Non thermal plasma-assisted MILD combustion of ammonia in a tubular flow reactor: an experimental and numerical study

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Abstract
Ammonia represents a promising renewable fuel. However, its combustion suffers from some limitations, like the high NOx emissions and flame instabilities.
The aim of this study is to demonstrate the feasibility of a synergistic coupling between MILD oxidation and Non-equilibrium Thermal Plasma (NTP) to enable efficient and clean ammonia combustion at lower temperatures with enhanced stability, while reducing NOx emissions.
These objectives are being studied through experimental and numerical studies: several experimental campaigns in a laminar plug flow reactor were carried out to characterize the effect of plasma on ammonia/oxygen/nitrogen mixtures. The PLFR consists in an alumina tube (1m long, ID=1cm). 12 thermocouples (type-N) were installed to resolve the oxidation process along the axial dimension of the reactor. The reactor exit was provided with a quartz window for optical inspections.
The reactor was allocated into a couple of semi-cylindrical fibre electrical heaters, electrically connected in parallel to a maximum electrical power supply of 5 kW.
To ensure a better system-thermal insulation, ceramic fibre blankets were positioned around the heaters, and all the system was located inside a vermiculite box.
The temperature profiles detected by each thermocouple are continuously acquired by a LABVIEW program realized ad-hoc. It allows also for the control of the heaters temperature through a PID control. The exhausted species were analysed through several instruments (TESTO 350, Horiba FTIR, SICK, micro-GC) for the measurement of stable species (H_2, NH_3, N_2) and pollutants (NO, N_2O, NO_2).
The plasma is generated through G2000 REDLINE, while current and Voltage probes were installed and connected to a TEKTRONIX MSO24 oscilloscope. Real time voltage, current and deposited power were continuously acquired.
The preliminary experimental tests showed non-thermal plasma can improve the ammonia oxidation process towards a higher reactivity and larger stability ranges, while reducing NO_x emissions. Simultaneously, ChemPlaskin software, coupled with Chemkin PRO, were used for the simulation of the experimental data. The simulations were able to predict the main effects of non-thermal plasma effect on the ammonia oxidation chemistry under MILD conditions.
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