Dielectric barrier discharge system with catalytically active porous segment for improvement of water treatment

P. Baroch[1], N. Saito[2]

[1]*Department of Physics, University of West Bohemia, Univerzitni 22, 306 14 Plzen, Czech Republic*
[2]*CREST, JST, Furo-cho, Chikusa, Nagoya, 464-8603, Japan*

1. Introduction

As the purification and disinfection of polluted water becoming more and more important topic, great effort is devoted to the development of new systems with enhanced efficiency and operating stability. For example, one of the critical issues becoming the destruction of pharmaceutical drugs from drinking water which are impossible to decompose by conventional ways. Recently, system utilizing dielectric barrier discharge (DBD) and operated with additional porous ceramic segment serving as a flowing water guide has been introduced [1]. The system enabled stable and homogeneous operation of plasma discharge as well as increase of system efficiency when compared with conventional one [2]. To further increase the treatment efficiency of the system we have focused on the study of additional effect of various catalysts coated onto the surface of porous ceramic segment.

2. Experimental details

Special design of the atmospheric DBD system is characterized by incorporation of a porous ceramic segment to the zone between electrodes. Schematic drawing of the system is shown in Figure 1. Such a configuration enables to reduce the distance between upper electrode and water surface which consequently led to the increase of intensity, stability and homogeneity of the discharge. It was observed that with this configuration a transition from filamentary mode to semi-homogeneous mode of the plasma discharge could be realized.

3. Results and discussion

Discharge properties were investigated by optical emission spectroscopy method and the results showed the domination of nitrogen lines in UV-A region. This feature can be utilized either for direct UV decomposition of organic pollution in water or to possible activation of photocatalytic coatings placed inside flowing water. For this purpose photoactive TiO_2 layer was deposited onto the porous segment in various ways [3]. Efficiency of such a system was measured and results were compared with efficiency obtained for system with pure porous alumina.

Further, it was observed that the system can be independently operated in wide range of liquid conductivities and under negligible heat deposition to the liquid solution. This is a very important finding due to the fact that waste waters often vary in conductivity which significantly influences the treatment process itself.

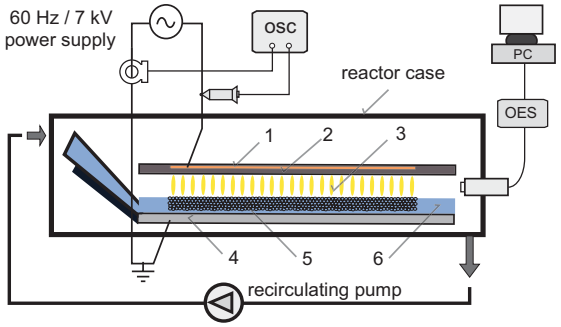

Fig.1 Schematic drawing of experimental system. 1, 4 - metal electrodes, 2 - dielectric barrier (Al_2O_3), 3 - discharge zone, 5 - porous ceramic or metallic segment, 6 - flowing water

To characterize the effect of plasma discharge generated above the water surface on the plasma-chemical reactions occurring in liquid phase the measurements of pH, H_2O_2 and dissolved ozone were performed. It was found that pH of the solution decreases during the operation of plasma discharge. On the other hand the concentrations of hydrogen peroxide H_2O_2 and dissolved ozone O_3 increase almost linearly with the discharge operation time.

Finally, for characterization of the system efficiency, the decomposition tests with organic dye (Acid Orange) were performed. These tests were based on the spectrophotometrical measurement of absorption spectra of the organic dye during the treatment process. Obtained results show positive effect of the catalyst for the increase of the system efficiency.

Ackmowledgements

The work was supported in part by the Ministry of Education of the Czech Republic under Project MSM 4977751302 and in part by the JST CREST Project.

References

[1] P. Baroch, N. Saito, O. Takai, J. Phys. D: Appl. Phys., 41, 085207 (2008).
[2] M.M. Kuraica, B.M. Obradovic, D. Manojlovic, D.R. Ostojic, J. Puric, Vacuum 73 705–8, 2004.
[3] J. Sicha, J. Musil, M. Meissner, R. Cerstvy, Applied Surface Science, 254, 3793-3800, (2008).