LASER ELEMENTAL ANALYSIS (LIBS) IS A UNIQUE INNOVATIVE TECHNIQUE OF CHEMICAL COMPOSITION DETERMINATION IN SUBSTANCES AND MATERIALS

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The implementation of the existing LIBS technology in the Laser Elemental Analyzer LEA-S500, serially manufactured by SOL instruments, has been reported. Use of the unique device for analysis of different chemical composition of solid state samples, pure and super pure materials, metals, alloys, glass, ceramics, plastics, compacted and other compositions without a preliminary change of a sample aggregate state, for control of technological manufacturing process of potash fertilizer, for determination of concentration of both vital (essential) and toxic elements in human hair, investigations in the wide spheres, has been presented. /1/

Laser elemental analyzer LEA-S500 allows to carry out qualitative, semi-quantitative, and quantitative analysis of different materials, to determine automatically the type of material for the basic elements of the material being analyzed.

The following procedures have been developed for measuring chemical composition of

- alloys based on iron (steels of different types, cast iron), copper (brass, bronze), aluminum (cast and wrought), titanium, nickel, magnesium, zinc, etc.
- pure and super pure materials (Cu, Sn, Ni, Ag, Au, etc). /2/

Table 1. The results of analysis of pure copper

№	Element	Symbol	Measurement range, %	RSD, %	
				Standard	LEA-S500
1	Nickel	Ni	0.0001 - 0.3	10.0 - 7.0	10.0 - 4.8
2	Zinc	Zn	0.0001 - 0.06	25.0 - 10.0	10.0 - 6.8
3	Silver	Ag	0.0006 - 0.05	7.0	10.0 - 3.9
4	Iron	Fe	0.0001 - 0.08	12.0 - 9.0	10.0 - 5.2
5	Lead	Pb	0.00015 - 0.06	14.0 - 10.0	10.0 - 5.8
6	Tin	Sn	0.0001- 0.09	10.0 - 5.0	10.0 - 4.1
7	Antimony	Sb	0.00015 - 0.09	12.0 - 7.0	10.0 - 7.0

8	Cadmium	Cd	0.0002 - 0.005	13.0	10.0 - 6.0
9	Arsenic	As	0.01 - 0.03	20.0	16.0 - 12.0
10	Phosphorus	P	0.003 - 0.01	33.3 - 10.0	14.0 - 12.0

Table 2. The results of analysis of slags of blast-furnace production

Oxide	Measurement range, %	RSD, %	
		Standard	LEA-S500
Al_2O_3	6.0 - 15.0	5.0 - 2.8	4.0 – 1.5
SiO_2	28.0 - 44.0	3.0 – 2.0	4.0 – 2.0
Fe_2O_3	0.3 - 2.0	100.0 - 10.0	20.0 - 8.0
TiO_2	1.0 - 10.0	14.0 - 4.0	5.0 – 2.0
MgO	5.0 - 15.0	8.0 - 5.0	4.0
V_2O_5	till 0.5	not certified	5.0
P_2O_5	till 2.5	12.5 – 8.0	7.5 – 5.0
MnO	0.5 - 4.0	20.0 - 10.0	5.2 – 3.0
CaO	28.0 - 38.0	2.0	2.0

LEA-S500 provides measurement data surpassing in accuracy, convergence and reproducibility measurements by other methods of analysis (XRF, ICP-OES), and in some cases LIBS is the only feasible method, e.g. in determination of impurity in gold bars (the measurements have been performed on the LEA-S500 in the analytical laboratory in Holland). Black and brown spots on the surface of three gold bars have been found. Only with the help of LEA-S500 a great amount of silver and copper have been detected in the gold bars.

Determination of composition of casual inclusions in glass products of 0.01 mm size is possible only with the LEA-S500. It allows to find out the reasons of different inclusions in finished products, to avoid appearance of defective goods, strictly control technological process. The developed technique of glass composition determination can be successfully applied on glass plants, research institutes. /3/

Table 3. The results of analysis of glass

Oxide	Sodium-calcium-silicate glass				Boron-silicate glass			
	Measurement range, %		Relative standard deviation, %		Measurement range, %		Relative standard deviation, %	
	Min mass fraction	Max mass fraction	Min mass fraction	Max mass fraction	Min mass fraction	Max mass fraction	Min mass fraction	Max mass fraction
SiO_2	70.39	74.63	0.25	0.25	69.76	81.59	0.25	0.20
Al_2O_3	0.19	3.53	3.0	0.9	1.9	6.6	0.9	1.1
Fe_2O_3	0.029	0.46	9.5	3.0	0.02	0.12	13	5.0

CaO	5.51	11.83	1.0	0.8	0.03	4.75	14	0.8
MgO	0.007	4.91	16	1.2	0.01	3.17	12	1.2
Na_2O	10.65	15.85	0.7	0.7	3.34	9.7	1.1	0.7
K_2O	0.028	4.97	9.0	3.0	1.00	2.42	3.5	3.0
SO_3	0.005	0.51	27	7.0				
B_2O_3	0.001	0.46	13	3.5	4.2	12.04	1.3	1.0
BaO	0.012	2.40	6.0	1.0	0.01	3.5	5.0	0.9
SrO	0.003	0.29	9.0	2.0	0.001	0.058	13	4.0
ZrO_2	0.003	0.20	14	3.0	0.01	0.032	8.0	4.5
PbO	0.012	0.06	15	6.0	0.003	0.005	26	20
Cr_2O_3	0.01	0.09	7.5	2.5				
CeO	0.04	0.10	5.5	3.0		0.20		2.3
TiO_2	0.01	0.051	9.5	3.5	0.01	0.026	10	4.0
P_2O_5	0.009	0.115	12	3.0				
ZnO	0.002	0.33	22	4.0	0.002	0.012	23	8.0
MnO_2	0.001	0.029	20	7.5	0.0013	0.0085	18	10
Sb_2O_3	0.04	0.40		5.0				

Further research on determination of the oxides in glass has been recently conducted what enables to determine light elements Li, Be, and B with detection limit of 0.015, 0.07 and 3.0 ppm, respectively.

Use of LEA-S500 allows to determine extremely low concentrations of elements in studied samples (from ppb to 100%).

We are proud of our recent achievement pertaining to analysis of impurity in drinking water. In the table 4 the comparative results of determination of some elements in drinking water obtained by various methods, have been presented.

Table 4.

Method	Co µg/l (ppb)	C µg /l (ppb)	Pb µg /l (ppb)	P µg/l (ppb)	Mn µg /l (ppb)	Li µg /l (ppb)
ICP-OES $(X_{LQ})^1$	1	2	5	9	0,4	6
ICP-OES $(X_{LQ})^2$	1	1	1	undetermined	1	1
AAS $(X_{LQ})^2$	1	1	1	undetermined	1	undetermined
ICP-MS $(X_{LD})^3$	0,2	1	0,1	5	3	1
LIBS, LEA-S500_(X_{LD})	**0,1**	**0,1**	**0,1**	**4**	**0,1**	**0,03**

Note: [1] ISO 11885 (2007), [2] standard ,[3] ISO 17294-2 (2003)

The table shows that the results obtained with LEA-S500 are incomparably higher that the data obtained with other certified methods.

Due to the arisen interest in control of health state of population of the Republic of Belarus, the specialists of SOL instruments have developed the

unique technique on human hair analysis allowing to get reliable results with minimum sample preparation consisting in preliminary washing (according to the IAEA guidelines) and pasting of a lock of hair by specially selected means.

The developed technique allows to get the results of hair analysis on 30 macro - and microelements (Ag, Al, Ba, B, Be, Ca, Co, Cr, Cu, Fe, K, La, Li, Mg, Mg, Mo, Na, Ni, P, Pb, Rb, Si, Sn, Sr, Ti, V, Zn, Zr) of any individual within 30 minutes, to judge about an organism health state, its metabolism, to determine deficiency of vital elements and make all necessary corrections in proper time in food, to carry out a treatment complex, if required.

The offered technique possesses unique properties allowing of monitoring the temporal dynamics of accumulation of essential elements along a hair lock in the process of growth (it's very important for diagnostics of a child health state to receive reliable results). /4/

Guaranteed detection limits for some elements are given in www.solinstruments.com.

The laser atomic-emission analyzer for elements LEA-S500 allows to solve a very broad range of scientific research and production engineering tasks.

LEA-S500 with a laser source of spectrum excitation is the instrument of the future. The given effect reduces substantially the lower limit of elements detection of different materials, increases measurements accuracy, extends analytical capabilities of atom-emission spectrometry.

References

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ANALYSIS:

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