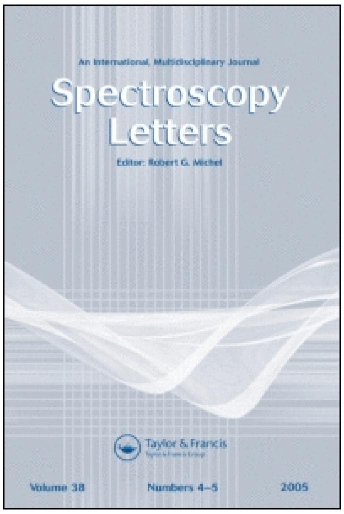


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# Atomic Absorption Flame Temperature Distribution Measured by Fiber Optics

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# ATOMIC ABSORPTION FLAME TEMPERATURE DISTRIBUTION MEASURED BY FIBER OPTICS[1]

Key Words: Atomic Absorption Spectroscopy; Flame Temperature; Fiber Optics; Remote Analysis.

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**Abstract**

Atomic absorption flame temperature distributions have been investigated. The two-line method based on the fiber optics coupling light into the rapid-scanning spectrometer to measure temperature has been developed. Its feature is that a simpler apparatus used can obtain temperature distributions over the entire section of the flame in high resolution. The result shows some characteristics of premixed air-acetylene flame used for analytical spectrometry.

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## INTRODUCTION

In atomic absorption spectroscopy a single-slot burner pre-mixed air-acetylene is popularly used. It is significant to study combustion characteristic of the burner. The temperature distributions of atomic absorption flame involve the distributions of atomic number density, ion number density, molecules and their dissociation products and the absorbance values in the flame[1-4]. So it is very important to study flame temperature distributions. Among the various spectroscopy techniques measuring flame temperature, although the line reversal, modified line reversal, emission-absorption and slope methods are used most extensively[4,5], they generally need complex optic apparatuses. In especial to use common apparatuses measuring temperatures in a small space is very difficult. Fiber optics provides a convenient method coupling light into the spectrometer and of monitoring inaccessible light sources[6]. In addition, it allows the exploration of small region, small volumes, closed or far away systems monitored[7-9]. This paper will show we develop the two-line method based on the fiber optics coupling a rapid-scanning spectrometer for measuring flame temperature distribution of atomic absorption spectroscopy. Its advantage is using simpler optic apparatus to study temperature distributions over the entire section of the flame in high resolution. It makes employment of the fiber optics extremely useful as the measuring temperature method in a common laboratory of spectrochemical analysis.

## EXPERIMENTAL

The experimental set-up used in this study is given in Fig. 1. The glass optic fiber couples light emitted by the flame into the rapid-scanning spectrometer.

The light generation, signal detection and data processing system are performed by use of a slot burner, double-grating monochromator, photomultiplier, recorder and micro processing computer listed in Table 1.

Resonance lines 766.5 and 404.4 nm of potassium were measured. The flow rates of the flame for air and acetylene are 6.7 and 1.7 l/min, respectively. Potassium chloride was used to prepare standard stock solution of 1000 μg/ml

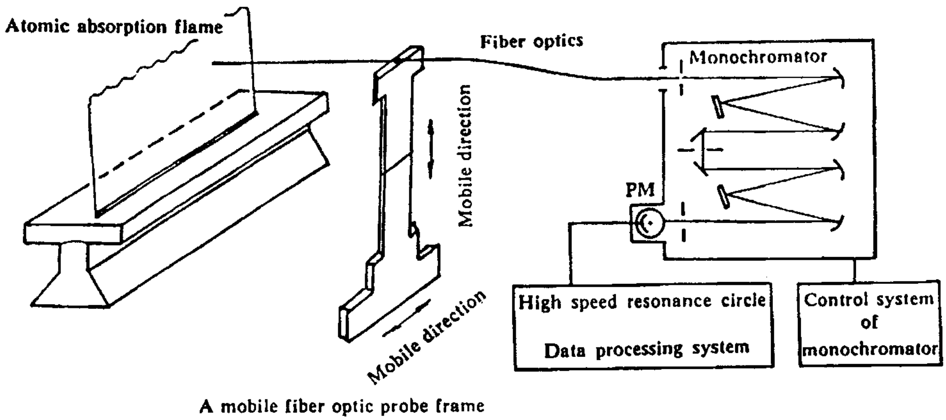


Fig. 1. Schematic diagram of apparatus for measuring flame temperature distribution by fiber optics.

Table 1. Instrumentation

| Component | Description | Manufacturer |
|---|---|---|
| Slot burner | Premixed air-acetylene, Slot; 0. 5mm wide, 100mm long. | Nanjing Analytical Instrument Factory |
| Nebulizer | Concentric pneumatic nebulizer. | Nanjing Analytical Instrument Factory |
| Optic fiber | Glass optic fiber, A diameter of 3mm. | Nanjing Glass Optic Fiber Factory |
| Monochromator | Jobin-Yvon Czerny-Turner mounting double grating monochromator Model HRD-1 with two holographic gratings, 1200 grooves/mm; dispersion 0. 66nm/mm. | Instruments S. A. |
| PM | Photomultiplier R374. Spectral Respones; 160-850nm. | Hamamatsu |
| Data processing system | Super 386. | Taiwan |
| Recorder | Model IF4000, Output signal: 0-500mv. | Ifelec |

K. From this standard stock solution, a standard solution of 100 μg/ml K introduced into the concentric pneumatic nebulizer for the premixed burner was made.

The glass optic fiber is held on a supporter made by oneself. The fiber can be accurately moved along the lines of horizontal and vertical on this supporter. When the optic fiber is moved , the distance between the end of the optic fiber and the vertical of the flame slot is consistently kept in 8mm, in order to prevent destruction of the fiber optics by the flame and to keep unanimous in the collecting light condition. Thus, accurately scanning entire flame will be ensured. The glass fiber optics has fiber diameter of 3. 0mm. The photomultiplier supply voltage is -740 volts.



## RESULTS AND DISCUSSION

1. Temperature calculation can be given measuring temperature theory of two-line spectroscopic method. The equation for the flame temperature is given by[10]

$$T = \frac{\frac{hc}{k}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)\log e}{\log\left(R \cdot \frac{I_{\lambda_1}}{I_{\lambda_2}}\right) - \frac{1}{2}\log\left(\frac{f_{\lambda_1}}{f_{\lambda_2}}\right) - \frac{1}{2}\log\left(\frac{r_1}{r_2}\right) - 3\log\left(\frac{\lambda_2}{\lambda_1}\right)} \quad \text{in Kelvin} \quad (1)$$

where $h$ is Planck's constant. $k$ is Boltzmann constant. $c$ is the speed of light. The wavelengths $\lambda_1$ and $\lambda_2$ are 766. 5 nm and 404. 4 nm for potassium, respectively. For potassium oscillator strengths $f_{\lambda_1}$ and $f_{\lambda_2}$ equal 1. 4 and 0. 23[11], respectively. The damping constant $\frac{r_1}{r_2}$ equals 0. 4. R is the instrument response function of the optic fiber rapid scanning spectrometer system. After spectral line intensities $I_{\lambda_1}$ and $I_{\lambda_2}$ for potassium are measured, flame temperature T can be estimated by this expression.

2. We know photomultiplier spectral response and energy transmissive attenuation of monochromator and fiber optics vary with the change in the wavelength. It is necessary to calibrate the rapid-scanning spectrometer with the fiber optics to eliminate influence of photomultiplier spectral response and energy

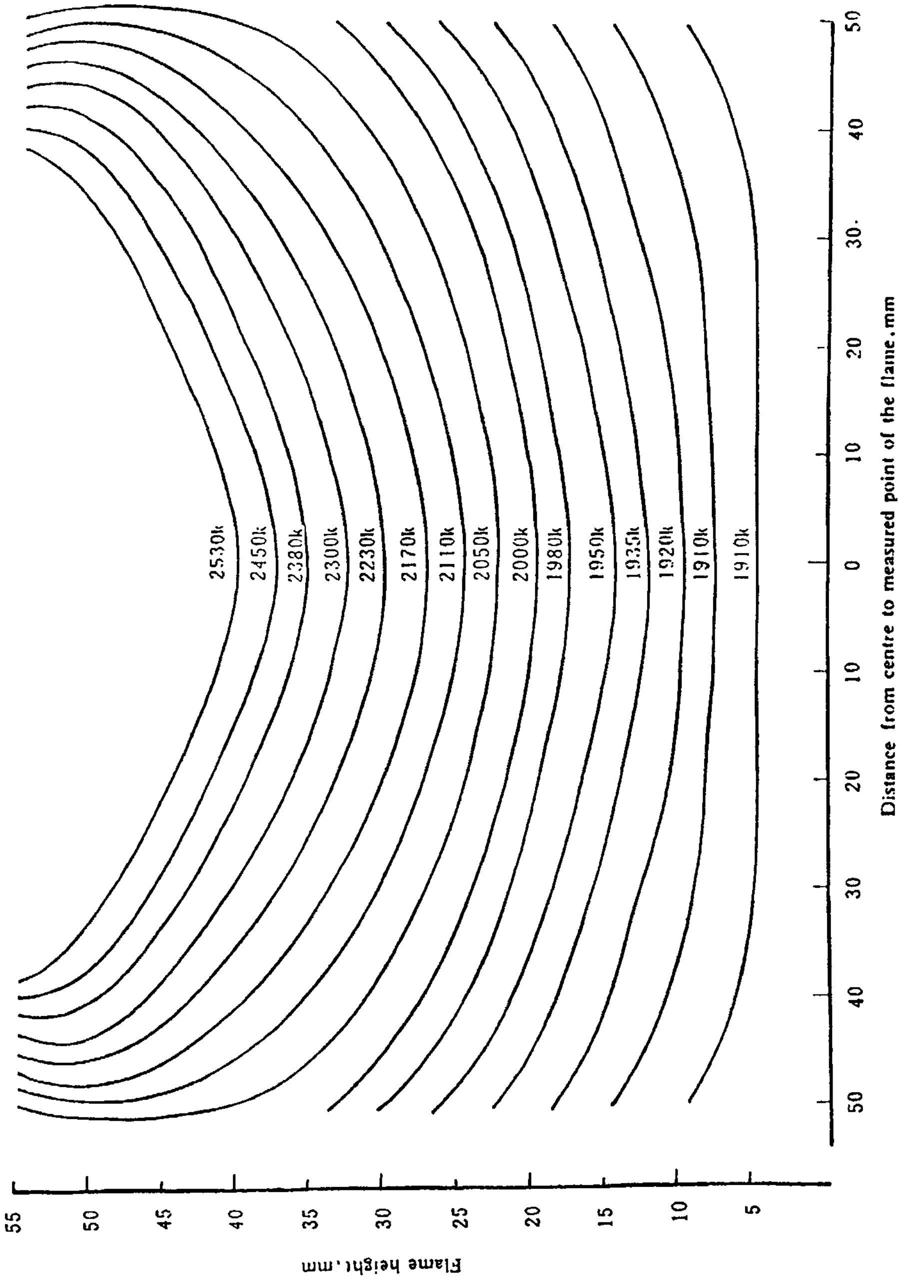


Fig. 2. Flame temperature distribution of slot burner premixed air-acetylene.

transmissive attenuation of both monochromator and fiber optics on measured spectral intensities at various wavelengths. The conventional procedure is used to complete this system. To do this, a standard tungsten ribbon lamp was placed in front of the fiber input end . The distance between the end and lamp is 8mm. Then we measure light intensities $W_{\lambda_1}$ and $W_{\lambda_2}$ of the lamp at 766. 5 and 404. 4 nm, respectively. The light intensity $W_{\lambda_1}$ was divided by light intensity $W_{\lambda_2}$ to give the instrument response function (R), i. e. $R = W_{\lambda_1}/W_{\lambda_2}$. For this system, R equals 4. 55.

3. After measuring $I_{\lambda_1}$ and $I_{\lambda_2}$ of various points scanning the entire flame, we can obtain flame temperature distributions through Eq. 1. The flame isothermal distribution map measured shows in Fig. 2. The flame temperatures are obout between 1910~2530 K depending on the flame height. The flame temperatures increase with the flame heights. The flame maximum temperature is about 2500K. The maximum temperature measured in the present paper is in agreement with the literatures[12-14].

4. From the whole data measured, the flame is stabler when the height is in 5-25 mm. As the flame height increases, the flame stability decreases.

5. Its advantage is that a simpler apparatus used can accurately obtain temperature distribution over the entire section of the flame in high resolution.



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