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Chemiluminescence Characteristics and Local CO Emissions of Premixed Flames

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Chemiluminescence

Imperial College London

What is Chemiluminescence?



Main excited molecules in hydrocarbon flames: OH^* , CH^* , C_2^* , CO_2^*



premixed CH₄ - air

premixed C_3H_8 - air



Open issues on the chemiluminescence?

- Use Chemiluminescence as a diagnostic.
 - Is chemiluminescence in thermal equilibrium state?
 - Its relation with flame condition?
- The mechanism of Chemiluminescence's formation and quenching.
 - For OH^{*} and CH^{*}, their formation reaction paths are well known.
 - For C_2^* , few knowledge.
 - For CO₂^{*}, not known!

How to quantitate chemiluminescence?

Mole fraction of chemiluminescent species ~ 10⁻⁹ to 10⁻¹⁵ (ppt level)

- Analytical spectral analysis Spectrograph!
 - High wavelength resolution ~
 <0.1nm.
 - Wide wavelength range ~ UV-Vis.
- Spatial resolved
 - Collecting light only from a small volume.
- Time resolved
 - High SNR.
 - Short response time.
 - Spectral analysis ability.



Whether in thermal equilibrium state?



Calculated Chemiluminescent Intensity and Heat release rate (HRR) vs. Equivalence Ratio



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Calculated OH*/ CH* (A) chemiluminescent intensity ratios



Calculated CO₂*/ CH*(A) chemiluminescent intensity ratios



Relation between chemiluminescence and flame conditions



New CO₂^{*} chemiluminescence mechanism



CO+O₂+Ar mixture in shocktube



New CO₂^{*} chemiluminescence mechanism



What is Laser-induced fluorescence (LIF)



How to conduct the CO-PLIF measurement



How to conduct the CO-PLIF measurement



How to conduct the CO-PLIF measurement

Simi-quantitative measurement

- Online measure laser profile distribution with CO PLIF
- Remove chemiluminescence intensity



Primary result of CO-PLIF



Laser induced fluorescence

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Primary result of CO-PLIF



Take home message and future work

- Chemiluminescence can indicate flame's heat release rate, equivalence ratio and fuel compositions.
- The newly developed CO2* model combining with the existing OH*, CH* and C2* can reproduce the experimental results very well.
- C2* chemiluminescence and CO-PLIF can be employed to understand the position of CO generation, and what influence CO generation in fuel lean and rich flames.
- Chemiluminescence mechanism for blended fuel flames
- Chemiluminescence characteristics and mechanisms of cold flames and warm flames
- Laser profile calibration of CO-PLIF and instantaneously measurement of CO-PLIF.

Spectroscopy Based Combustion Diagnostic Techniques

Questions?

