Influence of dielectric barrier thickness on the reactor temperature of glass beads packed bed DBD reactor

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A glass beads packed bed dielectric barrier discharge (PBDBD) reactor is used in this work to study the effect of wall thickness of the reactor on the evolution of the reactor wall temperature and on the formation of by-products such as NO_x and ozone. The temperature of the reactor wall increases with increasing the input voltage. The formation of ozone decreases when the reactor wall temperature is 47±1˚C which results in the formation of toxic by-products such as NO_2. The maximum ozone concentration is obtained for the reactor with a wall thickness of 1.5 mm, which shows a lower increase in temperature for a particular input power. The maximum toluene removal efficiency of 60±4% is obtained for the PBDBD reactor with a wall thickness of 1.5 mm.

1. Introduction

The removal of low concentration volatile organic compounds (VOCs) from an air stream using non thermal plasma (NTP) technology such as PBDBD reactor is of great interest due to its cost and energy efficiency. The temperature of the reactor and the packing material increases with the input voltage and this influences the plasma discharge characteristics and thus the VOC removal efficiency and the formation of by-products.

In this work, the influence of the dielectric barrier thickness of the PBDBD reactor on the reactor wall temperature and formation of by-products such as ozone and NO_2 are examined.

2. Experimental

The PBDBD reactor used in this work is a cylindrical DBD reactor filled with borosilicate glass beads (ϕ 3 mm, ε_r = 4.6). The inner stainless steel high voltage electrode (powered by an AC power supply of 50 kHz) is placed along the axis and an iron mesh around the outer surface of the dielectric barrier acts as ground electrode. The different reactor wall thicknesses (w) used in this work are 1.5, 2.0 and 3.0 mm. Dry air polluted with 300 ppm of toluene is fed into the plasma reactor.

The formation of different by-products after plasma treatment is investigated with FTIR. The concentration of ozone in the outlet stream is measured using an UV absorption based ozone detector (Teledyne, Model 465M). The temperature of the reactor is measured using a thermocouple (Farnell, Type-K) attached to the reactor wall in the middle of the discharge region.

3. Results

The temperature of the reactor wall increases with increasing the input power for a particular reactor wall thickness. Figure 1 shows that the increase in temperature (ΔT) is the lowest for the reactor with lowest wall thickness (w=1.5 mm). Figure 1 shows that the ozone concentration increases with increase in specific input energy (SIE) and then decreases when the reactor wall temperature of is higher than 47±1˚C due to thermal dissociation of ozone[1] and thus formation of NO_2 increases[2] due to ozone generation stop.

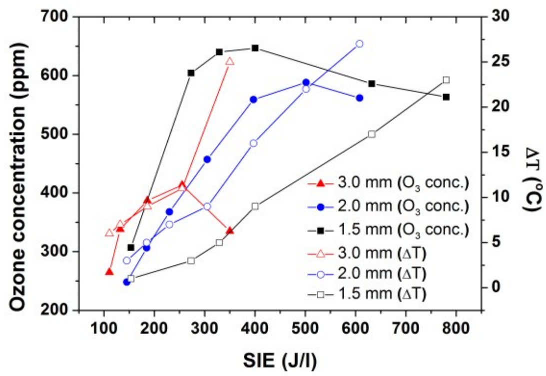

Figure 1. Ozone production (solid symbol) and increase in wall temperature (ΔT) after 10 minutes of plasma ignition (open symbol) as a function of SIE for PBDBD reactor of different reactor wall thicknesses (3.0 mm, 2.0 mm and 1.5 mm)

Thus the formation of ozone is higher for the reactor with wall thickness 1.5 mm as the increase in temperature for this reactor is lower for a particular input power. Also, the maximum toluene removal efficiency of 60±4% is obtained for the PBDBD reactor with the wall thickness of 1.5 mm.

4. References

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