Experimental and simulation investigations of the combustion of blends of ammonia with hydrogen and natural gas in industrial non-premixed burners

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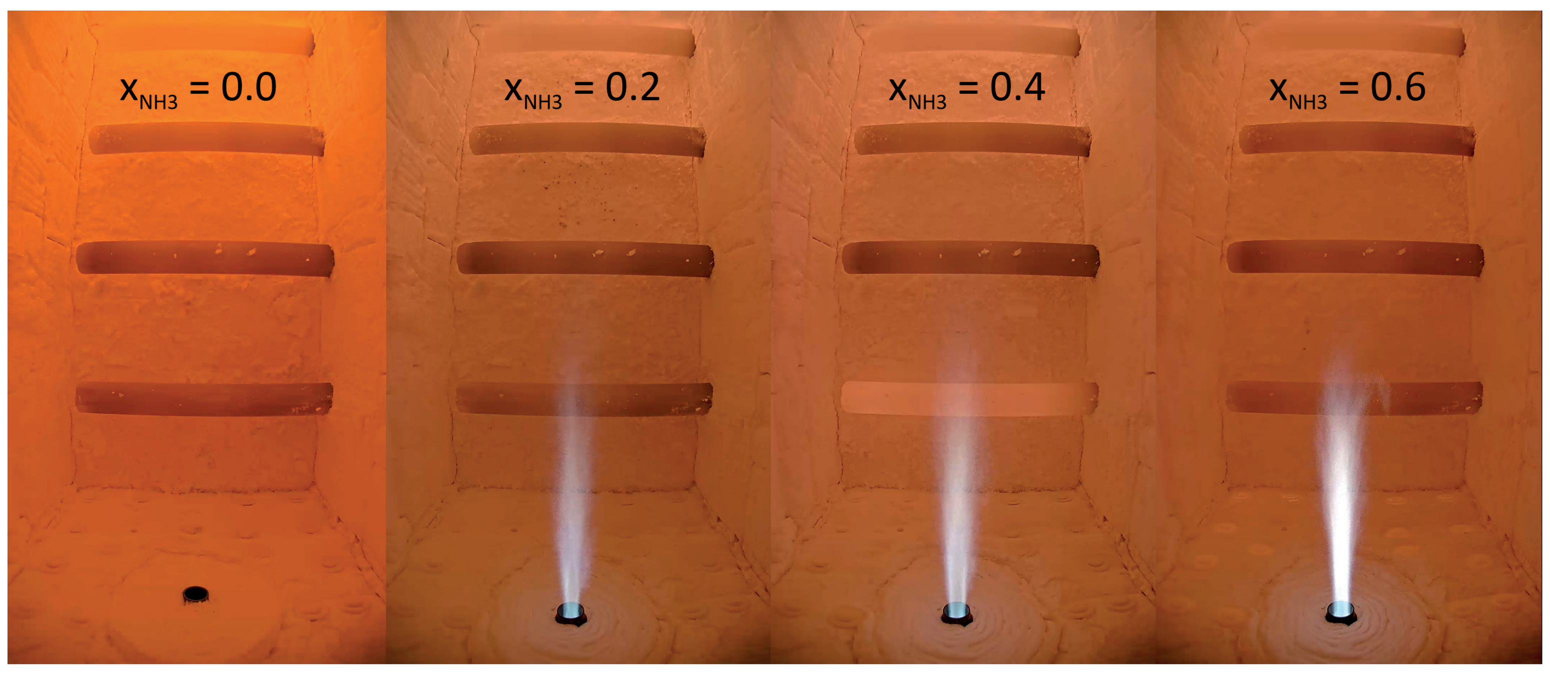
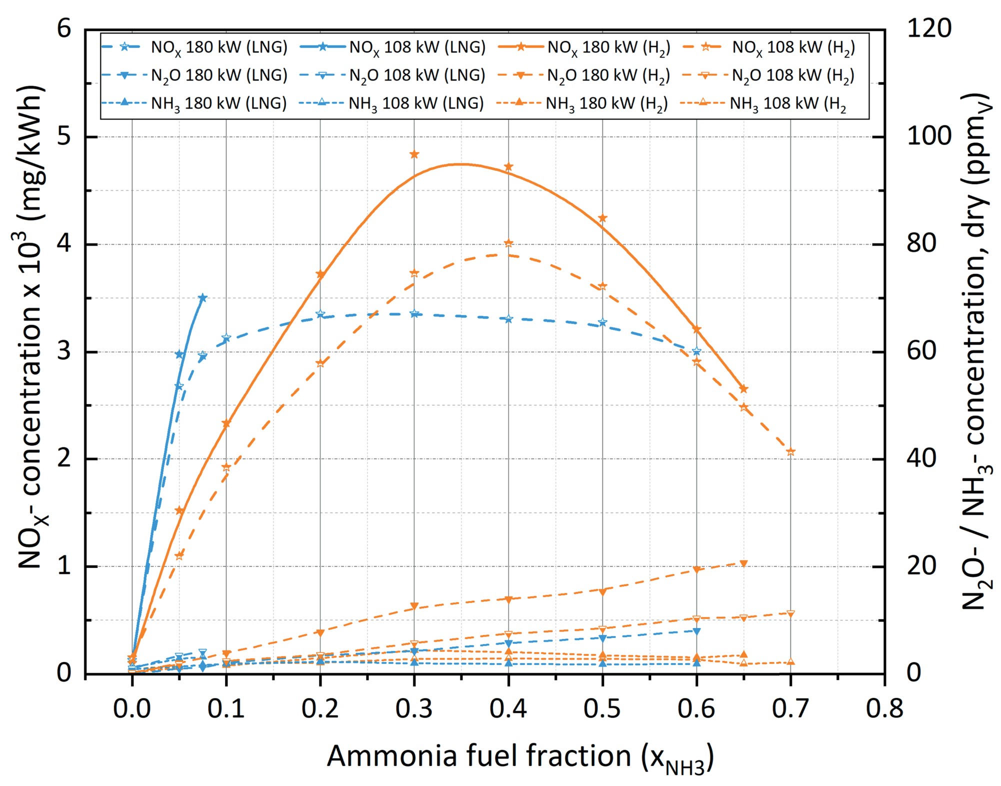
Objectives

In the context of decarbonization, the use of renewable fuel gases such as hydrogen or synthetic methane (SNG) is a promising option to replace fossil fuels in the thermal processing industries. In addition to hydrogen as a carbon-free energy carrier, ammonia (NH_3) is increasingly being considered as a possible fuel for combustion processes. While NH_3 has significant advantages over hydrogen in terms of liquefaction, storage and transport, its unfavorable combustion properties and high NO_x formation potential present many technical challenges. To this end, the use of ammonia as a fuel gas has been investigated both on a laboratory scale as well as under semi-industrial conditions.

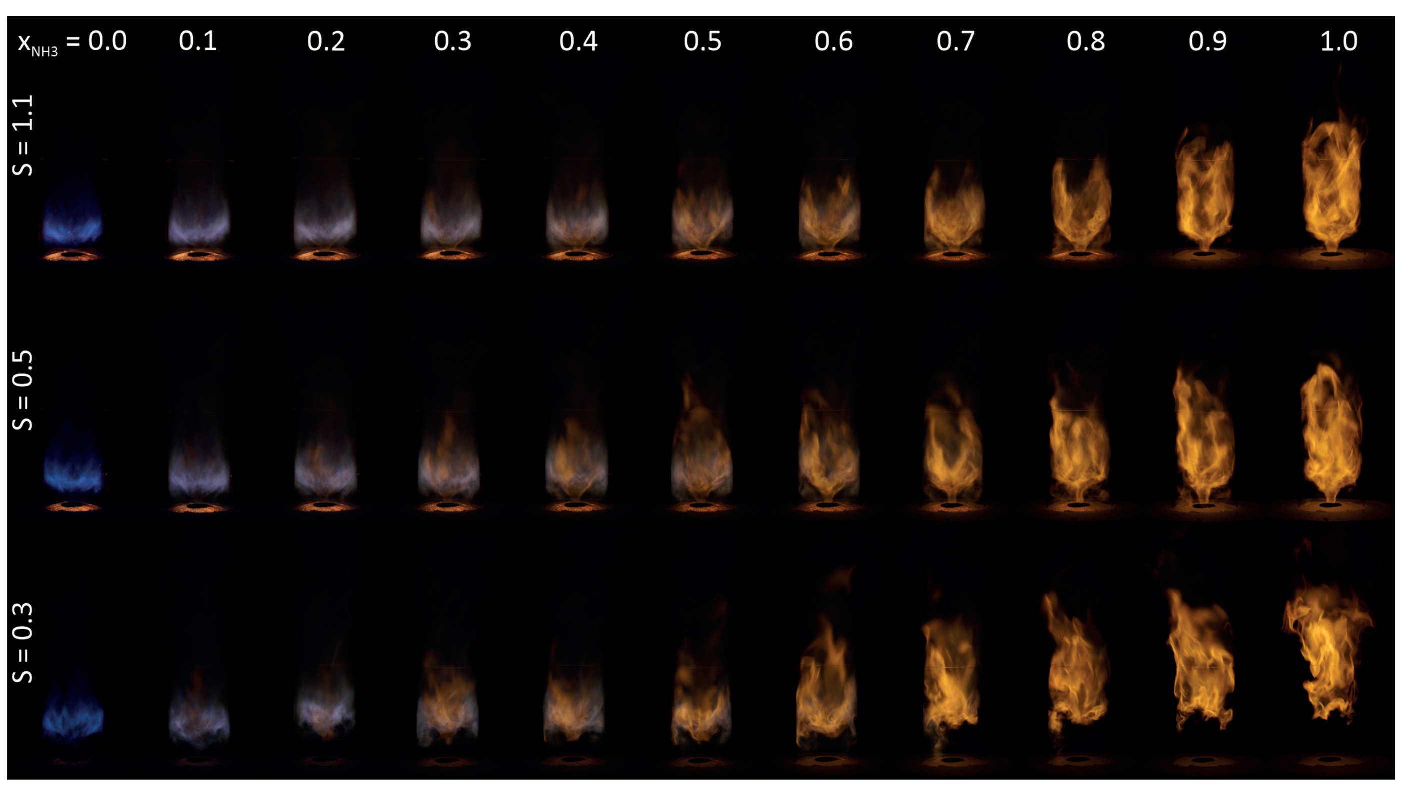


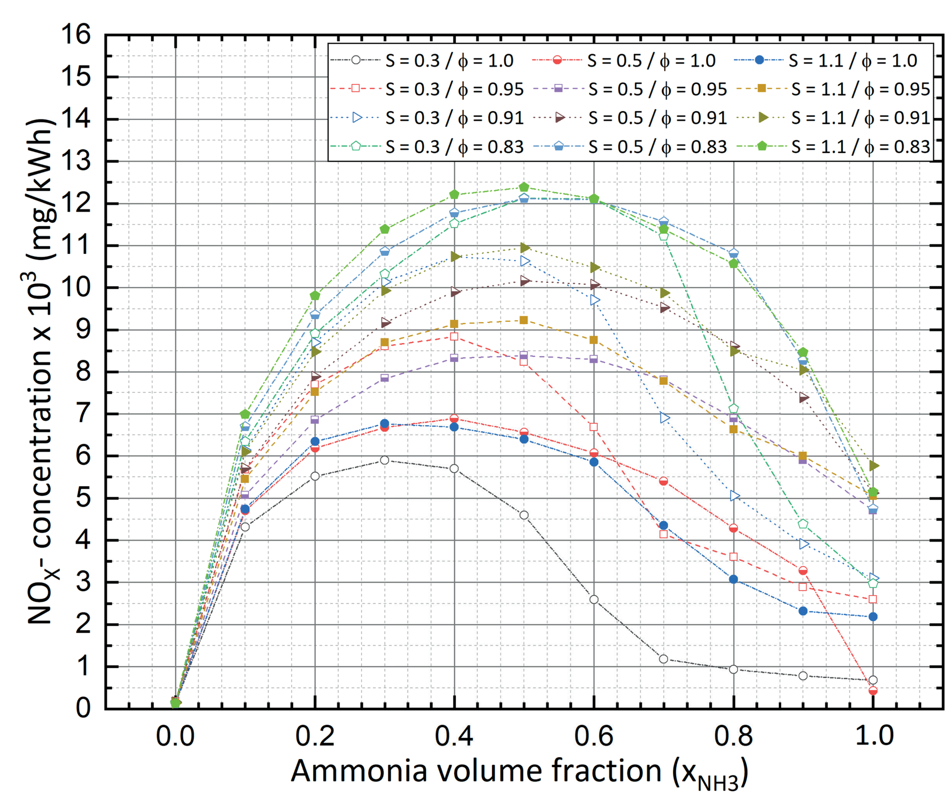


INITIAL STUDIES WITH AN INDUSTRIAL BURNER TO DETERMINE THE MAXIMUM NH_3 ADMIXTURE RATE IN COMBINATION WITH H_2 AND LNG

Experimental Results:

- flame stability limits were found to be x_{NH3} = 0.075 for LNG and x_{NH3} = 0.65 for H_2 at the nominal load
- small amounts (x_{NH3} = 0.05) lead to a drastic increase of NO_x compared to pure LNG / hydrogen
- the choice of the support gas (LNG or H_2) has a great impact on NO_x formation when burning ammonia





LABORATORY-SCALE EXPERIMENTAL STUDIES WITH A CUSTOM-DESIGNED BURNER

Experimental Results:

- a stable combustion of pure ammonia flames in the lab-scale burner could be established at a Swirl Number of S = 0.5 - 1.1 at equivalence ratios of $0.83 \leq \Phi \leq 1$
- low ammonia admixture rates increase the NO_x level drastically over those of a pure methane combustion and show a maximum concentration at approx. x_{NH3} = 0.5
- an admixture of $x_{NH3} \geq 0.6$ has a decreasing effect on the resulting NO_x, N_2O and NH_3 concentrations in the flue gas

Conclusions and Outlook

- ammonia is characterized by a high minimum ignition energy and low laminar combustion velocities
- flame stability was found to be highly dependent on the type of carrier gas and burner geometry
- all the studies that have been carried out show a tendency for NO_x concentrations to increase at low NH_3 admixture rates and for concentrations to decrease at higher ammonia volume rates. An increase in the equivalence ratio also led to a reduction in the NO_x concentration in all cases studied
- in summary, ammonia is in principle a suitable carbon-free fuel, both pure or admixed to other fuels e. g. Hydrogen. In order to achieve stable combustion and reduce the high NO_x levels, modifications

Project partner:

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