SHIMADZU APPLICATION NEWS

LAAN-A-AA-E015

● SPECTROPHOTOMETRIC ANALYSIS

No.A385

Al Analysis by Atomic Absorption

■ Introduction

Al is the third most abundant element found on the earth's crust following O and Si, and is found in feldspar, cryolite, mica, and other mineral ores. Industrially speaking, Al is precipitated on cathode during the process of separating alumina (Al_2O_3) from bauxites (ores comprised of Al_2O_3, or $Al(OH)_3$ and impurities) using carbon electrodes inside molten cryolite (Na_3AlF_6).

Al has a silvery-white color and is lightweight. Its malleability makes it easy to process and thus is used in a variety of industries. Oxide-coated aluminum has superior anti-erosion and insulating properties, and often is used in capacitors. Because staining may be used to apply carbon coating, this aluminum is also used in decoration and construction. Because they are lightweight and strong, duralumin (Cu 4%, Mg 0.5%, Mn 0.5%) and other aluminum alloys are used in buildings, vehicles, airplanes, and machine parts.

Like Zn, Al is an amphoteric metal, thus reactions with acids produce trivalent salts such as $AlCl_3$ and $Al(NO_3)_3$. Both Al_2O_3, an amphoteric oxide, and $Al(OH)_3$, an amphoteric hydrate, are insoluble in water but both are soluble in either hydrochloric acid or sodium hydrate solution. As $Al(OH)_3$ becomes a colloid that attaches ions or pollution to its surface at neutral region and then sinks, it often is used as a water purification agent. $Al(OH)_3$ is also used in antacids to neutralize stomach acid as well as in other pharmaceuticals. Not only does the ulcer drug Sucralfate (complex of Al and sucrose) work by binding with proteins in the stomach and intestinal membrane to protect affected areas, it also binds with pepsins to help control their effect on organs.

Corundum, a natural hard alumina crystal is used as an abrasive on metals and glass. Blue corundum (including Fe and Ti oxides) and red corundum (including Cr oxides) are processed into sapphires and rubies respectively. Al salts include alum, which is used in chemical fertilizers and dyes. Alum is a $MAl(SO_4)_2 \cdot 12H_2O$-type double salt that is formulated by mixing sulfuric aluminum with ammonia or alkali metal sulfates. Normally, alum means potassium aluminum alum, and K replaces M.

With characteristics resembling those seen in trivalent metal ions, aluminum ions easily bind with transferrin, an iron-transporting protein, and it is believed that excessive amounts of aluminum in the body absorbs into the bones and muscles, resulting in brittle bones and muscular atrophy, or accumulate in the brain resulting in Alzheimer's disease.

In this issue, we explain the relation of the sensitivity between the graphite tube types and the addition of interference inhibitors and points of the tube selection through the example of furnace measurement of Al.

■ Basic Data on Al

Atomic weight	: 26.982
Melting point	: 660.37 ˚C
Boiling point	: 2467 ˚C
Oxidation number	: +1 Vapor AlCl
	+3 Al_2O_3, $Al(OH)_3$, $AlCl_3$
Solubility:	: $AlCl_3 \cdot 6H_2O$ 41.1 g / 100 g water (15˚C)
	$Al_2(SO_4)_3$ 36.2 g / 100 g (20 ˚C)

Reference : New Knowledge of the 111 Chemical Elements
Physics, Chemistry Dictionary, etc.

■ Wavelengths of Ni

	Sensitivity
309.3	1.0
396.2	0.86
237.2	0.2

■ Furnace Analysis of Al

For that Al, Ca, and Si easily generate carbides whose boiling points are high; the pyro-coated graphite tube is usually used for furnace analysis. The pyro-coated graphite tube is designed not for generating carbides, so the higher sensitive analysis is possible compared with the furnace analysis by the high-density graphite tube. However, the sensitivity of the analysis by pyro-coated graphite tube comes under the influence of the composition of the sample solution. In some case, the high-density tubes are preferred even for the furnace analysis of Al, Ca and Si. So, it is necessary to consider which type of tube is suitable for the analysis beforehand.

Normally, additive recovery tests are performed at first, then the optimal tube is selected based on the rate of recovery. Even when using an interference inhibitor, these aspects must be checked in combination with the recovery rate because the level of sensitivity improvement and the effects of the interference inhibitor will differ depending on the type of tube. Figs.1 to 4 show the calibration curves for high-density tubes and pyro-coated tubes when 10 µL of magnesium nitrate at 200 ppm is added as an interference inhibitor and when it is not added. In both cases, a maximum 10 µL of Al at 20 ppb was injected and analyzed under the heat conditions shown in Table 1. ↘

↘The effect of the sensitivity by the interference inhibitor was greater for the pyro-coated tube in comparison with the high-density tube. So it is clear that, as far as sensitivity is concerned, the use of the pyro-coated tube is preferred. However, the increased sensitivity achieved via the magnesium nitrate can be seen as a form of interference and thus it can be said that the pyro-tube is more susceptible to the effects of interference.

Table 1 Heat Condition

Temp. (˚C)	Time (sec.)	Heating mode	Gas flow (L/min)
150	20	RAMP	0.1
250	10	RAMP	0.1
800	10	RAMP	1.0
800	10	STEP	1.0
2500	3	STEP	0.0
2600	2	STEP	1.0

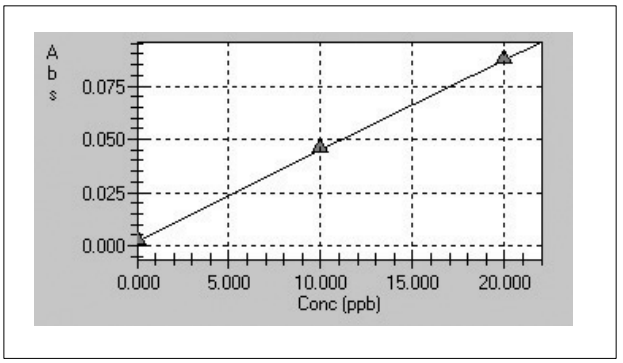

Fig.1 Calibration Curve (High Density, No Addition)

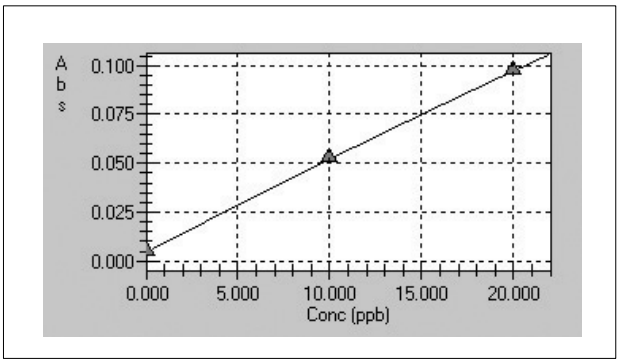

Fig.2 Calibration Curve (High Density, Addition)

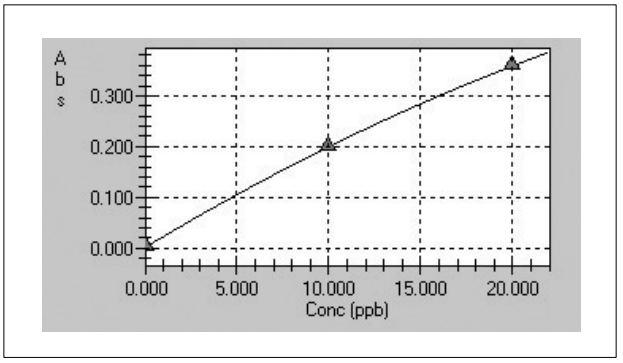

Fig.3 Calibration Curve (Pyro, No Addition)

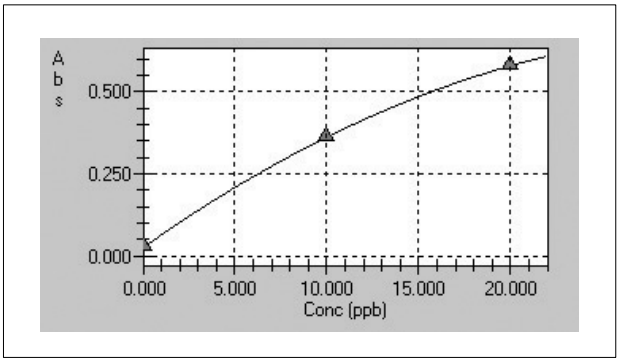

Fig.4 Calibration Curve (Pyro, Addition)

■ Conclusion

Because Al is abundant on the earth's crust, it is easily contaminated from the environment during analysis. Also, as Al is one of the elements found in glass, the use of glass instruments must be avoided during trace-level Al analysis. When addressing coexisting elements in a furnace analysis, if there is background problems occurring by the presence of Al, the use of a high-density tube may be more effective for reducing them compared to a pyro-coated tube due to differences in sensitivity.

SHIMADZU

SHIMADZU CORPORATION. International Marketing Division

3. Kanda-Nishikicho 1-chome, Chiyoda-ku, Tokyo 101-8448, Japan Phone: 81(3)3219-5641 Fax. 81(3)3219-5710

Cable Add.:SHIMADZU TOKYO

Printed in Japan 3100-03602-10A-IK