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Design and Performance of the Air-Propane Nebulizer Burner for Atomic Absorption Spectrometry

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Synopsis. A new air-propane nebulizer burner, by the use of which the sensitivity and precision for atomic absorption measurements was approximately equal to those with an air-hydrogen nebulizer burner, has been developed. The flame with this burner has other characteristic features, such as low auditory noise, high stability, and low radiation noise in the OH band.

Various kinds of chemical flames have been widely used for atomic emission, absorption, and fluorescence spectrometry. There are two types of burners,[1-3] that is, the nebulizer burner and the premix burner. Recently the premix burner has been most often used because it is silent in operation and has a high efficiency[4,5] in atomizing.

However, the nebulizer burner has many merits: less clogging of the burner with high concentrations of various solutes, no necessity to change the burning conditions between aqueous and organic solvents because of the energetic flame, smaller volume of sample consumption for measurement, freedom from flashback, and simplicity in cleaning and use. Another merit is that a strongly acidic or alkaline sample solution can be nebulized directly, without any trouble like corrosion, as the solution passes through only the capillary. The material of the capillary can also be easily changed according to the solution.

It is well known that the exhaust speed of an oxidant of a nebulizer burner is very high. Therefore, some flames with a high burning velocity[2] (*e.g.*, oxygen–acetylene, oxygen–hydrogen, and air–hydrogen flames) have been obtained with the nebulizer burner, while flames of a low burning velocity have blown out.

The maximum temperature of an air–propane flame has been reported to be 2200 K,[1,6] about 100 K lower than that of a relatively low-temperature air–hydrogen flame (*i.e.*, 2300,[1] 2290 K[7]).

In this paper the construction of a new type of nebulizer burner for flames of low-burning velocity, such as an air–propane flame, and its characteristics are reported.

Construction and Experimental

A cross-sectional diagram of the newly constructed nebulizer burner is shown in Fig. 1. By thoroughly mixing propane with air and by equipping the burner with the side cover (H), we prevent the air–propane flame from blowing out. The propane enters from its inlet portion (A) and then passes through a nozzle (D) 0.2 mm in dia., with 12 holes (E) 2 mm in dia. and 16 holes (F) 1.6 mm in dia., into the flame. The propane is concurrently diluted with air from 6 holes (C) 2.5 mm in dia. and thoroughly mixed in the space (G). The side cover (H) has 24 holes 2.5 mm in diameter.

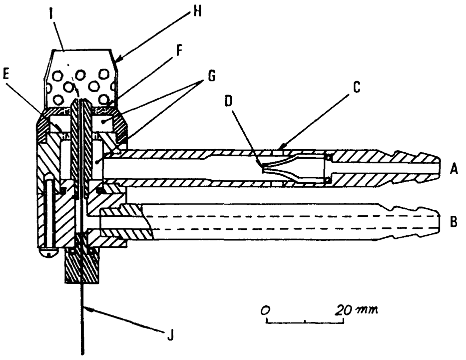

Fig. 1. Cross-sectional diagram of the air–propane nebulizer burner.
A; Fuel inlet, B; air inlet, C; holes, D; nozzle, E; holes, F; holes, G; mixing chamber, H; side cover, I; nozzle, J; capillary.

As an oxidant propane requires about ten times as much air (in volume) than does hydrogen for stoichiometrical burning at its maximum burning velocity. Therefore, we must mix propane with air to a great extent before the propane reaches the flame. The holes of the side cover (H) also serve as a cooler for the sidecover by the stream of entrained air. The burner is made of stainless steel; this makes in significant any contamination in the determination of iron, chromium, and nickel.

The solution passes through a platinum–rhodium capillary (J) 0.55 mm in inside dia. and 0.8 mm in outside dia., and is then sprayed by the air at the nozzle (I) 1.1 mm in diameter. The pressures of air and propane at the inlet ports (B) and (A) are 0.8×10^5 and 2.0×10^5 Pa respectively. The air–propane flame concurrently provides suitable flame conditions in terms of stability and sensitivity for the atomic absorption measurements of several elements.

An atomic absorption and emission spectrophotometer AA-1E (Nippon Jarrell-Ash Co., Ltd.) equipped with a 0.5-m monochromator was used for getting the emission spectra and the other spectra. A photomultiplier, R456 (Hamamatsu T.V. Co., Ltd.), and a grating with 1200 grooves/mm, blazed wavelength 300 nm were used. The voltage applied to the photomultiplier was 500 V. The slit width of the monochromator was 100 μm for both entrance and exit, while the scanning speed of wavelength was 12.5 nm/min. An air–hydrogen flame with a Hetco burner (conventional nebulizer burner, Nippon Jarrell-Ash Co., Ltd.) was used for comparison. The burning gas conditions were 1.0×10^5 Pa and 0.5×10^5 Pa in pressure for air and hydrogen respectively, as usual. Both flames were measured 50 mm above the burner tops, where the highest sensitivities were obtained with both flames for most of the elements listed in Table 1.

Table 1. Sensitivities of several elements with atomizer burners

Element (Wavelength nm)	Sensitivities (ppm/1% absorption)[a] Air–propane	Air–hydrogen
Li (670.8)	0.03	0.04
Na (589.0)	0.01	0.01
K (766.5)	0.02	0.02
Cs (852.1)	0.5	0.2
Mg (285.2)	0.05	0.01
Ca (422.7)	0.5	0.2
Sr (460.7)	1	0.2
Cr (357.9)	2	0.4
Mn (279.5)	0.05	0.1
Fe (248.3)	0.1	0.1
Co (240.7)	0.1	0.2
Ni (232.0)	0.1	0.2
Cu (324.8)	0.05	0.05
Ag (328.1)	0.05	0.05
Zn (213.9)	0.01	0.02
Cd (228.8)	0.04	0.03
Hg (253.7)	2	5
Pb (283.3)	1	0.6
Bi (223.1)	0.2	0.5
Te (214.3)	0.2	0.5

a) Obtained with a single path.

Results and Discussion

The flame emission spectra scanned, originating from the air–hydrogen and the air–propane flames with the nebulizer burners under the same analytical conditions except for the burning-gas conditions, are shown in Fig. 2. The air–propane flame proved relatively smaller in its OH-band spectrum and inversely larger in its swan-band spectra. The spectrum of the oxygen–acetylene flame with the Hetco burner under the same measurement conditions almost scaled out (not shown).

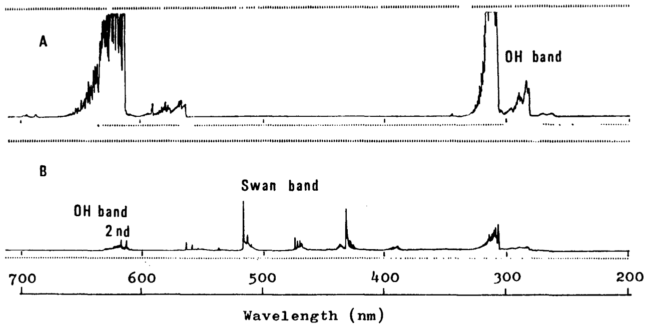

Fig. 2. Emission spectra of (A) air–hydrogen flame and (B) air–propane flame using atomizer burners.
Burning gas conditions: (A) air; 1.0×10^5 Pa, hydrogen; 0.5×10^5 Pa (B) air; 0.8×10^5 Pa, propane; 2.0×10^5 Pa.

The precision and sensitivity were investigated by means of atomic absorption measurements. The coefficient of variation at 4 ppm magnesium in an aqueous solution was 0.9% ($n=10$). Table 1 shows the sensitivities of several elements with the air–propane nebulizer burner (Hetco burner). There was no significant difference in sensitivities for the elements investigated between the two burners. It is apparent that a decrease of about 100 K in the flame temperature, as has been described earlier, leads to something of a loss in sensitivity for magnesium, calcium, strontium, and chromium, which form a relatively stable oxide. A lower sensitivity for cesium was obtained with the air–propane flame than with the air–hydrogen flame, though among the alkali metals cesium was expected to give a higher sensitivity in terms of the ionization potential.

Furthermore, no flashback of the flame occurred at any pressure ratio of air to propane. An air–town gas flame can be obtained by using this burner without holes (C) and nozzle (D). The audible noise of the air–propane and air–town gas flames with this nebulizer burner was much less than that of the air–hydrogen flame with a conventional nebulizer burner. As the background at the OH band is small, this burner can also be used for emission and atomic fluorescence spectrophotometry.

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