HAKONE XII

12th International Symposium on High Pressure Low Temperature Plasma Chemistry

Book of Contributed Papers

Trenčianske Teplice, Slovakia
September, 12-17, 2009

Edited by J. Országh, P. Papp, Š. Matejčík

Book of Contributed Papers of 12th International Symposium on High Pressure Low Temperature Plasma Chemistry
Symposium organised by Department of Experimental Physics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava (Slovakia); Society for plasma research and applications in Trenčianske Teplice, 12th-17th September 2010

Editors:	J. Országh, P. Papp, Š. Matejčík
Publisher:	Department of Experimental Physics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava (Slovakia); Society for plasma research and applications in cooperation with Library and Publishing Centre CU, Bratislava, Slovakia
Issued:	September 2010, Bratislava, fist issue
Number of pages:	576
Print:	125 pieces
URL:	http://neon.dpp.fmph.uniba.sk/hakoneXII
ISBN:	978-80-89186-72-3

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DECOLORIZATION OF FOUR AZO DYES USING WATER FALLING FILM DBD REACTOR

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In this paper we present experimental results of the decolorization of four commercial reactive azo dyes using falling film DBD reactor. In this reactor water forms a falling film which is in direct contact with plasma. Water samples containing 40 mg/L of dye were passed from one to seven times through the plasma region of the DBD reactor. Kinetic of the dye decolorization was monitored using spectrophotometer. The dependence of the decolorization on the system parameter solution pH value was investigated. For each dye decolorization has similar kinetics for all three starting solution pH values.

1. Introduction

The largest pollution of natural water resources caused by waste water originates from different industries, especially those in which colour processes are involved as it is the case in textile industry. Among the textile dyes the largest problems are caused by azo dyes, because they represented 90 % of dyes used. At the same time, azo dyes are the most toxic commercial dyes. Reactive dyes are intensively used in the last years due to their superior performance, but they are environmentally hazardous.

In the present paper, the decolorisation of four commercial reactive azo dyes Reactive Black 5, Reactive Blue 52, Reactive Yellow 125 and Reactive Green 15 (Clariant, Germany) was studied using advanced oxidation processes (AOPs) in non-thermal plasma reactor based on coaxial dielectric barrier discharge (DBD).

2. Experiment

The coaxial DBD was designed as atmospheric non-thermal plasma reactor for treatment of various water solutions /1/. In this reactor water forms a falling film which is in direct contact with plasma, see Fig. 1. Such reactor design allowed successful removing of phenols from water /2,3/. This reactor is very efficient because the plasma that is formed above the water besides ozone also produced UV radiation, radicals (e.g. OH), excited atoms (e.g. O) and molecules, electrons and ions.

A schematic diagram of experimental setup is shown in Fig. 1. A cylindrical reactor is made of pyrex glass with the inner diameter of the tube 28.5 mm and length of 600 mm. An outer electrode is made of aluminum foil glued on the outside of the glass tube on a length of 400 mm. The inner electrode was a stainless steel cylinder with a diameter of 21.3 mm. Barrier discharge is generated between the inner metal electrode and the glass tube. When the discharge source works as a falling film reactor, water flows up through a vertical hollow cylindrical electrode and flows down making a thin dielectric film over the electrode. A discharge is generated within ~3.5 mm gap between the glass and the water layer by applying voltage of up to 20 kV at 200 Hz. Discharge power was 60 W.

The capability of the plasma reactor in decolorisation of four azo dyes Reactive Black 5, Reactive Blue 52, Reactive Yellow 125 and Reactive Green 15 was tested with three samples prepared by dissolving of commercial dye without preceding purification in distilled water. In all cases water

samples containing 40 mg/L of dye were passed from one to seven times through the 40 cm long plasma region.

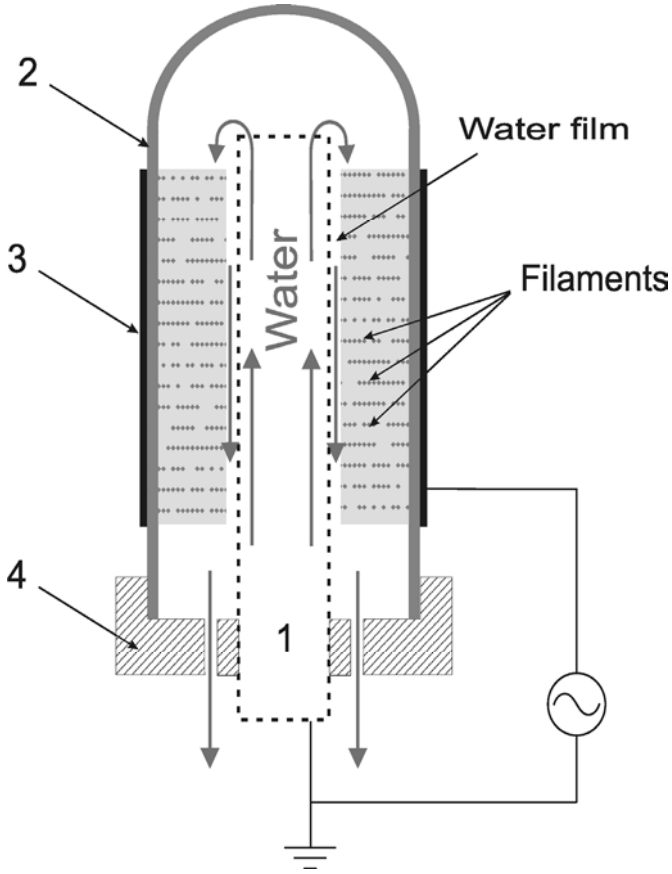

Fig. 1. Schematic picture of coaxial falling film reactor. 1-steel tube, 2-glass, 3-aluminium foil, 4-plastic holder.

Kinetic of the dye decolorisation defined as $(A_0 - A)/A_0$, where A_0 is initial absorption and A - absorption after plasma treatment, was monitored using the spectrophotometer (UV-VIS) at maximum absorption for each dyes. The dependence of the decolorisation on the system parameter solution pH was investigated (pH 9.00, 7.00 and 5.00). Solution pH has been determined after each recirculation.

3. Results

Azo dyes decolorisation has similar kinetics for all three starting solution pH values as shown in Fig. 2. The largest percent of decolorisation has been observed for initial solution of pH 7.00 or 5.00, although similar values have been observed for dye solutions with starting solution pH 9.00. After the period of 24 h from plasma treatment, decolorisation of the solution for the first treatment has been increased for 20-30 %, when compared with decolorisation value obtained 5 min after passing through the DBD reactor. For dye Reactive Black 5 decolorisation value obtained 24 h after the first passing through DBD reactor is equal to decolorisation value obtained after the second passing through DBD reactor measured after 5 min. For dye Reactive Blue 52 decolorisation value obtained 24 h after the first passing is equal to decolorisation value obtained after forth passing through DBD reactor measured after 5 min. For dyes Reactive Yellow 125 and Reactive Green 15, decolorisation value obtained 24 h after the first passing is equal to decolorisation value obtained after the third passing through DBD reactor measured after 5 min.

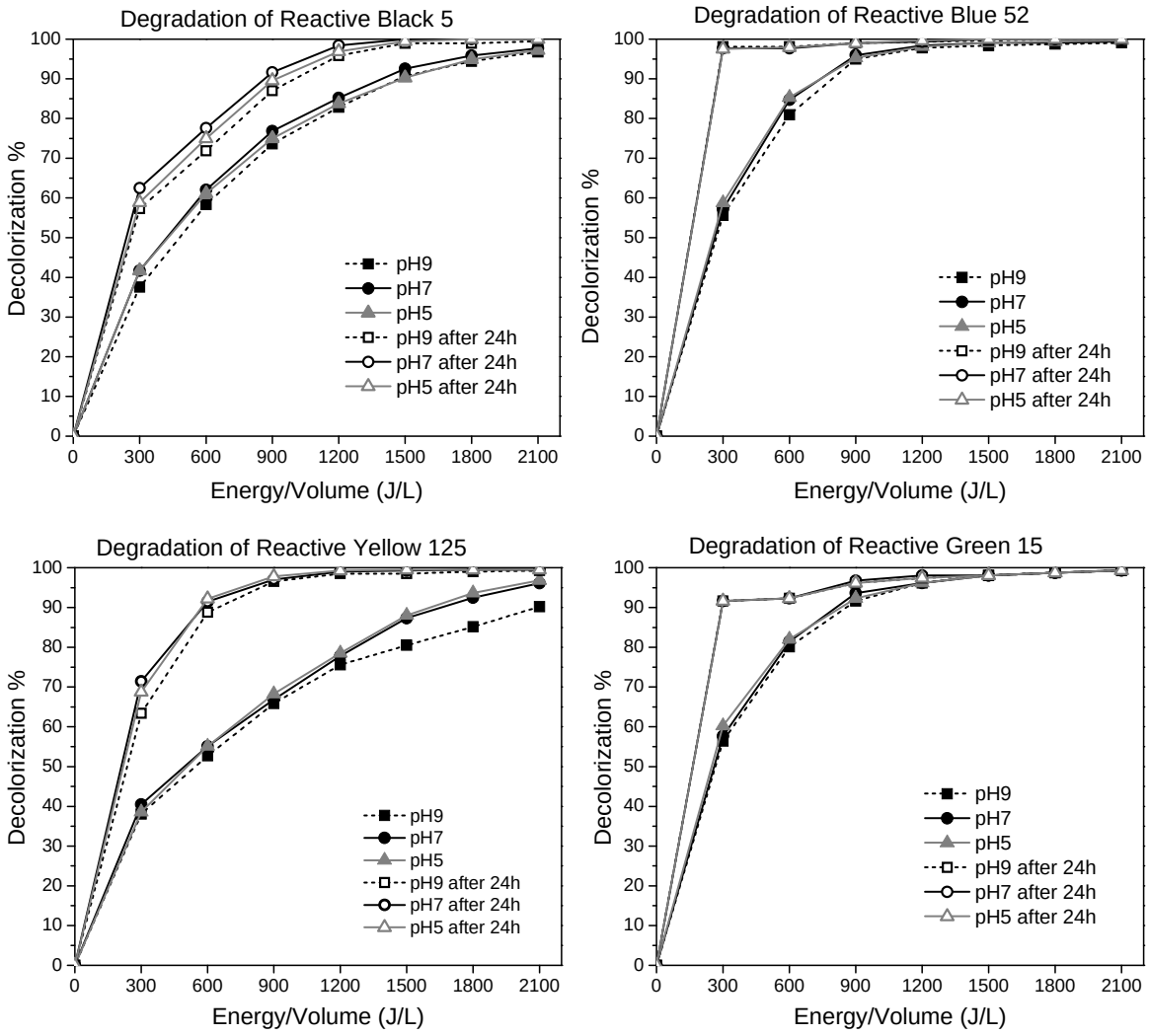

Fig. 2. Effects of pH on the decolorisation efficiency in the DBD plasma reactor. Decolorisation is monitored 5 min and 24 h after the treatment.

The pH value of the solution, 5 minutes after the first passing through DBD reactor for all four dyes and for all three investigated starting solution pH values (pH 9.00, 7.00 and 5.00), has decreased to 3.5 pH. The solution pH values gradually decreased with every passing through DBD reactor, reaching 3.0 after the seventh passing.

4. Conclusion

The waste water containing the investigated dyes, irrespective of acid, base or neutral nature, exhibits very similar, almost same decolonization kinetics. The decolonization percent of solution has significantly increased 24 h after the plasma treatment.

The solution, regardless of the starting pH value, became acidic already after the first passing through the DBD reactor and pH value is slightly changed after subsequent recirculations.

Acknowledgments. This work within the Project 141043 is supported by the Ministry of Science of the Republic of Serbia.

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