

COAXIAL DIELECTRIC BARRIER DISCHARGE FOR WATER SOLUTION TREATMENT

B. M. Obradović¹, V. Kovačević¹, B. Dojčinović²,
G. Roglić³, D. Manojlović³, M. M. Kuraica¹ and J. Purić¹

¹*Faculty of Physics, University of Belgrade, Studentski trg 12-16, 11000 Belgrade, Serbia*

²*Institute of Chemistry, Technology and Metallurgy, Center of Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia*

³*Faculty of Chemistry, University of Belgrade, Studentski trg 12-16, 11000 Belgrade, Serbia*

obrat@ff.bg.ac.rs

1. Introduction

Ozone, which is commonly used in Advance Oxidation Processes (AOP), is mainly produced from air or oxygen by electrical discharges. Besides the ozone, electrical discharges in humid air also produce a variety of chemically active species, such as O^{\bullet} , $\bullet OH$, N^{\bullet} , HO_2^{\bullet} , N_2^{\bullet} , N^{\bullet} , OH^- , O_2^- , O^- , O_2^+ , N_2^+ , N^+ , O^+ , etc. These species are short lived and decay before ozone enriched air/oxygen reaches the treated water solution. However, if the reactor is designed in such a way that the electrical discharges are formed in close proximity to the water surface, i.e. just above the water, some of these species may enter the water thereby destroying the pollutants /1/. Possibility of obtaining very active species like $\bullet OH$ in water solution was a basic idea that encouraged many researchers to design different discharges above the water surface. Here we mention several electrical discharges which have been used for degradation of various organic compounds: phenols, benzenes, pharmaceutical compound and less extent organic dyes /2-9/. It was shown that the principle reactive species involved in degradation of organic compounds are $\bullet OH$ radical and H_2O_2 /10/. The $\bullet OH$ radical, especially, is known to play an important role in degrading organic compounds since its oxidation potential is higher than that of atomic oxygen and ozone.

2. Experiment and results

Our discharge is a coaxial dielectric-barrier-discharge (DBD), designed as atmospheric non-thermal plasma reactor for treatment of various water solutions /4-6,11/. Cylindrical reactor is made of glass with the inner diameter of the tube 27 mm and length of 600 mm. The outer electrode is made of aluminium foil glued on the outer side of the glass tube on a length of

400 mm. The inner electrode is a stainless steel tube with a diameter of 20 mm. To avoid possible chemical reactions with the electrode surface, recently we started to use the inner electrode made of glass cylinder which is silverised on the inner side. Barrier discharge is generated between the inner electrode and the outer glass tubes. Water solution flows up through a vertical hollow electrode and flows down making a thin dielectric film over the electrode, see Fig 1. The discharge is generated within 3.5 mm gap between the glass and the water layer by applying the voltage of 17 kV at frequency of 50 - 200 Hz. Plug-in power for the discharge is 60 W. Water solutions were pumped with a flow rate of 70 mL/min using a peristaltic pump. Energy density of ~ 15 kJ/L per one pass through the reactor was introduced in the solution. Each solution was circulated several times.

Water falling film DBD was used for treatments of phenols dissolved in bidistilled water and water from the river Danube [5,6]. The percentage of phenol removal from Danube water was considerably lower than the corresponding value for bidistilled water. Lower removal of chlorophenols from sample prepared with Danube water is explained by shielding effect of fulvic and humic acids which also reacted with $\cdot\text{OH}$ radical.

Reference [11] is devoted to the comparison of two procedures for arsenic removal - one using a classical ozonator and the second using the falling film DBD reactor for primary oxidation. It has been shown that the DBD reactor has significantly larger arsenic oxidation efficiency and consequently, the arsenic removal efficiency during flocculation and adsorption processes.

We also studied decolorization of four reactive textile dyes. It has been

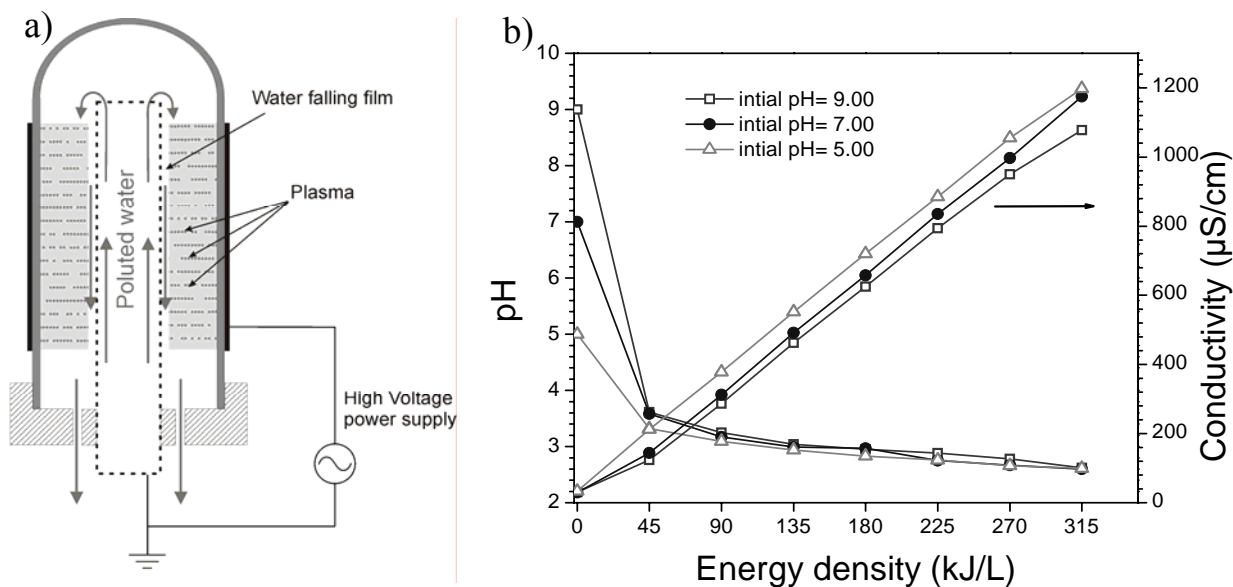


Fig. 1. a) Schematic picture of the falling film DBD. b) The change in the solution pH and conductivity values during the treatment of a reactive textile dye.

shown that the treated solutions containing investigated dyes, exhibit very similar decolorization kinetics for all four dyes.

A common characteristic for all treatments using the DBD reactor is acidification of the water solution caused by air plasma. Fig. 1b shows variation of pH values of a textile dye solution during the treatment. Values of pH in the treated deionized water were almost identical to that in the treated dye solutions. The variation of pH value is caused by acidic substances such as nitric acid and nitrous acid which are produced during the discharge process in air.

References

1. **Malik M.A., Ghaffar A.S., Malik A.**, Plasma Sources Sci. Technol., **10** (2001) 82–91.
2. **Hoeben W.F.L.M., Van Veldhuizen E.M., Rutgers W.R., Kroesen G.M.W.**, J. Phys. D: Appl. Phys., **32** (1999) 133–137.
3. **Grabowski L.R., Van Veldhuizen E.M., Pemen A.J.M., Rutgers W.R.**, Plasma Chem. Plasma Process. **26** (2006) 3–17.
4. **Kuraica M.M., Obradović B.M., Manojlović D., Ostojić D.R., Purić J.**, Vacuum, **73** (2004) 705-708.
5. **Manojlović D., Ostojić D.R., Obradović B.M., Kuraica M.M., Krsmanović V. D., Purić J.**, Desalination, **213** (2006) 116-122.
6. **Dojčinović B. P., Manojlović D., Roglić G. M., Obradović B. M., Kuraica M. M., Purić J.**, Vacuum, **83** (2009) 234–237.
7. **Bubnov A.G., Burova E.Yu., Grinevich V.I., Rybkin V.V., Kim J.-K., Choi H.-S.**, Plasma Chem. Plasma Process., **26** (2006) 19–30.
8. **Baroch P., Saito, N. Takai O.**, J. Phys. D: Appl. Phys., **41** (2008) 085207
9. **Magureanu M., Piroi D., Mandache N.B., Parvulescu V.**, J. Appl. Phys. **104** (2008) 103306-7.
10. **Lukes P., Clupek M., Babicky V., Janda V., Sunka P.**, J. Phys. D: Appl. Phys., **38** (2005) 409 – 416.
11. **Manojlović D, Popara A, Dojčinović B. P., Nikolić A., Obradović B. M. Kuraica M. M., Purić J.**, Vacuum, **83** (2009) 142 – 144