16th Symposium on Application of Plasma Processes

SAPP

Workshop on Research of Plasma Physics and Applications in Visegrad Countries

Visegrad Fund

Book of Abstracts

Podbanské, Slovakia
January, 20-25, 2007

Edited by J. Matúška, Š. Matejčík, J.D. Skalný

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Ozone Generation by Microdischarges in Porous Ceramics.

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Abstract

Plasma-chemical activity of microdischarges generated inside porous ceramics by AC high voltage was investigated. Generation of ozone in mixtures of nitrogen and oxygen were tested to evaluate the chemical efficiency of the discharges. The effects of discharge power, gas mixture composition and gas flow rate on ozone generation are described.

Introduction

The generation of microdischarges in small pores, cavities and narrow capillaries of various ceramic materials has been studied recently [1-5]. The objective of these studies was the investigation of the physical properties of such microdischarges, but also to test them for the removal of nitrogen oxides and volatile organic compounds. The microdischarges generating plasma inside porous ceramics and catalysts represent a method with very high potential for various environmental applications, especially flue gas treatment. In our previous works [4-5] we studied the generation of microdischarges by using AC and DC high voltage power. We performed various electrical and optical measurements to describe their physical properties and determine the conditions of their stable generations and distribution inside the ceramics. The objective of the presented study was to test the chemical efficiency of the microdischarges. Generation of ozone in mixtures of nitrogen and oxygen was selected as a model case. In the paper, the results of the ozone generation as the function of discharge power, gas mixture composition and gas flow rate are presented.

Experimental Setup

Figure 1 shows the experimental setup. In the discharge reactor, a porous ceramics was placed between two metal mesh electrodes. The ceramics was composed of mainly alumina and silica and had diameter and thickness of 31 and 7 mm, respectively. In the previous studies [4-5] the optimal discharge spatial distribution was observed for the ceramics of 30-80 µm pore size, therefore 80 µm ceramics selected for the tests. AC high voltage power supply connected via a 5 MΩ series resistor limiting the total discharge current was used to excite the discharge reactor. The power was measured by digital multimeter Metex 3860M. The voltage at the reactor was measured by a high voltage probe Tektronix P6015A and the discharge current was measured using a current probe Pearson Electronics 2877 (1V/A) linked to the digitizing oscilloscope Tektronix TDS1012 (100 MHz, 1 GS/s). Gas analysis was performed by FTIR absorption spectrometer Perkin Elmer Spectrum BX II. Mixtures of oxygen and nitrogen (10, 20, 50 and 100% of oxygen) with the total gas flow 0.4, 0.8, 1.2 and 2.0 were tested. The pressure drop across the discharge reactor was measured by the digital manometer PCE P-30.

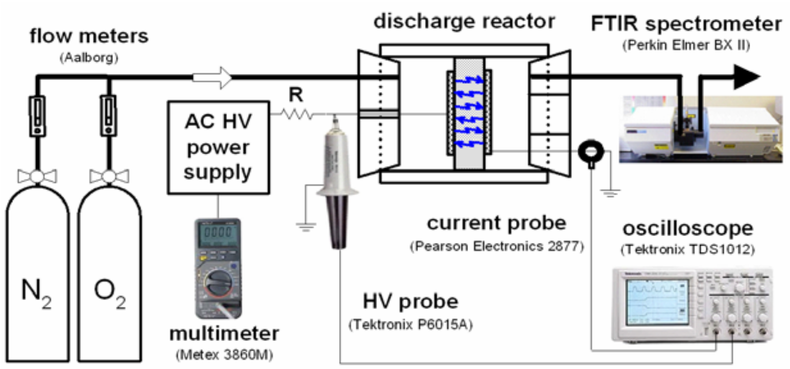

Figure 1: Schematic view of experimental setup.

Results and Discussion

The effect of the discharge power, the gas mixture composition and the gas flow rate was investigated. The pressure drop across the reactor was negligible and ranged from 0.1 kPa to 0.8 kPa for gas flow rates of 0.4 and 2.0 l/min, respectively. In pure oxygen, the concentration of generated ozone increased with the discharge power. For the given power, the concentration of ozone was higher for smaller gas flow (Fig.2). In the mixtures of nitrogen and oxygen, a maximum of the ozone concentration was observed at a certain power. With further increase of the power the ozone concentration decreased. The power at which the

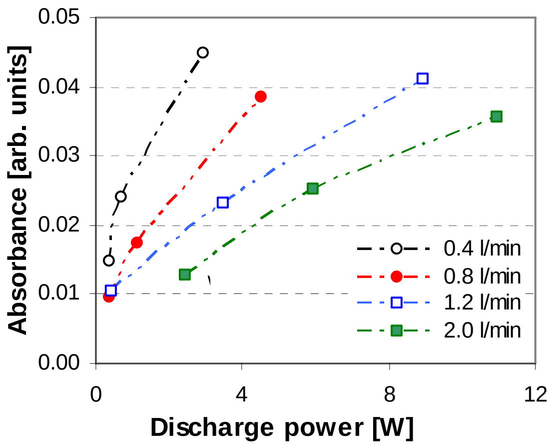

Figure 2: Ozone concentration as a function of power for various flow rate (pure O_2).

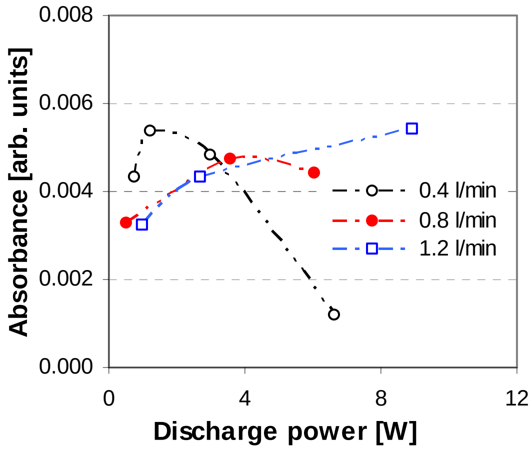

Figure 3: Ozone concentration as a function of power for various flow rates (20% of O_2 in N_2).

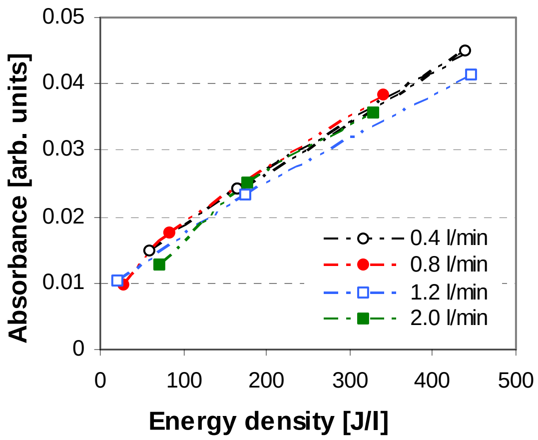

Figure 4: Ozone concentration as a function of energy density (pure O_2).

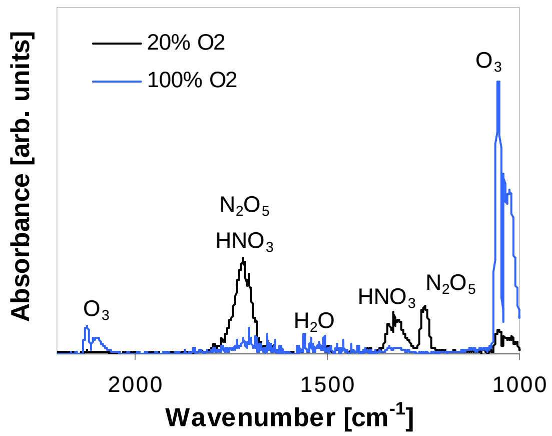

Figure 5: IR spectra of gaseous prodults in mixtures of 20% O_2 in N_2 and pure O_2 (1.2 l/min, 9.1W).

maximum concentration was observed decreased with the increasing flow rate (Fig. 3). Analysis of the FTIR spectra of the nitrogen containing mixtures showed that besides ozone also N_2O_5 and HNO_3 (from residual moisture) were formed. On the other hand, bands of neither NO nor NO_2 were observed (Fig. 5). Figure 4 shows ozone concentration as a function of energy density. On the contrary to Fig.2, there is almost no difference in the ozone generation efficiency for various gas flow rate if considering the energy density.

Conclusions

The plasma-chemical efficiency of microdischarges inside porous ceramics was demonstrated by the generation of ozone in various mixtures of nitrogen and oxygen. The effects of discharge power, gas mixture composition and gas flow were briefly described. We assume it may also be effectively used for flue gas treatment.

The research has been supported by Science and Technology Assistance Agency Grants APVT 20-032404 and SK-FR00506 and Slovak Grant Agency VEGA 1/3041/06.

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