Responses of OH($X^2\Pi$) and OH($A^2\Sigma^+$) to the electrical current of dielectric barrier discharge in a plasma-assisted burner flame

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This work is categorized into a fundamental investigation of plasma-assisted combustion. It has been shown by many works that combustion chemical reactions are activated by superposing a nonequilibrium plasma onto a flame. It is believed that the activated chemical reactions are driven by high-energy electrons in the nonequilibrium plasma, but the fundamental understanding on the elementary processes is insufficient to date. In this work, we examined the responses of OH($X^2\Pi$) and OH($A^2\Sigma^+$) to high-energy electrons produced by a dielectric barrier discharge (DBD).

We employed a premixed burner with CH_4/O_2/Ar mixture. The burner nozzle worked as the ground electrode of DBD. The side of the slender flame obtained by the burner was covered with a quartz tube, and an aluminum electrode was attached on the outside of the quartz tube. A high-voltage power supply with a rectangular waveform was connected to the aluminum electrode. We thus produced asymmetric DBD inside the quartz tube. Laser-induced fluorescence (LIF) imaging spectroscopy was adopted for measuring the density of OH($X^2\Pi$), while the density of OH($A^2\Sigma^+$) was measured by optical emission spectroscopy. In addition, we examined the rotational temperatures of OH($X^2\Pi$) and OH($A^2\Sigma^+$) by analyzing the spectra of the LIF excitation and the optical emission.

The OH($X^2\Pi$) density in the presence of DBD was slightly (roughly 50%) higher than that in the absence. However, we observed no pulsed increases in the OH($X^2\Pi$) density at the timings of the current pulses of DBD. This indicates that the increase in the OH($X^2\Pi$) density is not caused by the direct effect of high-energy electrons. On the other hand, we observed pulsed increases in the OH($A^2\Sigma^+$) density (the optical emission intensity of OH) at the timings of the current pulses. The comparison between the optical emission intensities of OH and Ar indicates that the dominant production process of OH($A^2\Sigma^+$) is not electron impact excitation but is chemical reactions. Hence, there is a possibility that the chemical reaction that produces OH($A^2\Sigma^+$) has a closer relationship with high-energy electrons of DBD. We observed the decreases in the rotational temperature of OH($A^2\Sigma^+$) at the timings of the current pulses, which would be helpful information for identifying its production process.