NO_x formation via microwave air plasma and down-stream catalyst

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In this contribution, we report measurements of NO_x concentrations and energy costs of a microwave (MW)-driven atmospheric pressure plasma and down-stream catalyst by FTIR spectroscopy and investigate possible reaction mechanisms of plasma assisted NO_x formation on the catalyst surface. Findings suggest that surface-mediated reactions involving plasma activated nitrogen and oxygen are responsible for additional NO_x formation.

1. Introduction

The coupling of plasma with heterogeneous catalysis has been shown to synergistically enhance NO_x formation beyond formation of NO_x from plasma or catalysis alone [1]. Models and experiments suggest that surface adsorbed N and O, via plasma activated nitrogen and oxygen, may be responsible for the observed synergy [2, 3, 4]. However, these synergies are observed for low temperature plasmas, such as glow discharges.

Here, we demonstrate that plasma-catalyst synergy is also a possible way to improve microwave plasma NO_x formation and that mechanisms are likely similar.

2. Methods

A MW-driven atmospheric pressure air plasma is used together with a 1.6 mm sphere diameter Al_2O_3 packed-bed down-stream. FTIR samples are taken after the packed bed. To investigate synergistic effects the fill volume of catalyst was varied together with the plasma-catalyst distance and the temperature of the pellet bed was monitored with K-type thermocouples (Fig. 1).

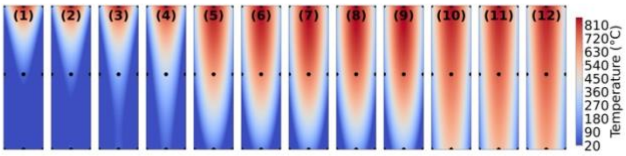

Fig. 1: Heat profile of the downstream catalyst bed for the twelve measurements taken in a total of 30 minutes.

3. Results and Discussion

Figure 2 shows energy cost, NO_x concentration and the NO_2/NO ratio, as a function of reference temperature, which is taken at the top outside of the catalyst bed, i.e. the catalyst bed is very inhomogeneous (fig. 1), and this metric only represents the passive heating up of the bed. It demonstrates how the NO_x formation is connected to the amount of catalyst, the plasma-catalyst distance and the catalyst temperature. As adsorption and desorption is possible, the NO_x concentration is time integrated to show enhanced total production. The extra production is speculated to be due to surface adsorbed N and O species on the Al_2O_3 surface, from the plasma exhaust [2, 3, 4].

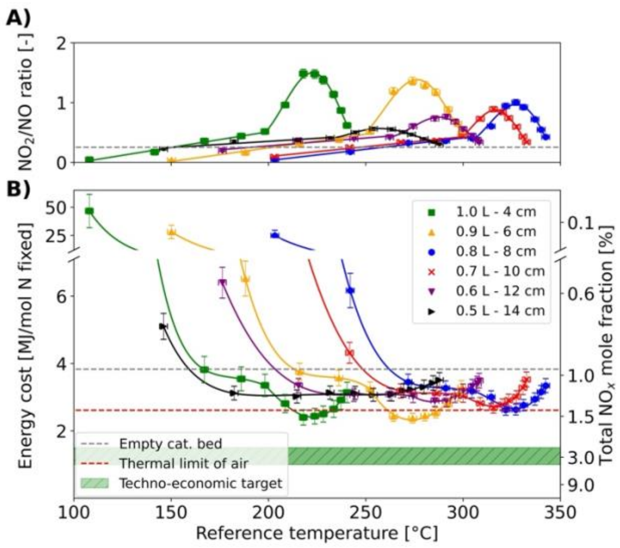

Fig. 2: A) NO_2/NO ratio and B) Energy cost and NO_x concentration with respect to the reference temperature for different Al_2O_3 fill volumes.

4. Conclusion

Microwave plasma-catalyst synergy was investigated for NO_x production. It was demonstrated that total NO_x formation can be enhanced by placing Al_2O_3 pellets down-stream. For optimization catalyst amount, plasma-catalyst distance and catalyst temperature play key roles.

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