Spatial and temporal analysis of acetone decomposition and subsequent OH formation in nanosecond diffuse discharge

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Planar laser induced fluorescence is employed to determine both the acetone (C_3H_6O) and the OH radical distribution during the post-discharge of a high voltage (85 kV), pulsed (10 Hz), nanosecond (10 ns), atmospheric pressure, centimeter gap (1.8 cm), diffuse pin-to-plane discharge operating in air containing different acetone concentrations (2000, 5000 and 10000 ppm). We determine both the spatial (in the whole interelectrode gap) and temporal (in post-discharge (t_{pd})) acetone Destruction and Removal Efficiency fraction DRE and the OH density [OH]. We emphasize both the largest acetone decomposition (~60 %) and the maximal OH density (5.10^{16} cm^{-3}) in the pin region for the highest acetone concentration value (10000 ppm).

1. Introduction

We investigated the spatial and temporal behavior of a pollutant, the acetone using Planar Induced Laser Fluorescence *PLIF* technic. Quantitative values concerning the destruction of the acetone and its conversion into OH are given. These spatial measurements are undertaken in a novel pin-to-plane discharge operated at very high voltage and short pulses. This study is intended to provide useful information about chemical kinetic in atmospheric plasma processes dedicated to environmental remediation.

2. Experimental

The pin-to-plane discharge set-up [1] consists of a pin electrode powered by a nanosecond (10 ns), pulsed (10 Hz) high voltage (85 kV) power supply and a grounded plane electrode which are separated by 18 mm and mounted on a cylindrical stainless steel chamber equipped with optical windows in order to achieve PLIF measurement. The acetone is mixed at 2000, 5000 and 10000 ppm with dry air thanks to a bubbler system and the total gas flow rate is set to 1 L/min. PLIF experiments were performed in temporal post-discharge. The PLIF technic and the absolute calibration for OH density determination have been largely described in the literature [2] and will be not detailed here. Concerning the acetone processing, as the acetone is already introduced in the gas mixture, it consists of taking the LIF image without and with plasma discharge. The subtraction of these two images divided by the LIF image without plasma gives directly the quantitative DRE of acetone,

$$\mathrm{DRE}\ (C_3H_6O) = \frac{[C_3H_6O]_0 - [C_3H_6O]}{[C_3H_6O]_0} \qquad \textbf{(1)}$$

where, $[C_3H_6O]_0$ and $[C_3H_6O]$ are the initial and the final concentration of acetone, respectively.

3. Results: an overview

The **Figure 1** gives an overview of the spatial distribution profile in the interelectrode gap for air plus 10000 ppm of acetone mixture at 85 kV of (a) the acetone DRE and (b) the OH radical density.

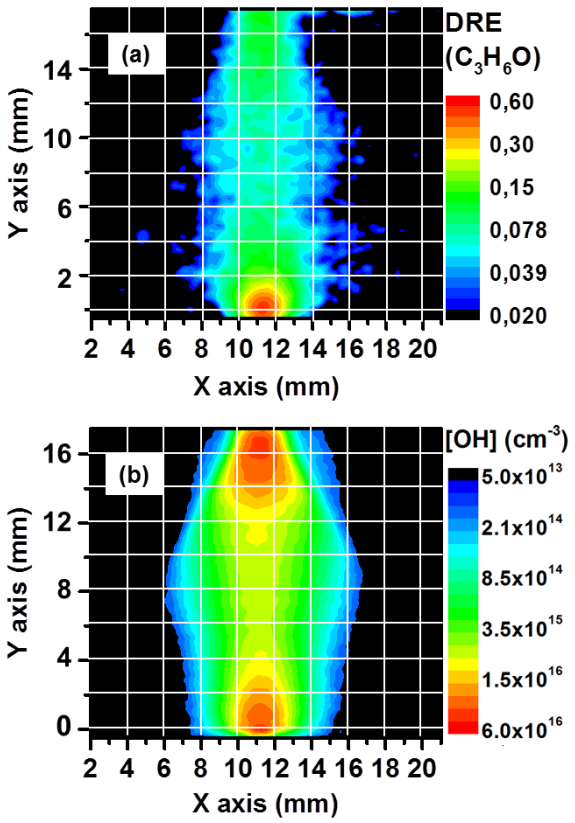

Figure 1. Spatial distribution of (a) DRE of acetone at t_{pd}= 200 µs and (b) OH density at t_{pd}= 0.5 µs.

3. References

[1] P Tardiveau *et al* 2016 *Plasma Sources Sci. Technol.* **25** 054005

[2] T Verreycken *et al* 2013 *J. Phys. D: Appl. Phys.* **46** 464004