Experimental study of premixed ozone-seeded DME/O 2 cool flames on a stagnation plate burner

Nabil Mokrani, Sébastien Batut, Laure Pillier, Christophe Hecquet, Guillaume Vanhove

▶ **To cite this version:**

Nabil Mokrani, Sébastien Batut, Laure Pillier, Christophe Hecquet, Guillaume Vanhove. Experimental study of premixed ozone-seeded DME/O 2 cool flames on a stagnation plate burner. European Combustion Meeting 2019, Apr 2019, Lisbonne, Portugal. . hal-04503631

HAL Id: hal-04503631
https://hal.science/hal-04503631

Submitted on 13 Mar 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

9TH EUROPEAN COMBUSTION MEETING 2019
14 – 17 APRIL 2019
LISBOA, PORTUGAL

Experimental study of premixed ozone-seeded DME/O_2 cool flames on a stagnation plate burner

N. Mokrani*, S. Batut, L. Pillier, C. Hecquet and G. Vanhove
Univ. Lille, CNRS, UMR 8522 - PC2A - Physicochimie des Processus de Combustion et de l'Atmosphère, F-59000 Lille, France
*nabil.mokrani@univ-lille.fr

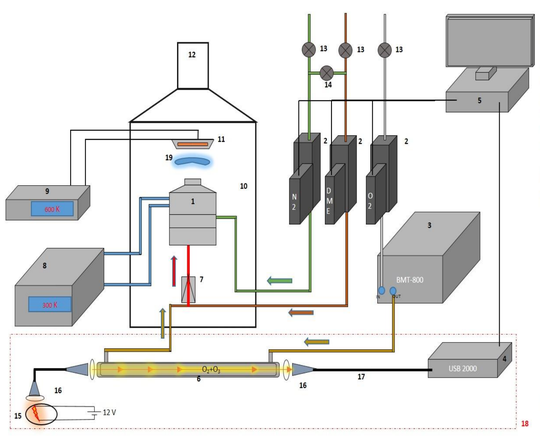
Introduction

Context: Need for research effort on the LTC kinetics to enable new low-emission engine concepts (SACI, PPCI, GCI…)

- Development of a new burner stabilized premixed cool flame setup,
- Burner characterization as a function of strain rate, equivalence ratio and ozone concentration,
- Development and validation of new kinetic models (the first tests are with : DME+ O_2 + 0 to 6,84 mol% O_3)

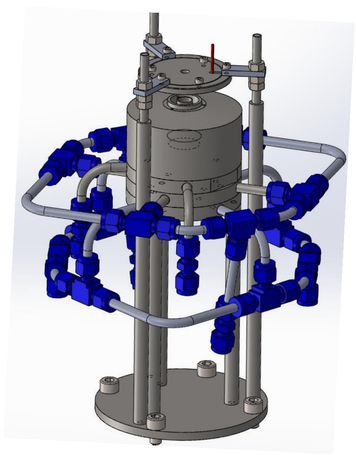
Experimental setup and procedure

Stagnation plate stabilized cool flame experimental setup



1. Pre-mix burner
2. Gas flow meters
3. Ozone generator
4. Spectrometer USB2000
5. Acquisition Unit
6. Optical cell (1 m)
7. Check valve (10 mbar)
8. Water cooler
9. temperature controller
10. Insulation and protection frame
11. Heated plate
12. Extraction of burned gases
13. Valves
14. Purge valve (for DME)
15. Lamp
16. Collimator
17. Optical fiber
18. O_3 measurement system
19. Cool-Flame

Stagnation plate burner



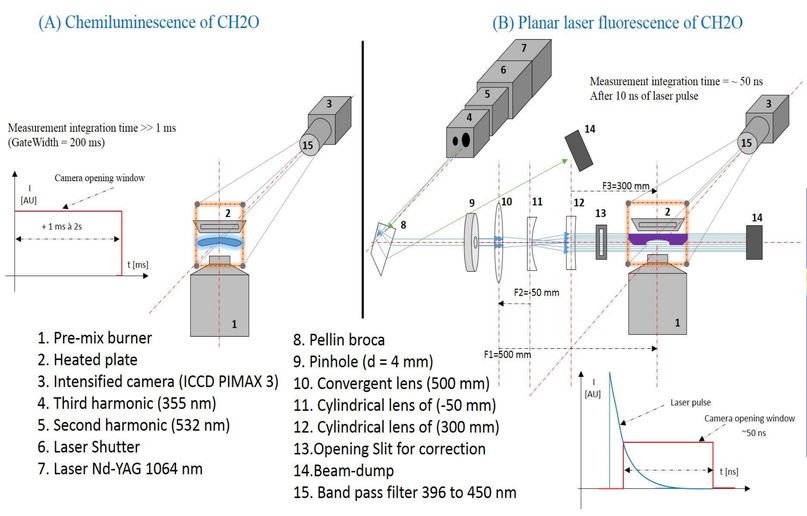
Ozone concentration:

$$C\,[g/m^3] = -\frac{10^6}{\sigma l}\frac{M}{N_a} ln\left(\frac{I}{I_0}\right) \quad (1)$$

Strain rate:

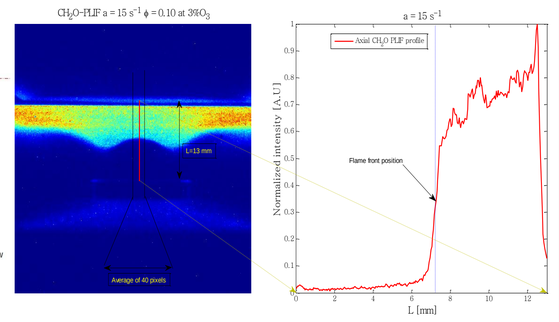
$$\alpha[s^{-1}] = \frac{V}{L} \quad (2)$$

Diagnostic methods used



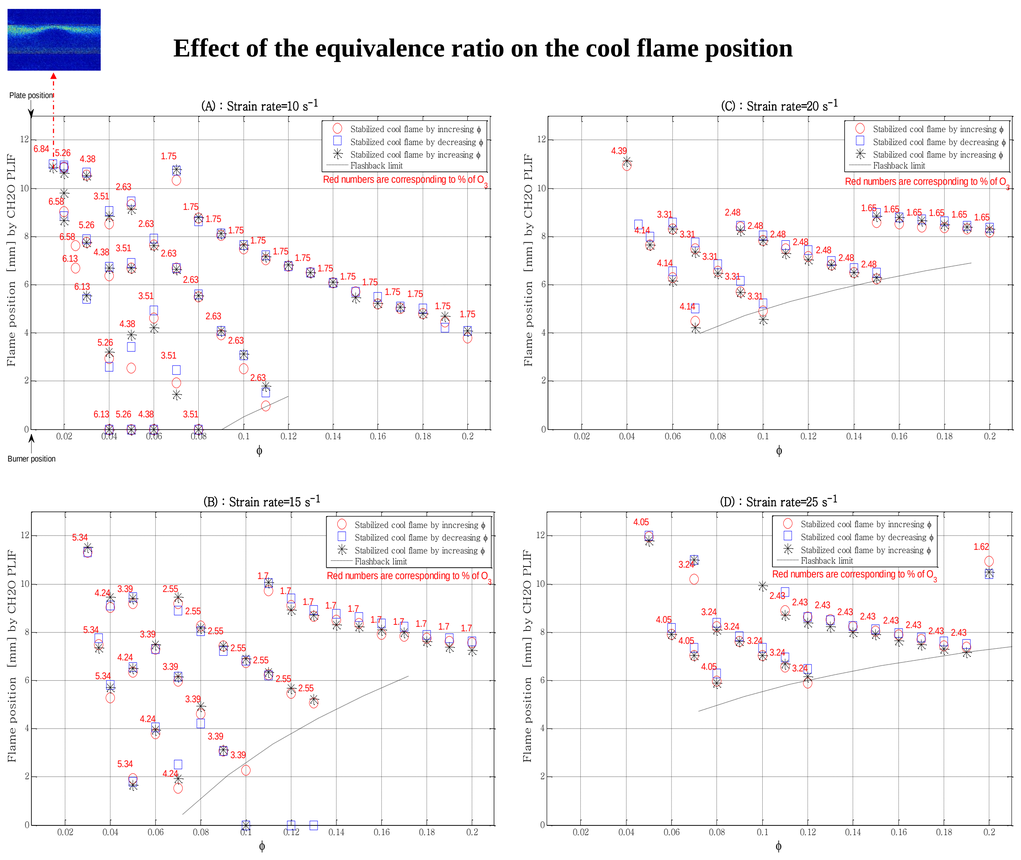
1. Pre-mix burner
2. Heated plate
3. Intensified camera (ICCD PIMAX 3)
4. Third harmonic (355 nm)
5. Second harmonic (532 nm)
6. Laser Shutter
7. Laser Nd-YAG 1064 nm
8. Pellin broca
9. Pinhole (d = 4 mm)
10. Convergent lens (500 mm)
11. Cylindrical lens of (-50 mm)
12. Cylindrical lens of (300 mm)
13. Opening Slit for correction
14. Beam-dump
15. Band pass filter 396 to 450 nm

Principle of analyses of the CH_2O PLIF images: determination of the flame front position



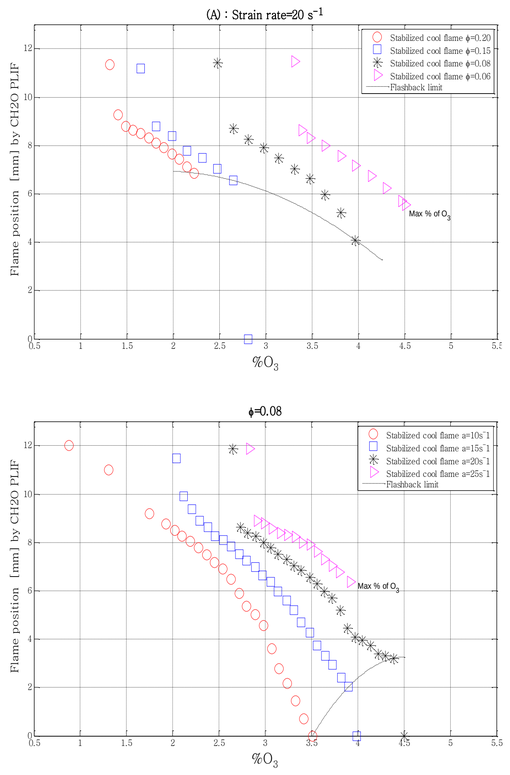
Results

Effect of the equivalence ratio on the cool flame position



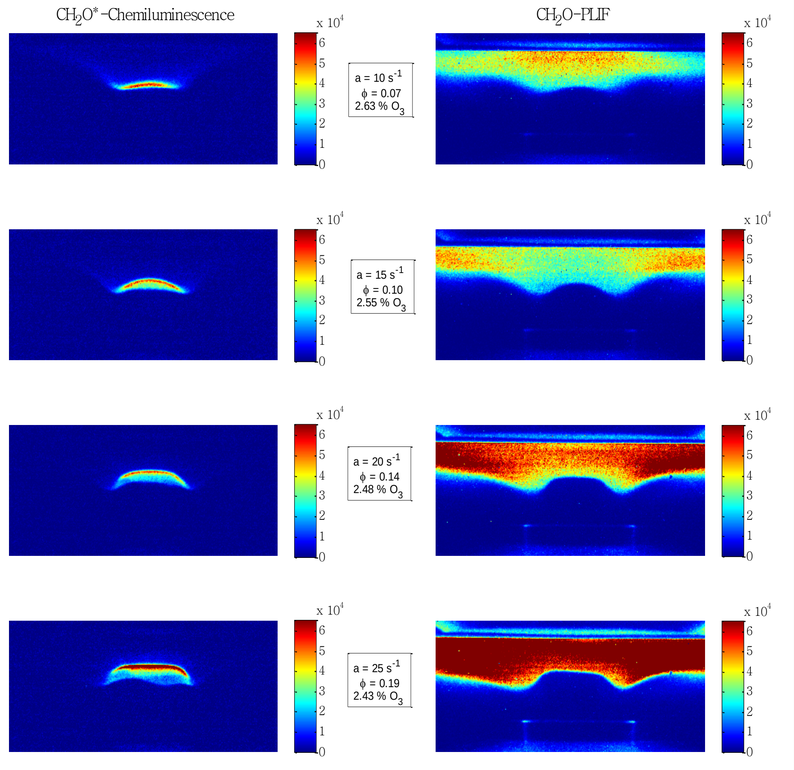
- Good reproducibility within a large range of operating conditions (α, ϕ and $\%O_3$).
- Flame front position decreases as the equivalence ratio increases.
- Increase of the strain rate enables the occurrence of flashback, especially at the highest equivalence ratios (ϕ > 0.10).
- Flashback domain tends to move towards the plate as the value of the strain rate increases

Effect of the ozone mole fraction



- As the equivalence ratio decreases, the necessary ozone for cool flame stabilization increases.
- As the strain rate increases, the necessary ozone for cool flame stabilization increases.

Chemiluminescence vs CH_2O-PLIF (Cool-Flame characteristics)



- Intensity of the CH_2O-PLIF and CH_2O^* signals increases with the strain rate and equivalence ratio.
- The shape of the flame front is more flat as the strain rate increases.

Conclusions

- The novel stagnation plate burner designed for the study of LTC reactivity is now functional
- An experimental database of flame front positions has been constituted
- Good reproducibility of the results in large range of α, ϕ , and $\%O_3$
- Ozone is strongly efficient in facilitating the LTC reactivity

Outlooks

Next step will be dedicated to the experimental study of the chemical aspects of the stabilized cool flames, by means of ex-situ (i.e., after sampling) methods. The current and future experimental data will be used as a validation target for kinetic models.

Acknowledgments

This work is a contribution to the CPER research project CLIMIBIO. The authors thank the French Ministère de l'Enseignement Supérieur et de la Recherche, the Hauts-de-France Region and the European Funds for Regional Economical Development for their financial support to this project. The authors also would like to thank the technical staff from PC2A laboratory for the help in the construction of the burner.