Experimental Study on Laminar Lifted Methane Jet Flame Diluted with Nitrogen and Helium

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ABSTRACT

Laminar lifted methane jet flame diluted with nitrogen and helium in co-flow air has been investigated experimentally. This paper examines the role of chemistry, intermediate species responsible for stabilization of lifted flame. To elucidate the stabilization mechanism in lifted methane jet flames with Sc<1, the chemiluminescence intensities of CH* and OH* were measured using ICCD camera at various nozzle exit velocities and fuel mole fractions. It has been observed that the OH* species can play an important role in stabilization of lifted methane jet flame as they are good indicators of heat release rate which can affect on flame speed and increase stability through reduction in ignition delay time.

Key Words : Lifted flame, chemical effect, lift off height, stabilization.

The stabilization mechanism of laminar lifted flame in the near field of co-flow jets for diluted methane fuel and stationary lifted flame has been investigated experimentally[3]. The stabilization mechanism is revealed as the balance between the local flow velocity and propagation velocity of flame edge.

Also the lifted flame stabilization in hot co-flow environments [5] affected by the chemisty,role of species such as CH, OH, CH2O (which increased with strain) in flame stability(through reduction in ignition delay) has been investigated. Also it has been shown that intensities of chemiluminescence from CH*,OH* are good indicators of heat release rate [4]. Motivated by this present study was to clarify the role of chemistry in stabilization mechanism of lifted flame for methane diluted fuel. The intensities of chemiluminescence CH*,OH* has been meas-ured by the ICCD camera to examine the pre-sence of chemiluminescence with the lifted fla-me behaviour.

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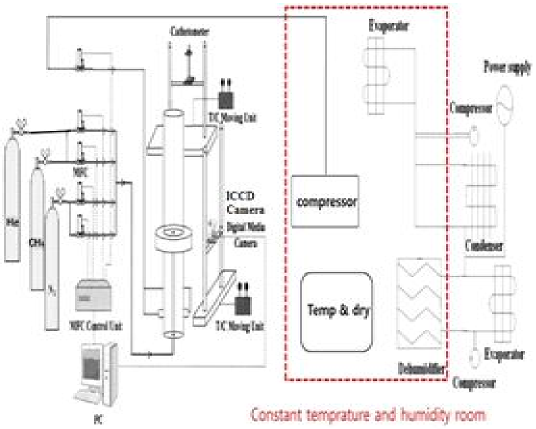


Fig.1 Schematic illustration of experimental set-up

The experimental apparatus consisted of a co-flow burner, mass flow controllers and measurement setup as shown in fig.1. The co-flow burner had a central fuel nozzle with I.d. 9.4mm and length is 100 times of the I.d. for the flow to be fully developed. The co-low air was supplied to the coaxial nozzle with 90.4mm I.d. through a glass beads and honeycomb for the velocity to be uniform. The tip of the fuel nozzle protruded 10.3mm over the honeycomb. A pyrex cylinder with 40cm length and 90.4mm I.d. was placed on the honeycomb, which confined the co-flow air to minimize outside disturbances.

The fuel was pure grade methane diluted with nitrogen and helium respectively, compressed air was used for the co-flow . The flow rates were controlled by mass flow controllers. The visualization setup consisted of a digital video camera and ICCD camera for visualization of chemical species. The lift off height was measured by a cathetometer.

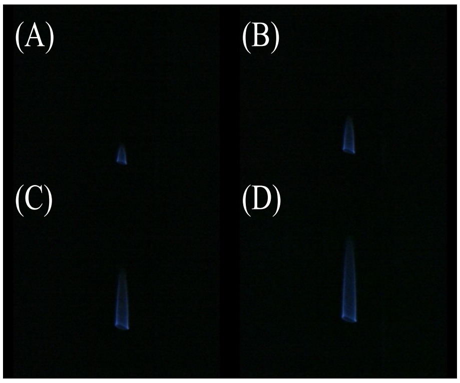


Fig.2. Direct photographs of stationary lifted flame with Xfo= 0.29 : (A) Uo= 5 (B) Uo= 10 (C) Uo= 15 (D) Uo= 20 cm/s.

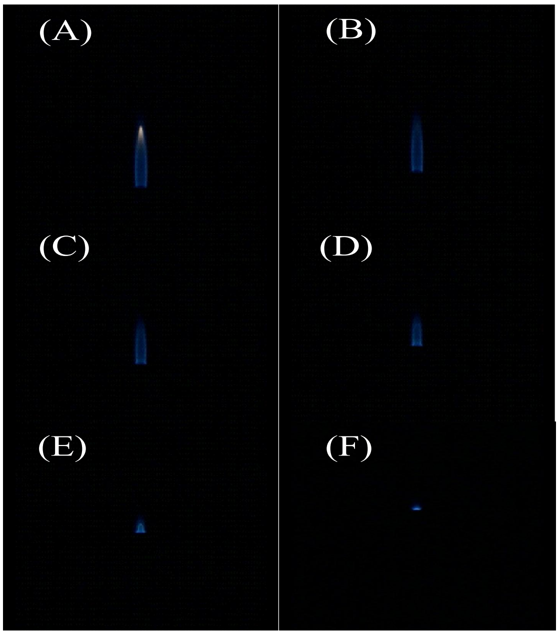


Fig.3. Direct photographs of lifted flame in methane diluted with helium at Uo= 14cm/s : (A) Xf,o= 0.45 (B) 0.4 (C) 0.35 (D) 0.3 (E) 0.25 (F) 0.21

Fig.2 and 3 shows the lifted flame behaviour in methane jet lifted flame diluted with nitrogen and helium respectively.

Chemiluminescence emissions occur when excited radicals such as CH*, OH* formed within the flame front. To exmine the chemical kinetics normalized intensities of CH*, OH* chemiluminescence were measured at various jet velocities and fuel mole fractions in fig.4 and 5.

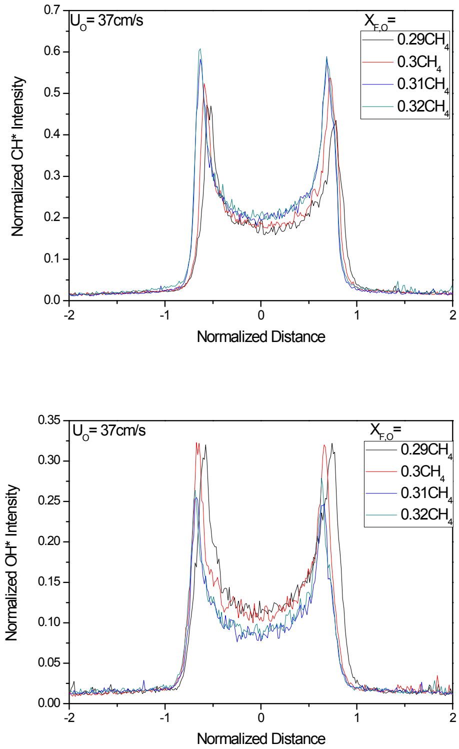
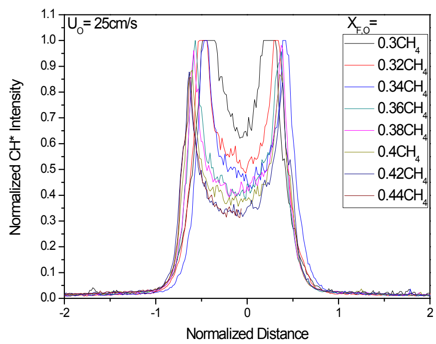


Fig.4. Measured CH* and OH* intensities at Uo=37cm/s for methane diluted with nitrogen.



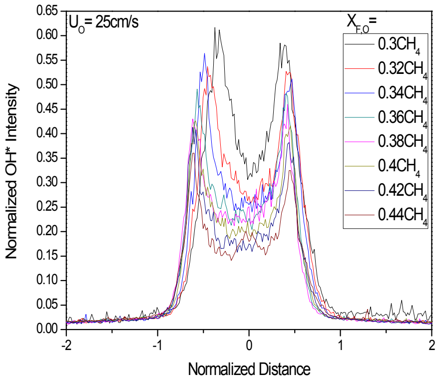


Fig.5. Measured CH* and OH* intensities at Uo = 25cm/s. for methane diluted with helium.

Conclusion

The stabilization mechanism of lifted flame in methane having SC<1 diluted with nitrogen and helium respectively has been studied. These lifted flame are observed due to chemical effect such as presence of CH*, OH* radicals which are good indicators of heat release rate and it affect on flame speed.

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