VIABILITY OF FLAME TEMPERATURE MEASUREMENTS BY LOW RESOLUTION OH EMISSION SPECTROSCOPY

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INTRODUCTION

When energy is supplied to a body in particular forms such as heat or electrical discharges, the body restores part of this energy in the form of electromagnetic radiation. The analysis of this radiation as function of its wavelength is called an emission spectrum. Applied emission techniques can provide valuable insights into many flame processes. This is important in a variety of contexts, but it must always be remembered that emission techniques, when applied in the ultraviolet and visible part of the spectrum, are of peripheral interest for the analysis of major flame processes. Nonetheless there have been many interesting studies of the structure of the flame emissions and there is a substantial body of literature. Moreover emission spectroscopy techniques are line-of-sight techniques and different parts of the flame such as the primary and secondary combustion zones and the interzonal region, are observed. These radiation components are difficult to be separated and the observed spectrum can be difficult to be interpreted. Therefore some caution should be used in applying emission spectroscopy for flame diagnostics, but properly employed the technique can be quite useful [1].

The light emitted by the flame may be used to monitor and control combustion [2]. Several phenomena contribute to the light emission process. Discrete emission spectra in the UV-visible range (chemiluminescence) correspond to electronically excited species produced in the chemical reactions in the flame: A + B → C + D*.

This chemically excited radicals or molecule D* may be destroyed by spontaneous emission (D* → A + hν) or collisional quenching (D* + M → D + M). Chemiluminescence corresponds to the spontaneous emission of photons (hν = E2 – E1, with E2 the energy of the excited state and E1 the energy of the final state). This emission generally takes place in the UV or visible range. Each molecule or radical produced in an excited state is responsible for a particular spectrum, which is related to its quantum radiative properties, and can be identified. The radiative decay of excited species as the (0,0) band transitions of OH (A2∑→X2Π), CHO (A2Π→X2Σ+), CH (A2Σ+→X2Σ+), C2H (B2Σ+→X2Σ+) are mainly responsible for the chemiluminescence observed in the combustion of hydrocarbon fuels [3]; however, the chemical processes of excited species formation has not yet been definitely established. Very little attention has been directed in recent studies to the formation of excited species [4-10]. In this work, the spectra of the natural chemiluminescence of the OH* radical in ethanol/oxygen flame was detected and compared with that simulated with LIFBASE software to estimate the temperature. This method was used by Izarra [11] to measure plasma temperatures.

EXPERIMENTAL SETUP

Figure 1 illustrates the experimental setup. The system includes a homemade burner used with liquid fuel, a length of 30 cm and a local length, a monochromator TRIAX 550 with slit width of 0.55nm, resulting a spectral resolution of 0.02 nm, coupled to a photomultiplier. These monochromator is controled by SPECTRAX software. The light emitted by the flame may be used to monitor and control combustion [2]. Several phenomena contribute to the light emission process. Discrete emission spectra in the UV-visible range (chemiluminescence) correspond to electronically excited species produced in the chemical reactions in the flame: A + B → C + D*

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RESULTS AND DISCUSSIONS

Figure 3 presents emission spectra of flames at different temperatures from 3060 to 3100 Å. The height of peaks G0 (3063.7 Å) and G1 (3067.7 Å) were measured relative to Gref (3089.8 Å). The calibration curve was constructed by the ratio G0/G1 as function of the temperature using the simulated spectra (LIFBASE) from 1000 K to 3200 K in the 3060 Å to 3100 Å range. Figure 4 shows the emission spectra obtained at 2 mm above the burner for rich ethanol/O2 flames. The ratio G0/G1 determined in the experimental spectra is 1.37 and this gives a temperature of 1800 K, in good agreement with the temperature measured by LIF in this condition (1950 K) [11].

Figure 3: Emission spectra of flames at different temperatures from 3060 to 3100 Å. The height of peaks G0 (3063.7 Å) and G1 (3067.7 Å) were measured relative to Gref (3089.8 Å). The calibration curve was constructed by the ratio G0/G1 as function of the temperature using the simulated spectra (LIFBASE) from 1000 K to 3200 K in the 3060 Å to 3100 Å range. Figure 4 shows the emission spectra obtained at 2 mm above the burner for rich ethanol/O2 flames. The ratio G0/G1 determined in the experimental spectra is 1.37 and this gives a temperature of 1800 K, in good agreement with the temperature measured by LIF in this condition (1950 K) [11].

Figure 4: OH emission spectrum of a rich atmospheric ethanol/oxygen flame (φ = 1.48).

CONCLUSIONS

The group of unresolved lines G0 and G1 in the UV OH spectrum shows a good variation with the temperature, as shown in fig. 3, and can be used to study the temperature of flames. Different fuel/oxidant ratio conditions of the flame should be considered in future works.

REFERENCES