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## 2<sup>nd</sup> Symposium on Ammonia Energy

# On the Difficulty of Interpreting NO-LIF Measurements in Confined Ammonia Flames

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### Introduction

Temperature measurements play an important role in understanding the chemical structure of a flame. One accurate technique that could be used to obtain a temperature profile in a flame is LIF thermometry. The concept of this technique is derived from the dependence of the population distribution of a molecule/atom on the temperature (Boltzmann distribution). In this method, an excitation scan is collected through tuning the laser over a range of excitation wavelengths to probe multiple ground states.

In this work, NO-LIF thermometry was selected to obtain the temperature profiles in three different laminar premixed ammonia flames stabilized at low pressure in a confined vessel. It is shown that NO-LIF measurements are difficult to assess in those conditions due to the accumulation of NO around the flame.

### Materials and Methods

Three laminar premixed ammonia flames ( $\text{NH}_3/\text{O}_2/\text{N}_2$ ) with different equivalence ratios ( $\phi=0.87, 1.1, \text{ and } 1.3$ ) are stabilized on a porous water-cooled stainless-steel McKenna placed in a stainless-steel enclosure at low pressure (10 kPa). To excite the NO A-X (0,0) band, a tunable laser source is used generating an ultraviolet beam at a wavelength around 225nm. The laser beam is delivered parallel to the burner surface intersecting it at the vertical axis. Two photodiodes are placed before and after the burner to check for laser energy variation at the center of the burner.

Fluorescence signal is collected at a right angle with respect to the laser beam. An optical system of two lenses is used to focus the image of a selected portion of the laser beam on the entrance slit of the monochromator. The monochromator's wavelength and bandwidth were adjusted to collect the fluorescence signal of NO A-X (0,2) vibrational band at 245 nm. A photomultiplier tube is placed directly at the exit slit of the monochromator. The collected signal is delivered to a numerical oscilloscope which transfers the data to a LABVIEW program.

To obtain the temperature profile, an NO-LIF excitation scan of range 225.45-225.71 nm is collected at each position in the flame. The collected signal has to be corrected for laser energy at the center of the burner. To do so, we divide the LIF signal by the signal collected by the photodiode placed after the burner.

To extract the temperature from the LIF excitation scan, an in-house software called "Thermo NO-LIF"<sup>1</sup> is used. Starting from the laser and instrumental bandwidth, this software synthesizes a library of NO excitation spectra. It then compares the experimental and the synthesized spectra to obtain the temperature through spectral fitting.<sup>2</sup>

### Results and Discussions

- Nearly stoichiometric ( $\phi=1.1$ ) and Rich ( $\phi=1.3$ ) Flames:  
The ratio of the two photodiodes (after/before burner) is constant along the scan range whatever the height above the burner (HAB) is. This indicates the absence of any wavelength dependent absorption in the range of measurement. Hence, it is possible to correct for energy at the center of the burner by considering the photodiode signal after the burner. The obtained temperature profiles are shown in Figure 1.

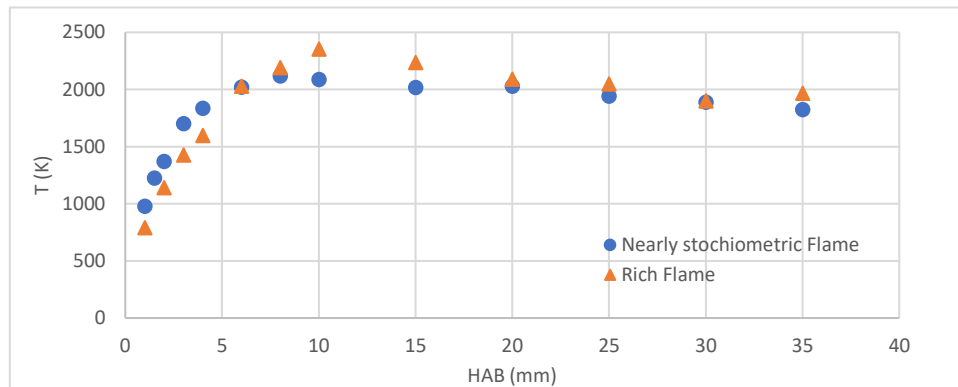


Figure 1 Temperature profiles obtained in the nearly stoichiometric and rich ammonia flames using NO-LIF thermometry.

- Lean ammonia flame ( $\phi=0.87$ ):

The ratio of the photodiodes shows clear NO absorption peaks. This is due to the accumulation of NO at low temperatures in the confined space around the burner. Figure 2 shows an excitation scan and the photodiodes ratio showing the NO absorption at HAB = 15mm. This shows that the laser energy at the center is not anymore represented by any of the photodiodes' signals.

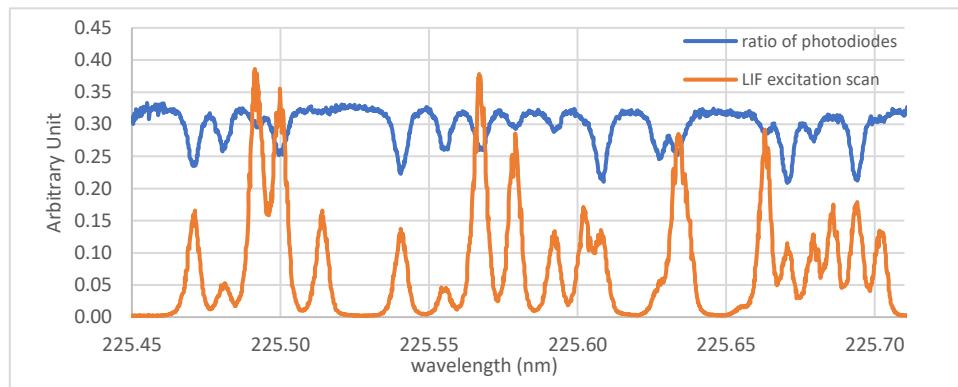


Figure 2 Excitation scan and photodiode ratio collected in the lean ammonia flame at HAB=15mm

## Conclusions

In this presentation, we propose alternatives to make NO-LIF measurements possible in the lean ammonia flames stabilized in confined vessels.

## Acknowledgement

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