Fundamental Studies on Plasma-Jet Spectrometry

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Summary. A plasma-jet generator as a new light source was described and various studies were carried out to obtain the optimum working conditions for emission spectrometry. The variation of spectral line intensity and the distribution of temperature in the plasma flame were examined. The background intensity was reduced and the sensitivity of the measurement increased by use of a mixture of argon and helium as tangential gas. It became possible to carry out the determination of aluminium, which was rather difficult by flame spectrometry and atomic-absorption spectrometry with the usual combustion flame because a stable oxide was formed in the flame. In addition, the detection limit was calculated and calibration curves were obtained with good linearity. Effects of acids and organic solvents were investigated, too.

1. Introduction

Some reports [2—10] have appeared in recent years on the application of the plasma-jet flame as a new light source for emission spectrometry but all the methods reported are not perfect with regard to stability of the flame and investigations on the detection limit, and sufficient examinations do not seem to have been made.

When the plasma-jet flame is used as a light source for emission spectrometry, it becomes possible to excite elements with high excitation energy because a high-temperature, stable flame can be obtained. In addition, it will make possible the determination of aluminium, which was rather difficult by flame spectrometry and atomic-absorption spectrometry using the usual combustion flame because aluminium formed a stable oxide in the flame.

The generator of plasma jet [11] used in the present study was constructed in order to avoid completely the consumption of electrodes and to give

* Dedicated to Prof. Dr. H. Kaiser on his 60th birthday.
a stable and high-temperature flame. This apparatus was examined in order to use the plasma jet as the light source for emission spectrometry. Examination of the characteristics of the plasma-jet flame included the determination of its working conditions as a light source for emission spectrometry, as well as the intensity distribution, measurement of the detection limit, preparation of a calibration curve, and effect of acids.

2. Reagents and apparatus

2.1. Reagents. All the sample solutions were prepared by dissolving the chlorides or other salts in distilled water, or by dissolving a metal in acid, evaporating off the excess acid, and diluting the residue with distilled water.

Salts, acids, and organic solvents used were all of analytical grade.

2.2. Apparatus. The plasma-jet apparatus was a product of Hitachi, Ltd. Electric source was a d.c. constant-current generator (rated output 500 A, 50 KW), and starting spark oscillator.

The measurement was made with Hitachi 139 autorecording spectrophotometer.

3. The plasma-jet spectrometer

A schematic diagram of a plasma-jet spectrometer is shown in Fig. 1. The plasma-jet generator consists of a nozzle-type anode (of copper) and a bar-type cathode (tungsten containing 2% of thoria); the plasma-jet flame emerges from the nozzle. The apparatus is worked in the range of 200—500 A (at a constant voltage of 23 V), using a constant-current generator with an output of 500 A, 50 KW; the starting is made by impressing a high-frequency pulse between the electrodes using a spark generator.

As shown in Fig. 1, the sample solution is introduced into the atomizer through a capillary and blown on the arc by a sample-spraying gas.