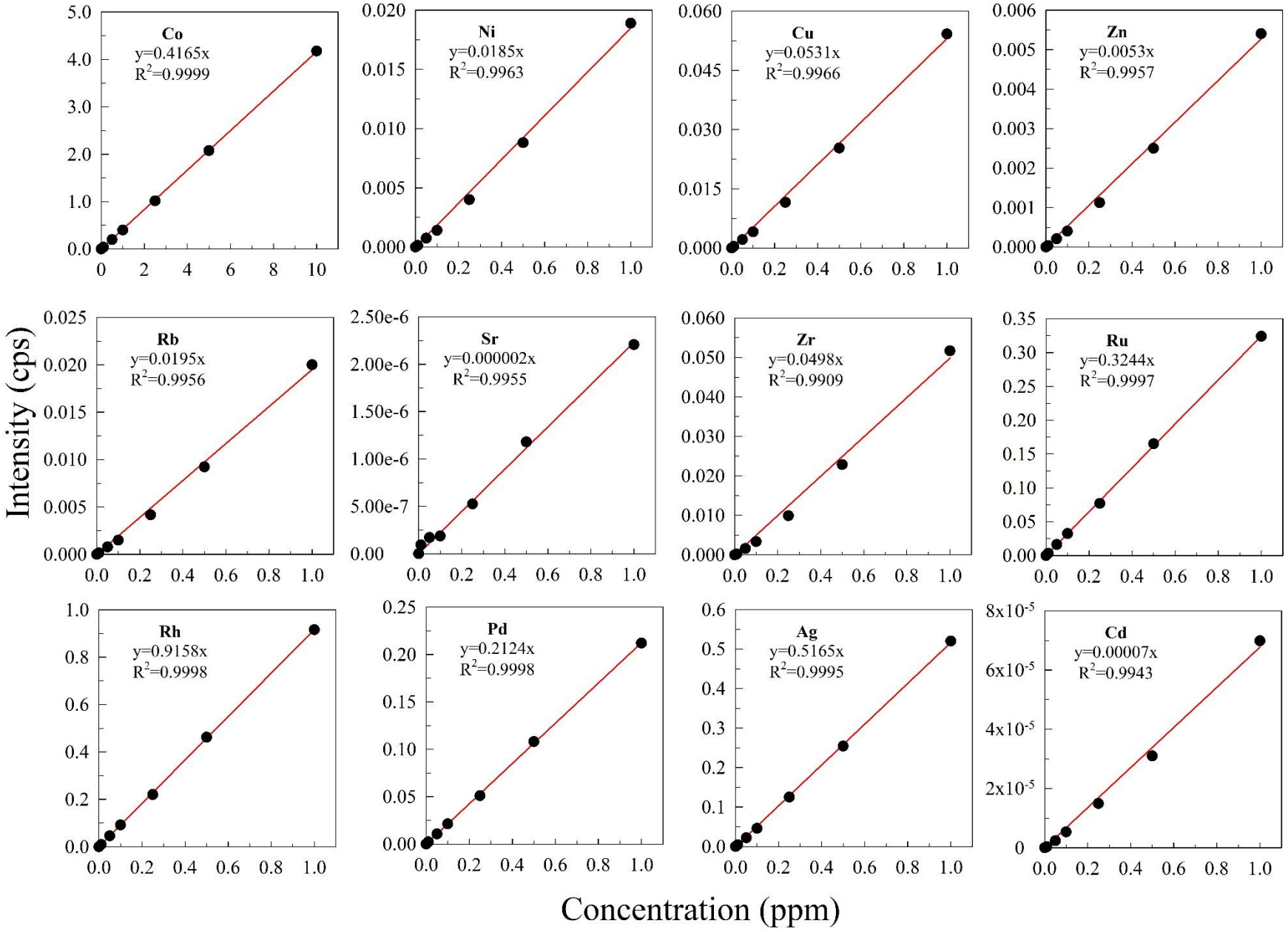

Figure S4. Calibration curves for individual elements (Co, Ni, Cu, Zn, Rb, Sr, Zr, Ru, Rh, Pd, Ag, Cd) measured by ICP-MS with solution-based calibration (standard additions mode).

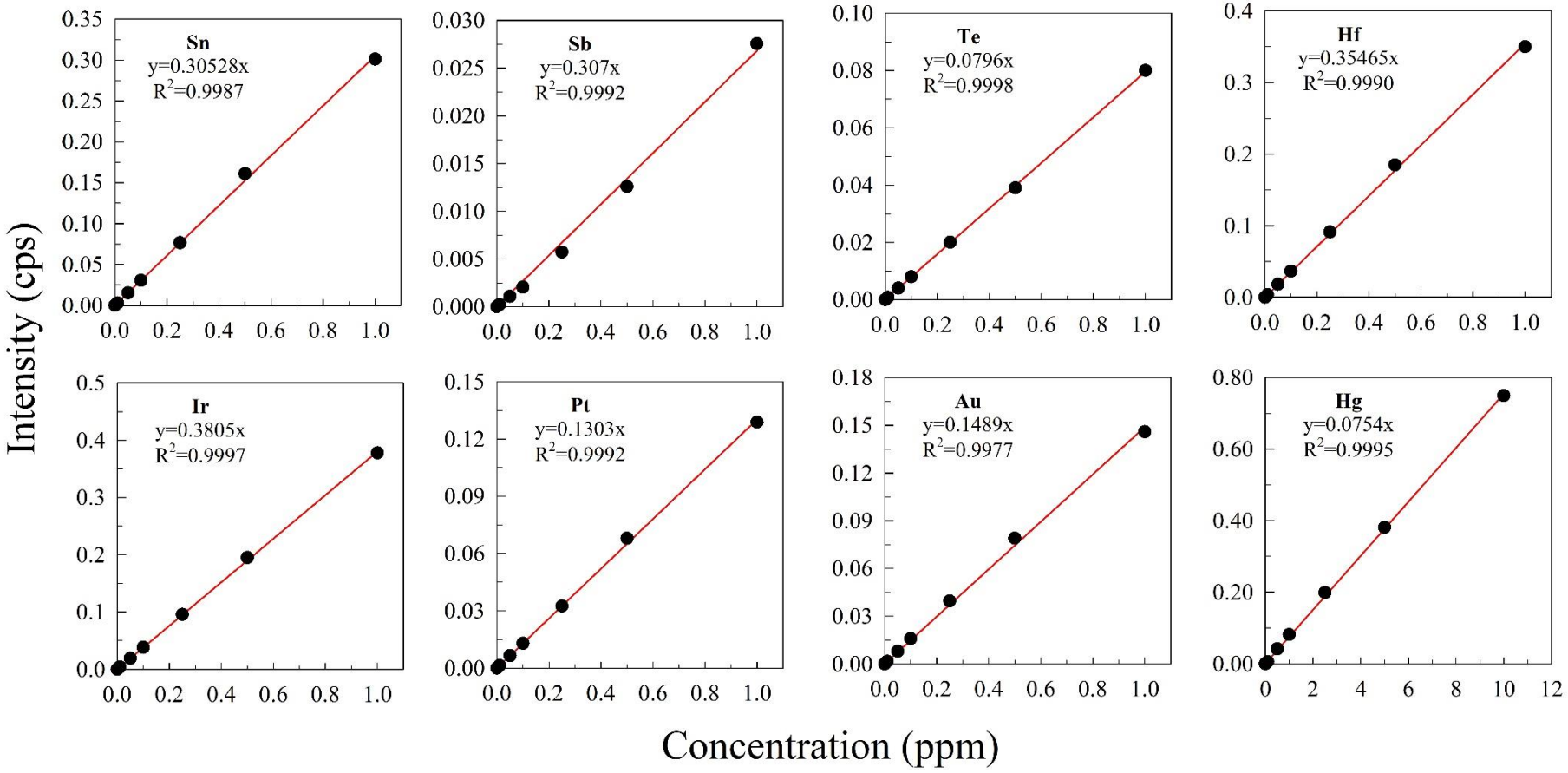

Figure S5. Calibration curves for individual elements (Sn, Sb, Te, Hf, Ir, Pt, Au, Hg) measured by ICP-MS with solution-based calibration (standard additions mode).

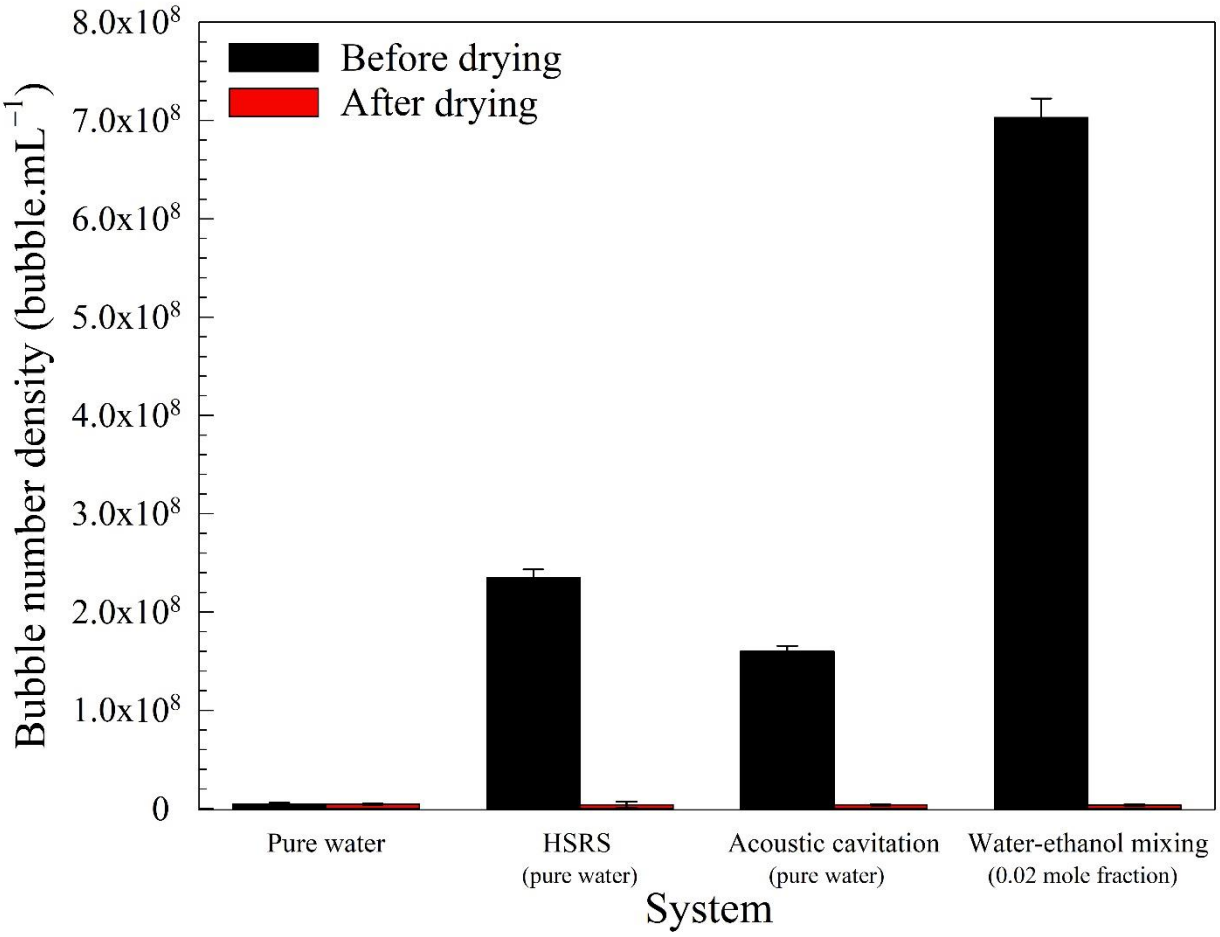

Figure S6. Bubble number density before and after complete evaporation of pure water and of nanobubble suspensions.

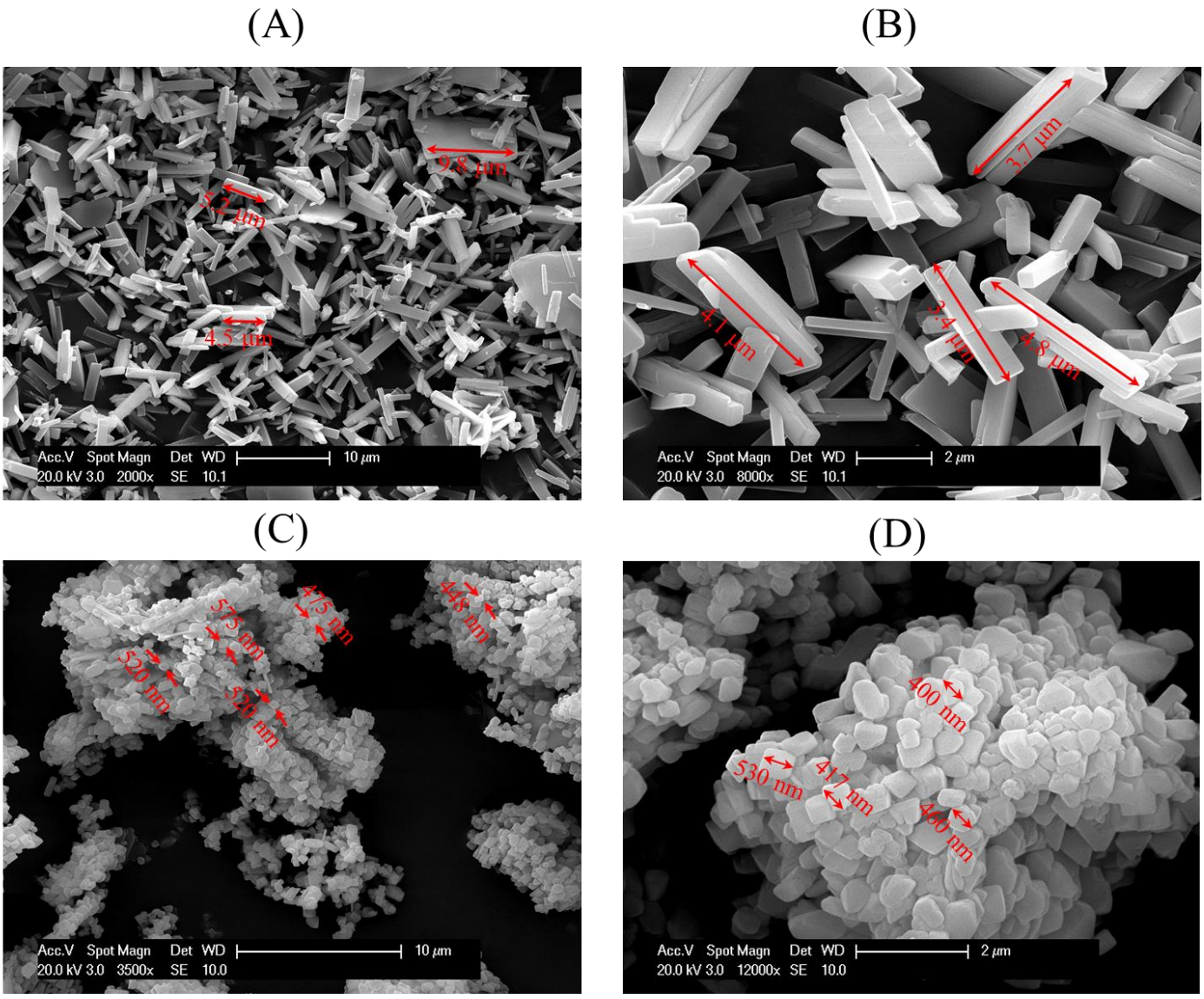

Figure S7. SEM micrographs of zinc phosphate nanoparticles prepared in pure water at magnifications of (A) 2000, (B) 8000; and prepared in nanobubble suspension at magnifications of (C) 3500, (D) 12000.

Table S1. GC-MS operating parameters.

Gas chromatography	
Instrument	7809A (Agilent)
Column	ZB–WAX 30 m × ϕ 0.25 mm, 0.25 μm (Phenomenex, UK)
Injection method	Split (1:10)
Injection volume	1 μL
Carrier gas	Helium
Flow rate	1 mL.min^{-1}
Injection temperature	250 ˚C
Oven temperature program	50 ˚C (2 min) → 5 ˚C/min → 250 ˚C (18 min)
Transfer line temperature	250 ˚C
Mass spectrometry	
Instrument	GCT Premier (Waters, UK)
Mode	Selected-ion monitoring
Ion source temperature	250 ˚C
Ionization mode	Electron impact (EI$^+$)
Electron energy	70 eV
Trap current	100 μA
Emission current	179 μA

Table S2. ICP-MS operating parameters.

Parameter	Value
RF applied power (kW)	1.6 kW
Auxiliary gas flow rate (Argon)	1.2 $L.min^{-1}$
Plasma gas flow (Argon)	18 $L.min^{-1}$
Nebulizer gas flow (Argon)	0.95 $L.min^{-1}$
Sample flow rate	0.3 $mL.min^{-1}$
KED Gas Flow (Helium)	4 $mL.min^{-1}$
Nebulizer type	Sea Spray concentric
Interface cone material	Nickel
Analog stage voltage	-1675
Pulse stage voltage	1050 V
Discriminator threshold	12 mV
Deflector voltage	- 10 V
Quadrupole rod offset	- 12 V
Cell entrance voltage	- 9 V
Cell exit voltage	- 20 V
Cell rod offset	- 15 V
Axial field voltage	475 V

Table S3. Concentrations (ppm) of elements in pure water and in nanobubble suspensions measured by ICP-MS.

Elements	System			
	Pure water	HSRS (pure water)	Acoustic cavitation (pure water)	Water + ethanol (0.02 mole fraction)
Na	0.0017213	0.0064366	0.0019421	0.0013771
Mg	0.0034085	0.0069099	0.0070269	0.0027268
Al	0.0014944	0.0103592	0.0269015	0.0011955
Si	0.0066192	0.0688691	0.0370155	0.0052953
P	0.0001872	0.0025428	0.0022671	0.0001497
K	0.0008307	0.0011169	0.0073439	0.0006646
Ca	0.0019513	0.0153653	0.0887717	0.0015610
Ti	0.0000229	0.0001009	0.0011559	0.0000183
V	0.0001358	0.0000509	0.0000707	0.0001087
Cr	0.0000105	0.0007605	0.0000204	0.0000084
Mn	0.0000425	0.0000731	0.0000683	0.0000340
Fe	0.0046523	0.0399060	0.0047178	0.0037218
Co	0.0004052	0.0001857	0.0001852	0.0003241
Ni	0.0001134	0.0001255	0.0008461	0.0000907
Cu	0.0000095	0.0000798	0.0000169	0.0000076
Zn	0.0002072	0.0005225	0.0031254	0.0001658
Rb	0.0001465	0.0009641	0.0000610	0.0001172
Sr	0.0001693	0.0012837	0.0081181	0.0027658
Zr	0.0001646	0.0000561	0.0000836	0.0001317
Ru	0.0000003	0.0000010	0.0000000	0.0000002
Rh	0.0000619	0.0000760	0.0000688	0.0000495
Pd	0.0000001	0.0000058	0.0000018	0.0000001
Ag	0.0000613	0.0001217	0.0001172	0.0000490
Cd	0.0002498	0.0005485	0.0002731	0.0001998
Sn	0.0000327	0.0007936	0.0001225	0.0000262
Sb	0.0000043	0.0002214	0.0000721	0.0000034
Te	0.0000058	0.0000043	0.0000024	0.0000046
Hf	0.0000006	0.0000045	0.0000023	0.0000005
Ir	0.0000021	0.0000066	0.0000031	0.0000017
Pt	0.0000072	0.0000375	0.0000102	0.0000058
Au	0.0000018	0.0000078	0.0000011	0.0000015
Hg	0.0370392	0.0330910	0.0245242	0.0296314