ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Contamination of whole blood/serum from sampling equipment

For many chemical elements, endogenous concentrations in whole blood and serum are very low. Thus, even minor contamination at any sampling, sample storage and handling or analytical stage has the potential to affect the accuracy of the results.

All efforts analytical laboratories make to provide relevant information for clinical samples, such as using extremely sensitive dedicated equipment and minimizing or correcting for all possible contamination sources at analytical stages, might be in vain if the sampling equipment has already contaminated the samples. Since apparent concentrations originating from contamination during sampling or storage (e.g. impurities released from sampling equipment or the container that the sample is stored in) will depend on many difficult to control parameters (e.g. type of needle, duration of storage, contact with cap, etc.), they are problematic to correct for.

Another serious risk of contamination is caused by the addition of reagents to the tubes. Certain tubes are intended for some special application. If these are then used for some other analysis, the reagents might be found to contain unacceptably high levels of impurities. For example, lithium heparin is added to some blood collection tubes as anti-coagulant, and should not, of course, be used for the determination of lithium.

Different products contaminate the samples with different elements and the suitability of any given equipment will therefore depend on the analytical task at hand. Manufacturers provide information about possible contamination from their tubes, but frequently they only specify that the contamination is lower than certain, often rather high, levels. It has been shown that the contamination is, in fact, much lower than the specifications, but often still significant with respect to normal levels in blood or serum samples.

To make it easier to choose suitable equipment, the contamination from common tubes/needles was tested.
The table shows the results of the tests, i.e. how much of the different elements the different products release. The values are based on 24 h leaching tests at room temperature, using 0.01M HNO_3 in deionized and distilled water, replicated 5-10 times.

Elements occurring at high levels in blood/serum are less sensitive for contamination than those present at low levels. To decide if the contamination from the tubes significantly changes the test result, the contamination should be compared with the expected content of blood/serum.

The contamination for elements commonly analysed for exposure assessment (e.g. Hg, Cd, Pb) will not affect the test result, instead it is when less common ‘ultra trace’ elements are determined that problems might arise. The contamination by manganese, for example, differs a lot between different tubes. The normal content of manganese in serum is about 0.3-1μg/l. Thus, the tube releasing 2 μg/l is impossible to use, while the tube releasing only 0.1 μg/l is better suited for endogenous levels.

Uranium is another example of elements that display variable leachable impurity levels between tubes. The normal content of uranium in serum is in the range 0.5-19 ng/l. The tube giving a contamination level of 1.4 ng/l can be used, whereas that releasing 380 ng/l should not.

Table Added concentrations to whole blood/serum from different types of sampling equipment.

Element		n1	n2
Ag	ng/l	0.5	0.7
Al	µg/l	0.1	0.1
As	ng/l	2	2
Au	ng/l	0.2	0.2
B	µg/l	0.9	0.7
Ba	µg/l	0.03	0.07
Be	ng/l	1	1
Bi	ng/l	0.02	0.03
Br	µg/l	<0.1	<0.1
Ca	µg/l	0.8	2.0
Cd	ng/l	0.1	0.1
Ce	ng/l	0.1	0.1
Co	ng/l	18	23
Cr	µg/l	0.06	0.12
Cs	ng/l	0.3	0.3
Cu	µg/l	0.040	0.085
Dy	ng/l	0.024	0.024
Er	ng/l	0.032	0.032
Eu	ng/l	0.001	0.001
Fe	µg/l	2.4	5.9
Ga	ng/l	0.020	0.052
Gd	ng/l	0.028	0.029
Ge	ng/l	<2	<2
Hf	ng/l	0.016	0.001
Hg	ng/l	0.4	0.5
Ho	ng/l	0.000	0.000
I	µg/l	<0.02	<0.02
Ir	ng/l	0.019	0.018
K	µg/l	0.1	0.1
La	ng/l	0.2	0.2
Li	µg/l	0.002	0.002
Lu	ng/l	0.000	0.000
Mg	µg/l	4.3	3.8
Mn	µg/l	0.22	0.55
Mo	ng/l	7	7
Na	µg/l	1.3	1.2
Nb	ng/l	0.06	0.14
Nd	ng/l	7.5	3.7
Ni	µg/l	0.28	0.28
Os	ng/l	<0.005	<0.005
P	µg/l	0.2	0.2
Pb	µg/l	0.007	0.001
Pd	ng/l	0.4	0.5
Pr	ng/l	0.04	0.02
Pt	ng/l	0.006	0.014
Rb	µg/l	0.0003	0.0003
Re	ng/l	0.000	0.000
Rh	ng/l	0.005	0.002
Ru	ng/l	0.01	0.01
S	µg/l	<10	<10
Sb	µg/l	0.0002	0.0002
Sc	ng/l	0.03	0.03
Se	µg/l	0.01	0.01
Si	µg/l	24	22

Sm	ng/l	0.010	0.003
Sn	µg/l	0.013	0.007
Sr	µg/l	0.005	0.007
Ta	ng/l	0.2	0.1
Tb	ng/l	0.006	0.005
Te	ng/l	<0.1	<0.1
Th	ng/l	0.02	0.03
Ti	µg/l	0.01	0.01
Tl	ng/l	0.02	0.06
Tm	ng/l	0.000	0.000
U	ng/l	0.1	0.3
W	ng/l	0.7	0.6
V	µg/l	0.002	0.004
Y	ng/l	0.8	0.7
Yb	ng/l	0.02	0.02
Zn	µg/l	1.1	2.9
Zr	ng/l	0.3	1.8

Table Added concentrations to whole blood/serum from different types of sampling equipment.

Element		t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11
Ag	ng/l	4.1	2.3	3.2	0.1	1.8	0.2	2.3	1.7	0.1	0.3	0.4
Al	µg/l	4.5	4.1	8.1	1.2	42	6.3	1000	600	1.8	3.7	3.7
As	ng/l	14	34	120	27	12	38	170	110	10	10	20
Au	ng/l	0.09	0.08	0.07	0.1	0.1	0.1	0.1	0.06	0.03	0.02	0.02
B	µg/l	30	30	29	36	28	36	1	1	0.1	1	2
Ba	µg/l	0.19	0.15	0.75	5.2	3.9	0.42	0.47	0.24	0.02	0.17	0.06
Be	ng/l	0.6	0.6	0.9	0.9	0.7	0.3	78	45	0.5	0.4	0.6
Bi	ng/l	0.5	0.4	1.6	0.2	1.4	1.7	59	49	0.5	0.3	0.4
Br	µg/l	1.3	1.4	0.6	0.8	97	350	0.2	0.6	34	33	38
Ca	µg/l	34	39	48	29	58	44	21	15	7	29	7
Cd	ng/l	3.7	7.9	16	2.5	2.4	2.6	2.9	1.1	0.2	41	14
Ce	ng/l	0.3	0.4	0.4	0.3	62	5.0	170	150	2.2	2.5	1.7
Co	ng/l	19	11	38	15	15	12	26	18	15	11	10
Cr	µg/l	0.33	0.17	0.56	0.15	0.13	0.28	0.06	0.06	0.07	0.13	0.06
Cs	ng/l	3.3	1.9	1.7	25	12	3.1	700	550	1.6	2.3	1.6
Cu	µg/l	1.2	0.8	3.8	1.8	2.7	0.8	0.4	0.3	0.01	2.1	0.9
Dy	ng/l	0.08	0.06	0.06	0.02	7.6	0.3	89	56	0.4	0.4	0.2
Er	ng/l	0.08	0.09	0.08	0.04	3.9	0.2	44	29	0.05	0.1	0.1
Eu	ng/l	0.01	0.01	0.02	0.10	0.9	0.07	12	8	0.04	0.07	0.02
Fe	µg/l	2.5	2.6	9.3	0.6	9.2	3.9	56	35	0.6	1.3	0.5
Ga	ng/l	0.2	0.3	0.2	0.1	13	2.6	380	250	0.4	1.1	0.7
Gd	ng/l	0.1	0.2	0.08	0.04	7.1	0.2	71	42	0.2	0.5	0.2
Ge	ng/l	14	14	15	9	18	12	12	8	1	6	5
Hf	ng/l	0.2	0.2	0.2	0.06	0.8	1.3	34	18	0.1	0.2	0.2
Hg	ng/l	3.3	3.4	3.1	1.7	1.4	2.0	2.0	1.5	0.1	0.5	0.4
Ho	ng/l	0.01	0.02	0.02	0.01	1.4	0.06	16	11	0.02	0.07	0.03
I	µg/l	0.7	0.3	0.2	0.05	0.1	0.1	0.02	0.04	0.03	0.2	0.01
Ir	ng/l	0.017	0.006	0.040	0.029	0.016	0.007	0.03	0.04	0.002	0.004	0.002
K	µg/l	5	5	8	7	12	850000	250	130	2	5	7
La	ng/l	0.3	0.6	0.6	0.3	24	1.1	46	35	0.5	1.1	0.9
Li	µg/l	7000	9600	13000	14000	1.7	9.1	0.3	0.2	0.005	0.02	3100
Lu	ng/l	0.09	0.3	0.5	0.2	0.5	0.2	4.7	3.2	0.01	0.01	0.01
Mg	µg/l	5	45	8	2	6	6	50	16	160	80	120
Mn	µg/l	0.14	0.09	0.25	0.10	2.2	1.1	0.5	0.4	0.02	0.07	0.02
Mo	ng/l	56	20	29	16	37	60	15	15	3	4	3
Na	µg/l	72	100	120	42	220	5800	45	35	3	12000	20
Nb	ng/l	0.7	0.4	1.1	0.5	8.3	2.4	110	75	0.4	1.1	0.5
Nd	ng/l	0.4	17	0.6	0.1	37	1.0	180	100	0.7	1.9	1.1
Ni	µg/l	0.08	0.05	0.24	0.06	0.1	0.09	0.05	0.08	0.04	1.1	0.2
Os	ng/l	<0.005	0.041	<0.005	<0.005	<0.005	0.033	<0.005	<0.005	<0.005	<0.005	<0.005
P	µg/l	23	34	52	21	170	230	30	22	0.2	8	10
Pb	µg/l	0.48	0.98	1.5	0.15	0.16	0.02	0.31	0.11	0.007	0.11	0.03
Pd	ng/l	10	9	8	2	6	7	340	150	2	6	3
Pr	ng/l	0.06	0.2	0.1	0.04	11	0.3	29	21	0.1	0.5	0.2
Pt	ng/l	0.08	0.06	0.09	0.04	0.41	0.38	0.04	0.03	<0.002	<0.002	0.002
Rb	µg/l	0.03	0.03	0.03	0.02	0.08	140	1.4	1.1	0.02	0.03	0.02
Re	ng/l	0.016	0.006	0.005	<0.001	0.005	0.036	0.002	0.002	<0.001	0.015	<0.001
Rh	ng/l	0.1	0.1	0.3	0.2	0.3	0.04	0.07	0.07	<0.01	0.02	0.1
Ru	ng/l	0.4	0.2	0.3	0.5	0.02	0.4	0.03	0.03	<0.01	0.05	0.03
S	µg/l	24000	34000	46000	50000	<10	870	30	20	<10	13000	12000
Sb	µg/l	0.02	0.01	0.03	0.01	5.4	5.9	0.03	0.02	0.9	1.6	1.3
Sc	ng/l	0.2	0.4	0.3	0.1	3.1	8.7	38	32	0.2	0.3	0.2
Se	µg/l	0.09	0.03	0.1	0.3	0.8	2.4	0.04	0.02	0.1	0.2	0.2
Si	µg/l	450	400	50	30	6000	180	2000	1200	5	20	20

Sm	ng/l	0.06	0.2	0.1	0.05	8	0.2	70	40	0.3	0.6	0.4
Sn	µg/l	0.2	0.2	0.2	0.02	0.08	0.29	0.25	0.14	0.04	0.04	0.06
Sr	µg/l	0.25	0.33	0.35	0.34	0.83	0.27	0.27	0.17	0.009	0.29	0.014
Ta	ng/l	12	12	15	0.4	2.7	2.0	37	23	0.1	0.2	0.1
Tb	ng/l	0.01	0.02	0.02	0.01	1.7	0.06	15	9	0.04	0.08	0.04
Te	ng/l	0.7	0.2	0.7	0.9	1.0	18	14	11	0.07	0.08	0.1
Th	ng/l	0.3	0.3	0.2	0.1	12	2.7	210	130	0.1	2.6	1.6
Ti	µg/l	0.04	0.2	0.8	0.05	1.6	0.6	1	0.5	0.03	0.06	0.04
Tl	ng/l	0.4	0.2	2.6	0.2	2.0	0.6	12	8	0.08	0.08	0.09
Tm	ng/l	0.01	0.02	0.03	0.01	0.4	0.04	6	4	0.01	0.02	0.01
U	ng/l	2.3	4.1	1.4	4.7	19	7.3	380	290	10	44	13
W	ng/l	23	17	26	10	31	5	220	150	2	2	3
V	µg/l	0.2	0.2	0.07	0.27	0.05	0.03	0.04	0.03	0.07	0.04	0.02
Y	ng/l	1.1	2.1	1.5	0.4	66	4.7	810	500	0.8	1.9	1.3
Yb	ng/l	0.07	0.09	0.12	0.02	4.6	0.2	38	24	0.04	0.1	0.07
Zn	µg/l	10	6	19	4	7	7	1	1	2	4	6
Zr	ng/l	7	6	8	4	34	33	760	450	3	9	5

Table Added concentrations to whole blood/serum from different types of sampling equipment.

n1 SARSTEDT Pr.N. 85.1162 ordinary needle
n2 SARSTEDT Pr.N. 85.1162.400 'trace element' needle
t1 SARSTEDT Monovette Li-H LH/4.9 ml green
t2 SARSTEDT Pr.N. 01.1604.100 Monovette Li-H LH/7.5 ml green
t3 SARSTEDT Pr.N 26.369 Li-H LH/10 ml orange
t4 SARSTEDT Monovette Pr.N 01.1604.400 Li-H LH/7.5 ml orange
t5 BD (Becton&Dickinson) Vacutainer Trace elements Serum, Ref. 368380 6 ml Blue cup
t6 BD Vacutainer Trace elements K2EDTA,Ref. 368381 6 ml Blue cup
t7 SARSTEDT Monovette Serum Z/7.5 ml red
t8 SARSTEDT Monovette Serum Gel S/7.5 ml brown
t9 Greiner-Bio-One Vacuette Z No Additive/3 ml
t10 Greiner-Bio-One Vacuette NH Sodium Heparin/4 ml
t11 Greiner-Bio-One Vacuette LH Lithium Heparin/4 ml