

Analysis of Glass

ARL ADVANT'X Series with IntelliPower™ Sequential X-Ray Fluorescence Spectrometer

Key Words

- ARL ADVANT'X - 3600W
- Glass
- X-Ray Fluorescence
- XRF

Limits of detection and precision

Introduction

The simplest form of glass is the single component fused silica (SiO₂). However it is both difficult to process and expensive. To reduce these difficulties, some other oxides are added imparting specific properties to the resultant glass.

Glasses used in construction are referred to as flat glasses. Most of them are composed of about 70 % silica, which is a glass former, soda as a flux in the form of carbonate and sulfate (about 14 %), lime as a stabilizer in the form of limestone (about 10 %). Other types of oxides like alumina or magnesia improve the physical characteristics of glass, particularly the resistance to atmospheric conditions.

In-depth coloring is obtained by incorporation of various metallic oxides: oxides of chromium, iron, manganese or copper. As for glasses for car windshields, slight colouration is achieved by addition of ppm levels of cobalt oxides and selenium.

Instrumentation

A Thermo Scientific ARL ADVANT'X Series spectrometer has been used to derive limits of detection and precision for the analysis of glasses. The geometry of the instrument is optimized to provide the highest sensitivity. It is equipped with a rhodium anode end-window X-ray tube type 4GN fitted with a 75µm Be window. The thin window improves the excitation efficiency of elements lighter than potassium (K).

Results

A series of flat glass standard samples have been measured on the ARL ADVANT'X. Calibration curves have been derived by relating intensities for each oxide (or element) to concentrations in the standard samples. X-ray fluorescence measures elements, but the results can be related directly to the oxide forms of these elements when only one single form is present in the sample. Using the calibration curves, limits of detection have been derived for the most common oxides found in flat glasses (Table 1).

OXIDE/ ELEMENT	LINE	CRYSTAL	DETECTOR	LOD ppm
Na ₂ O	Kα	AX-06	FPC	N.R.
MgO	Kα	AX-06	FPC	10.3
Al ₂ O ₃	Kα	PET	FPC	2.7
SiO ₂	Kα	PET	FPC	N.R.
Cl	Kα	PET	FPC	3
SO ₃	Kα	PET	FPC	0.9
K ₂ O	Kα	LiF 200	FPC	1.3
CaO	Kα	LiF 200	FPC	N.R.
TiO ₂	Kα	LiF 200	FPC	0.8
Fe ₂ O ₃	Kα	LiF 200	FPC	1.1
As ₂ O ₃	Kα*	LiF 200	SC	0.5
SrO	Kα	LiF 200	SC	1
Co ₂ O ₃	Kα	LiF 200	FPC	0.9
Se	Kα	LiF 200	FPC	1

Table 1: Analytical parameters and limits of detection for various oxides/element in flat glass (100 sec. counting time)

N.R. = LoD is not relevant for major elements

FPC = flow proportional counter

SC = scintillation counter

Excitation conditions: 50 kV / 70 mA

*: no Pb in samples, thus no spectral overlap



Precision tests have been carried out by running samples for ten repeat analyses. The results are summarized below:

	Na₂O %	MgO %	Al₂O₃ %	SiO₂ %	SO₃ %	K₂O %	CaO %	Fe₂O₃ ppm
TIME [s]	10	10	10	10	10	10	10	10
Run 1	11.35	0.245	2.78	69.97	0.214	1.91	9.97	369
Run 2	11.34	0.250	2.77	69.93	0.213	1.90	9.97	372
Run 3	11.36	0.250	2.77	69.97	0.211	1.91	9.96	373
Run 4	11.35	0.251	2.78	69.93	0.211	1.91	9.98	377
Run 5	11.33	0.252	2.77	69.95	0.210	1.91	9.97	376
Run 6	11.33	0.251	2.77	69.93	0.213	1.90	9.99	370
Run 7	11.35	0.252	2.78	70.00	0.211	1.91	9.97	372
Run 8	11.36	0.249	2.77	69.96	0.214	1.91	9.96	375
Run 9	11.35	0.252	2.78	69.95	0.210	1.91	9.97	374
Run 10	11.35	0.250	2.77	69.99	0.211	1.91	9.98	377
Avg.	11.35	0.250	2.77	69.96	0.212	1.91	9.97	374
Std.Dev.	0.012	0.0023	0.005	0.029	0.002	0.004	0.009	3

Table 2: Repeatability for the analysis of the main oxides in a flat glass (10s counting time i.e. 80s total counting time)

	Na₂O %	MgO %	Al₂O₃ %	SiO₂ %	SO₃ %	Cl ppm	K₂O ppm	CaO %	TiO₂ %	Fe₂O₃ ppm
TIME [s]	20	6	20	20	6	6	6	6	6	20
Run 1	13.75	4.13	0.580	71.33	0.388	117	128	9.61	0.017	145
Run 2	13.76	4.15	0.578	71.32	0.390	119	132	9.62	0.017	146
Run 3	13.76	4.15	0.575	71.31	0.391	115	133	9.62	0.016	148
Run 4	13.77	4.16	0.579	71.32	0.390	115	130	9.62	0.017	146
Run 5	13.77	4.15	0.579	71.34	0.388	120	136	9.62	0.017	146
Run 6	13.77	4.15	0.576	71.32	0.389	116	132	9.62	0.017	147
Run 7	13.76	4.15	0.578	71.32	0.385	114	131	9.62	0.016	147
Run 8	13.76	4.15	0.578	71.33	0.388	114	132	9.61	0.017	145
Run 9	13.76	4.15	0.580	71.32	0.386	121	129	9.62	0.018	145
Run 10	13.75	4.14	0.577	71.33	0.383	118	133	9.62	0.017	146
Avg.	13.76	4.15	0.578	71.32	0.388	117	132	9.62	0.017	146
Std.Dev.	0.009	0.01	0.002	0.007	0.002	2.4	2.4	0.004	0.0005	1

Table 3: Repeatability for the analysis of the main oxides in a flat glass (various counting times as shown, i.e. 116s total counting time)

Conclusion

Limits of detection at the 1 ppm level for metallic oxides in glasses are possible with the ARL ADVANT[®]X instrument. Even with short counting times very good short term stability is achieved. These results show that the ARL ADVANT[®]X spectrometer is well suited to produce high precision results for the determination of the main oxides and the coloring agents in glasses.

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