Decolorization of Reactive Black 5 using a dielectric barrier discharge in the presence of inorganic salts

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Abstract: Inorganic salts improve the coloration of textiles, which increases the pollution load of dye-house effluent in general. Decolorization of the reactive textile dye C.I. Reactive Black 5 was studied using Advanced Oxidation Processes (AOPs) in a non-thermal plasma reactor, based on the coaxial water falling film Dielectric Barrier Discharge (DBD). The initial dye concentration in the solution was 40.0 mg L^{-1}. The effects of the addition of different high concentrations of inorganic salt (NaCl, Na$_2$SO$_4$ and Na$_2$CO$_3$) on the degree of decolorization were studied. The dye solution was recirculated through the DBD reactor with an applied energy density of 45.0–315 kJ L^{-1}. The influence of residence time was investigated after 5 min and 24 h of plasma treatment. Decolorization of the dye was monitored spectrophotometrically. The pH value and the conductivity of the dye solution were measured after each recirculation. The most effective decolorization of over 90 % was obtained with the addition of NaCl (50 g L^{-1}) with an applied energy density of 135 kJ L^{-1} and after a residence time of 24 h of plasma treatment. Decolorization of the solutions containing inorganic salts Na$_2$SO$_4$ and Na$_2$CO$_3$ were lower than for the solution without salt.

Keywords: decolorization; Reactive Black 5; inorganic salt; plasma treatment; dielectric barrier discharge; DBD reactor.

INTRODUCTION

Synthetic organic dyes are widely used as colorants in different industries, such as in the textile, leather tanning, paper, plastics, color photography, pharmaceutical, food and cosmetic industries. More than 0.7 million tons of synthetic

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organic dyes are produced annually worldwide. It is reported that there are over 10,000 commercially available dyes that are classified by their application fields, namely acid, reactive, disperse, vat, metal complex, mordant, direct, basic and sulfur dyes.[1] Textile manufacture is one of the largest industrial producers of wastewater, which have high concentrations of organic and inorganic compounds and strong color, caused by residual dyes that were not fixed to the fibers during the dyeing process. Wastewaters from textile manufacture are characterized by highly fluctuating pH values, high chemical oxygen demand (COD), large amounts of non-biodegradable compounds, the presence of toxic substances, high temperature and large amounts of salt (ionic strength). Reactive dyes have been identified as the most environmentally problematic compounds in textile dye effluents. Research on textile effluent decolorization has been mostly focused on reactive dyes for several reasons. Firstly, reactive dyes are intensively used due to their superior performance and have an increasing market share, about 20–30 % of the total dye market, as they are used to dye cotton that contributes slightly less than half to the world's fiber consumption. Secondly, they are very soluble and approximately 10–15 % of the weight of applied reactive dyes is discharged from the dye houses. In addition, parts of the applied reactive dyes are wasted due to dye hydrolysis in the alkaline dye bath. Thirdly, conventional wastewater treatment plants, which rely on sorption and aerobic biodegradation, have a low removal efficiency for reactive and other anionic soluble dyes. Consequently, they lead to colored waterways, and public complaints, with the pollutants being transferred from to another phase rather than being destroyed.[2–7] Azo dyes constitute a major part (about 60 %) of all commercial reactive dyes employed in a dyeing process in the textile industry.[8]

Advanced oxidation processes (AOPs) are under investigation as alternative means of overcoming the limitations of the conventional techniques. Advanced oxidation processes were developed and used as potentially powerful methods capable to transforming pollutants into harmless substances. AOPs are based on the generation of very reactive non-selective transient oxidizing species, such as the hydroxyl radicals (•OH) which were identified as the dominant oxidizing species, that attack organic compounds with high reaction rates.[9] Amongst the many techniques employed in the AOP approach to industrial wastewater treatment are UV photolytic oxidation, the Fenton process, the photo-Fenton process, the ozonation process, sonolysis, the photocatalytic approach, radiation, supercritical water oxidation[10,11] and non-thermal plasma technology[12–17] induced degradation of organic pollutants. A literature survey revealed that there are a few studies on the effect of inorganic salts on the decolorization of textile dyes using advanced oxidation processes.[18–21]

In the present study, decolorization was based on the dielectric barrier discharge (DBD) reactor, which is a typical non-equilibrium high-pressure AC gas

discharge. Various discharges in water were described in a review article by Bruggeman and Leys.[22] A DBD is obtained between two electrodes, one of which at least is covered with a dielectric, by application of a high voltage AC to the electrodes. The dielectric is the key factor for the proper functioning of the discharge. It limits the charge transported in the discharge, *i.e.*, limits the current flow to the system, and distributes the discharge almost uniformly over the entire electrode area. A DBD is an excellent source of high-density energetic electrons, with energy between 1–10 eV. In humid air, a DBD can produce UV light and many reactive species, such as free electrons, negative ions, positive ions, uncharged short-lived radicals, H_2O_2 and O_3.[23,24] It was shown that the principle reactive species involved in the degradation of organic compounds are $^\bullet$OH and H_2O_2.[25] $^\bullet$OH, especially, is known to play an important role in the degradation of organic compounds since its oxidation potential is higher than those of atomic oxygen and ozone.

In the present study, the decolorization of the commercial reactive azo dye C.I. Reactive Black 5 was studied using an advanced oxidation process (AOP) in a non-thermal plasma reactor based on coaxial dielectric barrier discharge (DBD).[26] A very similar coaxial DBD plasma reactor to that used in this research was recently developed for the treatment of various aqueous solutions,[27] and successfully tested for the removal of phenols from wastewater.[28,29] An azo dye was chosen for study as azo dyes are the major colorants in the textile industry; they provide a wide spectrum of colors with outstanding colorfastness. However, azo dyes are the most toxic, mutagenic and carcinogenic of commercial dyes.[30]

Initial dye concentration in the treated water solution was 40.0 mg L^{-1}. The effects of various conditions, such as applied energy density (45.0–315 kJ L^{-1}) and the presence high concentrations of an inorganic salt, *i.e.*, NaCl, Na_2SO_4 or Na_2CO_3, were studied.
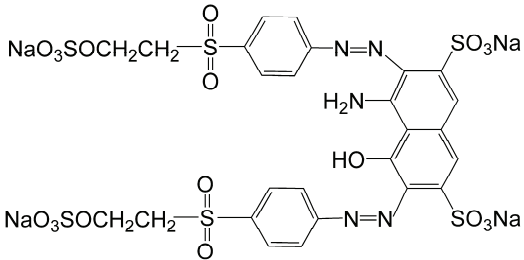
<div align="center">EXPERIMENTAL</div>

Materials

The textile dye, Reactive Black 5, was purchased from Clariant (Switzerland) and used without further purification. Reactive Black 5 is a dissociated anionic sulfonate in aqueous solution. The general characteristics of Reactive Black 5 are summarized in Table I. Other chemicals, purchased from Merck (Germany), were of analytical grade. All solutions were prepared using deionized water with conductivity between 1.0 and 1.5 μS cm^{-1}.

Instrument

The employed coaxial DBD was designed as an atmospheric non-thermal plasma reactor for the treatment of various water solutions.[26] In this reactor, water forms a falling film that is in direct contact with the plasma. The coaxial DBD is a source of a wide range of reactive species, created in both the gas and liquid phase. This discharge is able to produce O_3, H_2O_2, $^\bullet$OH and other active species. Ozone is considered as one of the most powerful molecule species because of its long lifetime and high oxidation potential. In such a discharge design, radicals are transferred from the plasma into the liquid phase, where reactions with pollutants oc-

cur. In addition, this discharge produces UV radiation, ions (*e.g.*, OH^-, O_2^-, O^-, O_2^+, N_2^+, N^+, O^+) and electrons. A schematic diagram of the experimental setup is shown in Fig. 1a. The cylindrical reactor is made of Pyrex glass with inner diameter of the tube 27.0 mm and length of 600 mm. The outer electrode is made of aluminum foil of length 400 mm glued to the outer side of the glass tube. The inner electrode is a glass cylinder with a diameter of 20.0 mm that is silver-plated on the inner side, Fig. 1a. The barrier discharge is generated between the inner glass and the outer glass tubes. When the discharge source works as a falling film reactor, water flows up through a vertical hollow glass tube and flows down making a thin dielectric film over the electrode, Fig 1a. The employed power supply was a high voltage transformer, which was fed by a frequency inverter, which allows variation of the sinusoidal voltage frequency up to 500 Hz. The frequency for the plasma reactor was set at the determined optimal value, 200 Hz. The discharge was generated within the 3.5 mm gap between the glass and the water layer by applying a voltage of 17 kV. To increase the total flow of the treated solution, three discharges are connected in parallel. The plug-in power for this system of discharges was 150 W.

TABLE 1. General characteristics of Reactive Black 5

Chemical structure	
Molecular formula	$C_{26}H_{21}N_5Na_4O_{19}S_6$
Molecular weight	991.82
Synonyms	C.I. Reactive Black 5, Reactive Black 5, Reactive Black B, Remazol Black 5, Remazol Black B, Drimaren Black R/K-3B
C.I. (*Color Index*) name	C.I. Reactive Black 5
C.I. (*Color Index*) number	C.I. 20505
Application class	Cotton
Chemical class	Azo
CAS registry number	17095-24-8
λ_{max} / nm	590

A solution of dye was pumped to the top of the reactor through the inner electrodes using a peristaltic pump. From the top of the inner electrode, the solution flows down in a thin layer over the electrode. After treatment, the solution was collected in a reservoir at the bottom of the reactor. The total flow rate through the three parallel DBD reactors was 210 mL min^{-1}. The collected solution was introduced through the reactor for the next treatment in such way that the presently treated amount of solution was never mixed with the amount of solution treated in the previous pass. An energy density of ≈45 kJ L^{-1} per one pass through the reactor was introduced in the solution. The introduced energy density was increased using multiple passes through the reactor. Each solution was recirculated seven times. In each series of experiments, the treatment was started with 2 L of dye solution (of a certain concentration and specified pH value). After each recirculation, 100 ml of the solution was sampled for analysis

after of 500 ml had passed through the DBD reactor. Each subsequent recirculation was realized immediately after completion of the previous one.
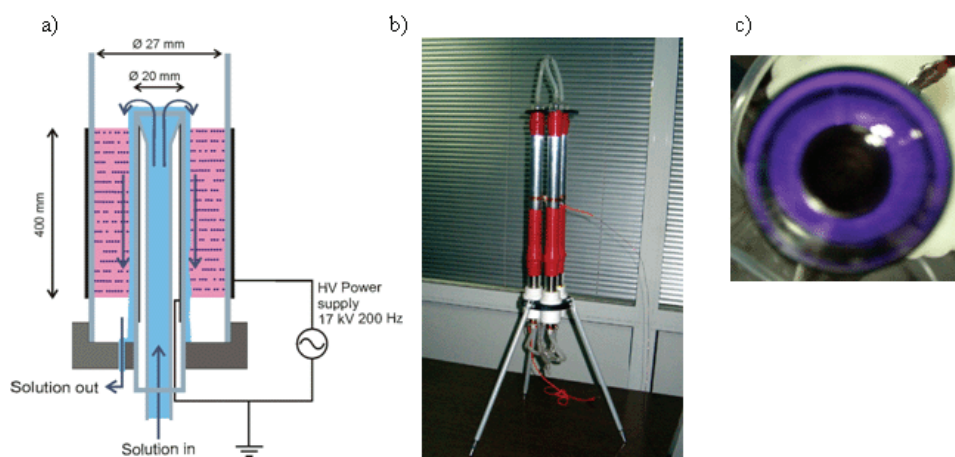

Fig. 1. a) Schematic of a coaxial DBD. b) Photo of three parallel-connected DBDs. c) Photo of the discharge viewed from the top. Dimensions: inner glass barrier (diameter 20.0 mm, length 500 mm, thickness 1.5 mm); outer glass barrier (diameter 30.0 mm, thickness 1.5 mm, length 600 mm); outer metal foil electrode (diameter 30.0 mm, length 400 mm).

Methods of analysis

The capability of the plasma reactor for decolorization of azo dye Reactive Black 5 was tested in triplicate. Each color solution was prepared by dissolving the commercial dye without preceding purification in deionized water. In all cases, water samples containing 40.0 mg L^{-1} of dye were passed from one to seven times through the discharge. The decolorization efficiency is defined as the percent decrease in absorbance according to Eq. (1):

$$\text{Decolorization (\%)} = 100 \frac{A_0 - A}{A_0} \tag{1}$$

where A_0 is the absorbance at the maximum absorption wavelength (λ_{max}) of the initial dye solution and A is the absorbance at the maximum absorption wavelength of the dye solution after the plasma treatment. The absorbance measurements were performed using a UV–Visible Cintra 6 spectrometer (GBC Scientific Equipment, Australia) 5 min and 24 h after the plasma treatment.

The effects of the addition of inorganic salts (NaCl, Na_2SO_4 and Na_2CO_3) on the decolorization efficiency of Reactive Black 5, $c_0 = 40.0$ mg L^{-1}, during the plasma treatment was tested. The concentrations of tested salts were: NaCl, 10 and 50 g L^{-1}, Na_2SO_4, 10 and 50 g L^{-1} and Na_2CO_3, 0.1, 10 and 50 g L^{-1}. For comparison, the efficiency of decolorization without added salt was also determined. Decolorization efficiency was monitored 5 min and 24 h after the plasma treatment.

A solution of sodium chloride of concentration of 50 g L^{-1} in the absence of dye was treated in the same way. After 5 min of plasma treatment, the concentrations of hypochlorite and hydrogen peroxide in the solution were determined. Ion chromatography was used to assay the appearance and quantity of hypochlorite formed. For this purpose, a Dionex ICS-3000

chromatographic set-up consisting of a single pump, a conductivity detector (ASRS ULTRA II (4 mm), recycle mode), an eluent generator (potassium hydroxide) with a Chromeleon® Chromatography Workstation and Chromeleon 6.7 Chromatography Management Software was employed. All the separation was performed using IonPac AS15 Analytical, 4 mm×250 mm and IonPac AG15 Guard, 4 mm×50 mm columns. The flow rate of the mobile phase was 1.20 mL min⁻¹ and the composition of mobile phase was changed during analysis in following order 0–15 min, 10 mM KOH; 15–25 min, 10–45 mM KOH; 25–26 min, 45 mM KOH; 26–31 min, 45–10 mM KOH; 31–36 min, 10 mM KOH. In addition, the following conditions were applied: column temperature 30 °C, conductivity cell temperature 35 °C and the suppressor current was 134 mA. The backpressure was ≈18 MPa.

A standard solution of hypochlorite was prepared fresh daily by diluting ≈15 % sodium hypochlorite solution, analytical grade (Carlo Erba, Italy), which was standardized by iodimetry.

The concentration of hydrogen peroxide was determined using the reaction of H_2O_2 with titanyl ions.[31] The absorbance was measured at $\lambda = 407$ nm.

In addition, the pH of each solution was determined after each recirculation. The pH value was measured using a pH monitor (Microcomputer pH-vision 6071, JENCO Electronics. Ltd., Taiwan). Five minutes after each recirculation, the conductivity of the treated solutions was determined using a Cond 330i/SET meter, WTW Wissenschaftlich, Germany.

RESULTS AND DISCUSSION

Given that different salts are added to the bath in textile industries in order to improve color fastness, the effects of Cl^-, CO_3^{2-}, HCO_3^-, SO_4^{2-}, $H_2PO_4^-$ and NO_3^- on the dye decolorization rates were also investigated as some of these anions are thought to act as scavengers of $^\bullet OH$, thereby reducing their effective concentration in the solution. The addition of inorganic salts to the dye bath increases the pollution load of the effluent generated and has an effect on various effluent treatment processes.[46–48] The influence of sodium sulfate, sodium chloride and sodium carbonate on DBD efficiency was studied.

The effect of the addition of NaCl

The influence of the sodium chloride concentration on the decolorization of Reactive Black 5 ($c_0 = 40.0$ mg L⁻¹) was measured as a function of the applied energy density. Two initial concentrations (10 and 50 g L⁻¹ NaCl) and the solution without added salt were examined. The results are shown in Fig. 2. The introduced energy was increased by multiple passes. For the dye solution without salt, the decolorization value measured 24 h after one pass through the DBD reactor reached the same value as the decolorization obtained in two passes (*i.e.*, an applied energy of 90 kJ L⁻¹) and measured after 5 min, Figs. 2 and 3. In all cases, decolorization after the first treatment (*i.e.*, 45 kJ L⁻¹) measured 5 min after passing through the DBD reactor was 30–45 % while 24 h after the plasma treatment, the decolorization had increased to 40–60 %, depending on the initial composition. This indicated that the effect of the plasma treatment could be intensified in aqueous solutions by the primary products formed during water treat-

ment. According to Magureanu *et al*.,[40] various oxidizing species are formed in plasma-treated aqueous solutions that contribute to the decomposition of organic dyes, but most of these oxidizers have very short lifetimes. Therefore, they can only react with the dye molecules while the solution flows through the DBD reactor. Ozone and hydrogen peroxide are the only oxidizers generated in the plasma, which are stable enough to react with the dye molecules outside of the plasma reactor, *i.e.*, later after the treatment. Reactions after plasma treatment can be partly attributed to reactions that are similar to the wet air oxidation and radiation. These reactions occur through the formation of alkyl and alkyl peroxide radicals, and hydroperoxides, with the latter being responsible for the auto-catalytic decomposition of organic compounds, as shown by Gözmen *et al*.[32] and Rauf *et al*.[33]
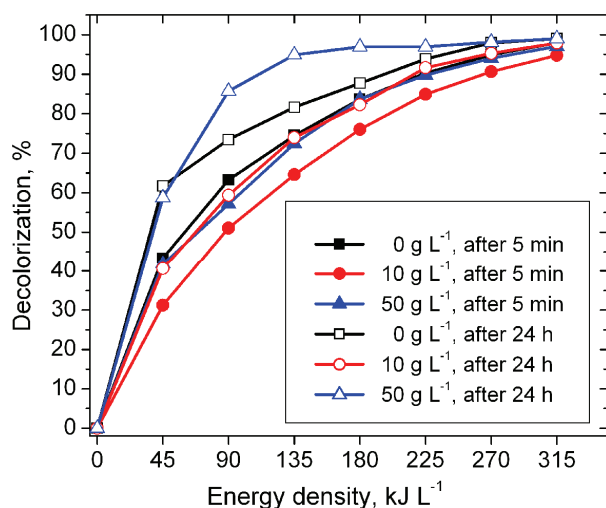

Fig. 2. Effect of the addition of NaCl on the efficiency of the decolorization of Reactive Black 5 (c_0 = 40.0 mg L^{-1}, 5 min and 24 h after treatment).
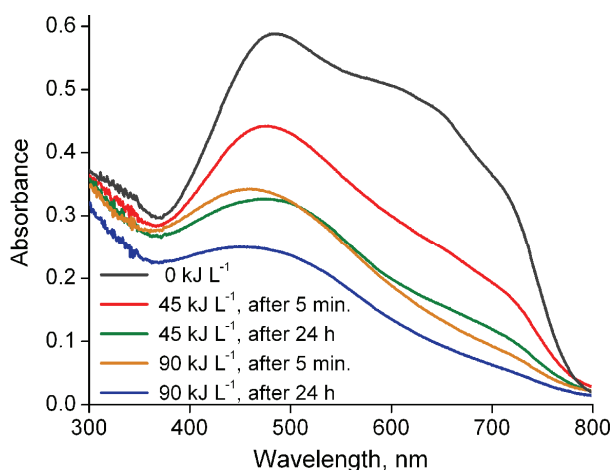

Fig. 3. The absorbance spectra of Reactive Black 5 without salt, recorded before and 5 min and 24 h after plasma treatment with an energy density 45 and 90 kJ L^{-1}.

For the continued process of decolorization during the residence time of the plasma-treated dye solution, molecular species (O_3 and H_2O_2) are primarily responsible, and possibly long-lived free radicals formed during plasma treatment. In the treated deionized water, the contents of O_3 and H_2O_2 were quantified 5 min after the treatment.[26,28]

For all the introduced energy densities, 5 min after plasma treatment, the addition of NaCl (10 and 50 g L^{-1}) reduced the effect of decolorization as compared to the solution without salt. Higher reductions in decolorization (approximately 10 %) were observed in the solution with 10 g L^{-1} salt. After 24 h of plasma treatment, with an applied energy density higher than 45 kJ L^{-1}, the resulting decolorization was largest for solution containing 50 g L^{-1} NaCl. In this solution, with applied energy densities of 90 and 135 kJ L^{-1}, the decolorization was higher by 13 % compared to the solution with no added salt. In addition, the shape functions of the decolorization of the dye solution containing 50 g L^{-1} NaCl, measured after 24 h of plasma treatment were different compared to all others. This significant increase in decolorization in this system can be explained by the formation of hypochlorite from the chloride ions during the plasma treatment. In order to confirm this explanation, the concentrations of hypochlorite and hydrogen peroxide in treated solution of NaCl (concentration: 50 g L^{-1}) were measured. During the first pass, the maximal concentration of hypochlorite of 3.46 mg L^{-1} for 45 kJ L^{-1} was obtained and with increasing energy density, its concentration decreased (finally, the concentration dropped to below the detection limit). On the other hand, the concentrations of hydrogen peroxide gradually increased and for an energy density of 315 kJ L^{-1}, a concentration of 6.52 mg L^{-1} was attained. A possible explanation is that the chloride oxidation reaction was faster than hydrogen peroxide formation but it appeared that hypochlorite further reacted with the formed hydrogen peroxide, Eq. (2):

$$ClO^- + H_2O_2 \rightarrow Cl^- + H_2O + O_2 \tag{2}$$
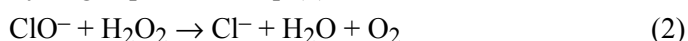
Hence, these two types of oxidation species cannot simultaneously exist in the solution.

Changes of the visible spectra of Reactive Black 5 solutions (c_0 = 40.0 mg L^{-1}) without salt after the plasma treatment for introduced energy densities of 45 and 90 kJ L^{-1} are shown in Fig. 3. Spectra were recorded 5 min and 24 h after plasma treatment. The changes of the visible spectra of dye could be used to understand the dye degradation during the treatments. It can be seen that the absorbance was reduced over the whole spectra with increasing introduced energy. The decrease of absorbance in the visible part of the spectrum indicates the loss of the conjugated system in the compound.

A photograph of solutions of Reactive Black 5 (c_0 = 40.0 mg L^{-1}) without the addition of salt 24 h after plasma treatment for energy densities from 0 to 315 kJ L^{-1} with an increment of 45 kJ L^{-1} are shown in Fig. 4.
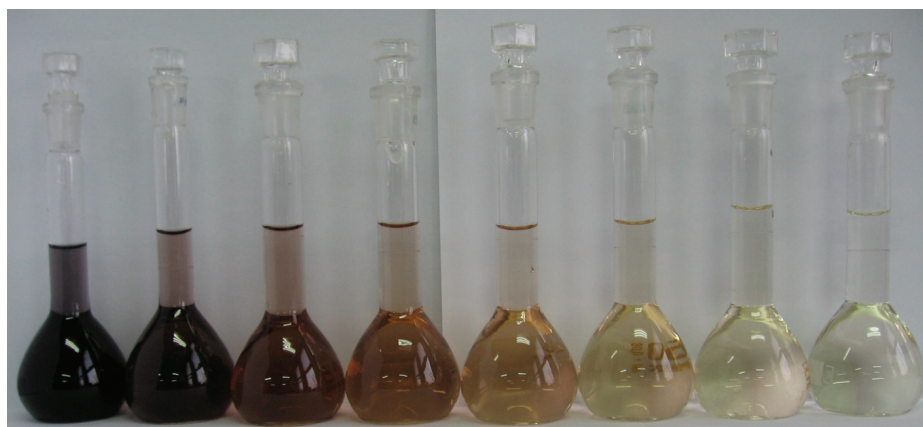

Fig. 4. Solutions of Reactive Black 5 (c_0 = 40.0 mg L^{-1}) 24 h after of plasma treatment (energy density 0–315 kJ L^{-1} with increment of 45 kJ L^{-1}, from left to right).

The effect of the addition of Na$_2$SO$_4$

Large amounts of sulfate in the dye bath are generally essential for successful dyeing with reactive dyes, which results in high concentrations of sulfate in the effluent. To examine the effect of the Na$_2$SO$_4$ concentration on decolorization efficiency, solutions with different amounts of this salt were plasma treated. The color removal efficiency for an introduced energy density of 315 kJ L^{-1} decreased from 99 to 83 and 38 % after 24 h residence time with increasing Na$_2$SO$_4$ concentration from 0 to 10 and 50 g L^{-1}, respectively (Fig. 5). The highest concentration of salt (50 g L^{-1}) had the most negative effect on the decolorization. A possible explanation is that at high concentrations, the excess SO$_4^{2-}$ reacts with the hydroxyl radicals to generate SO$_4^{-\bullet}$, which is less reactive than a hydroxyl radical,[34] Eq. (3). Thus, the excess SO$_4^{2-}$ reduces the effect of the hydroxyl radicals:

$$SO_4^{2-} + {}^{\bullet}OH \rightarrow SO_4^{-\bullet} + OH^- \tag{3}$$

The excess SO$_4^{2-}$ reduces the photodegradation of the dye since SO$_4^{-\bullet}$ ($E^{\ominus}$ = = 2.6 V) is less reactive than $^{\bullet}$OH ($E^{\ominus}$ = 2.7 V).[34]

It is known that SO$_4^{-\bullet}$ and $^{\cdot}$OH react with organic compounds mainly by three mechanisms: hydrogen abstraction, hydrogen addition and electron transfer.[35] In general, SO$_4^{-\bullet}$ is more likely to participate in electron transfer reactions than $^{\bullet}$OH, which is more likely to participate in hydrogen abstraction or addition reactions,[36,37] and hence reactivity of $^{\bullet}$OH is less selective than SO$_4^{-\bullet}$.
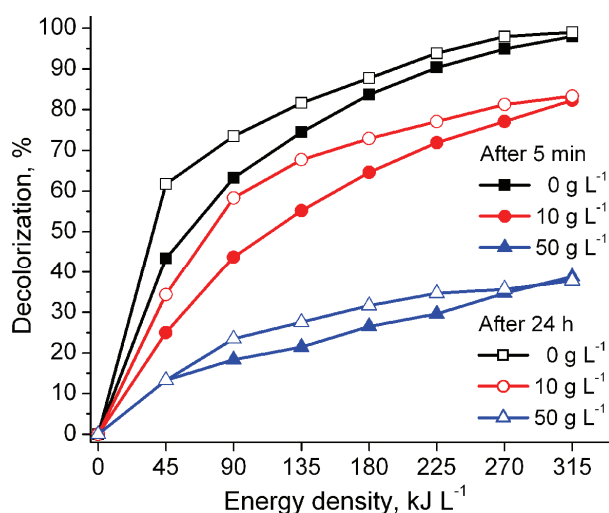
Fig. 5. The effect of adding Na$_2$SO$_4$ on the decolorization efficiency of Reactive Black 5 ($c_0 =$ = 40.0 mg L^{-1}, 5 min and 24 h after treatment).

The effect of the addition of Na$_2$CO$_3$

The effect of addition of different concentrations of Na$_2$CO$_3$ on decolorization efficiency of Reactive Black 5 ($c_0 = 40.0$ mg L^{-1}) is shown in Fig. 6. The tested concentrations of Na$_2$CO$_3$ were 0.1, 1 and 10 g L^{-1}. The results showed that the decolorization was inhibited in the presence of Na$_2$CO$_3$ in a dose dependent manner. Increasing amounts of salt in the dye solution resulted in decreasing efficiency of decolorization, *i.e.*, for an energy density of 315 kJ L^{-1}, on increasing the salt concentration from 0 to 10 g L^{-1}, the percentage decolorization decreased from 99 to 88 %. In addition, in the presence of Na$_2$CO$_3$, the effect of increased decolorization 24 h after of plasma treatment was not ob-
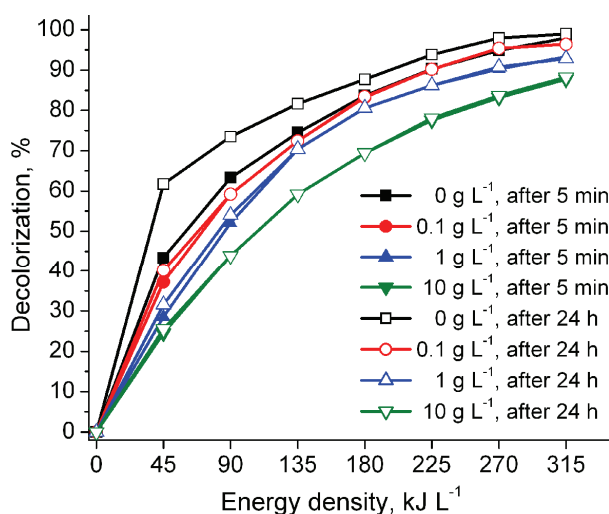

Fig. 6. The effect of addition of Na$_2$CO$_3$ on the decolorization efficiency of Reactive Black 5 ($c_0 = 40.0$ mg L^{-1}, 5 min and 24 h after treatment).

served (contrary to the studied systems without sodium carbonate). Additionally, with increasing added Na_2CO_3, the lower the efficiency of decolorization after 24 hours was more pronounced in comparison with the staining solution without salt the lower energy density, when the lowest energy was applied. Moreover, in the literature, CO_3^{2-} and n-butanol were used as $^{\bullet}OH$ scavengers.[38]

Effect of the salts on the pH during plasma treatment of the dye

    The variations of pH values of the solutions containing the employed inorganic salts during the treatment process are shown in Fig. 7. The curves show that the pH value decreased considerably for all the tested systems, except for the solutions of the dye to which 1 and 10 g L^{-1} Na_2CO_3 had been added. A certain contribution to the pH variation during the plasma treatment derived from sulfuric acid and carboxylic intermediates, produced from the degradation of dyes. The variation of pH value is probably caused by several specific acidic substances, such as nitric acid and nitrous acid, which are produced during the discharge process in air.[26] It can be concluded that the addition of Na_2CO_3 (> 1g L^{-1}) had sufficient neutralization potential, so that the decolorization reaction in these systems during the subsequent recirculation was realized at almost the same pH (buffer system). Since the decolorization shape functions in all tested systems were very similar, it could be concluded that the pH of the solution during the plasma treatment did not affect the decolorization reaction.
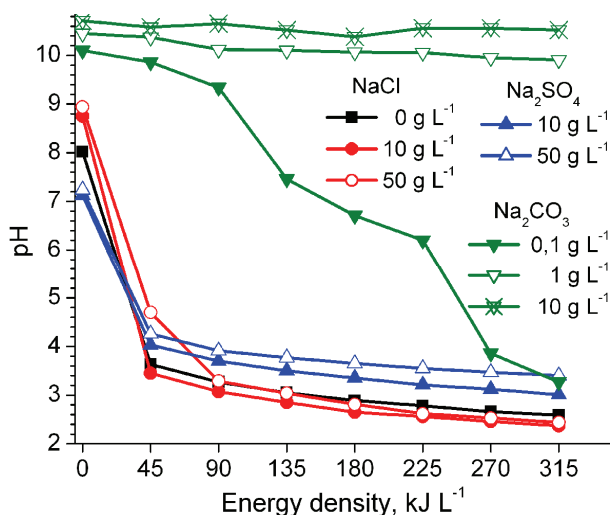

Fig. 7. The change in the pH values during the reaction process without and with salt after each recirculation (Reactive Black 5, $c_0 = 40.0$ mg L^{-1}).

Effect of the salts on conductivity during plasma treatment of the dye

    The variations in the conductivity of the solutions containing the examined inorganic salts during the treatment process are shown in Fig. 8. For the highest concentration of inorganic salts that were tested (1, 10 and 50 g L^{-1}), the

conductivity of the solution during the plasma treatment ($0–315$ kJ L^{-1}) increased by about 30 %. The conductivity of the dye solution without salt during treatment increased 56 times, while in the system with 0.1 g L^{-1} Na$_2$CO$_3$, the conductivity doubled. Based on these increases in conductivity in the matrix of inorganic salts during the plasma treatment, it could be concluded that the increases in the conductivity arose from the increase in the number of ionic species (organic intermediates, nitrates and nitrites that originated from the nitrogen in the air).
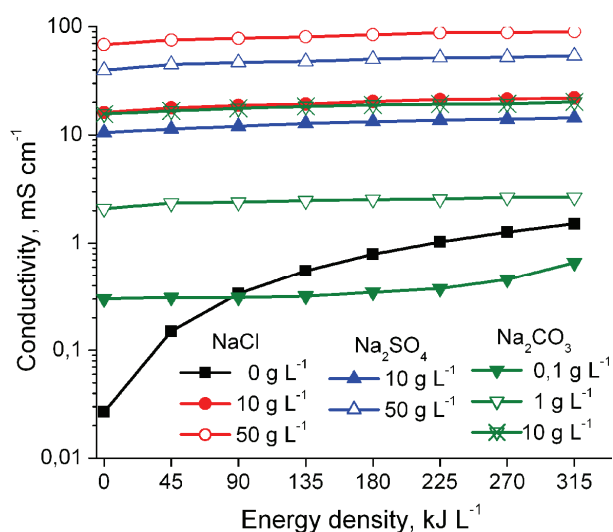

Fig. 8. The change in conductivity during the reaction process without and with salt after each recirculation (Reactive Black 5, $c_0 = 40.0$ mg L^{-1}).

CONCLUSIONS

The results indicated that decolorization of the dyes was significantly limited in the presence of salts. Increasing the concentrations of inorganic salts in the water reduced the efficiency of decolorization of the dye, to varying degrees depending of the salt used. The most effective decolorization, of over 90 % was obtained with addition of 50 g L^{-1} NaCl with applied energy density of 135 kJ L^{-1} 24 h after plasma treatment. Decolorization in the presence of the inorganic salts Na$_2$SO$_4$ and Na$_2$CO$_3$ was lower than the solution without salt. The increased decolorization with addition 50 g L^{-1} NaCl was explained by the formation of hypochlorite from the chloride ions during the plasma treatment.

Finally, studies on dye oxidation in saline systems are not frequent; however, wastewater from the textile industries may contain appreciable levels of salts, which could impair the treatment processes, as confirmed in this work.

ИЗВОД

ОБЕЗБОЈАВАЊЕ РЕАКТИВНОГ ЦРНОГ 5 ПОМОЋУ ДИЕЛЕКТРИЧНОГ БАРИЈЕРНОГ ПРАЖЊЕЊА У ПРИСУСТВУ НЕОРГАНСКИХ СОЛИ

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Неорганске соли побољшавају бојење текстила. Повећана концентрација соли у отпадној води која потиче из текстилне индустрије додатно оптерећује отпадну воду у целини. У оквиру овог рада проучавано је обезбојавање реактивне текстилне боје реактивно црно 5 користећи унапређени оксидациони процес (AOP) помоћу коаксијалног реактора на бази нетермичке плазме. Реактор ради на принципу диелектричног баријерног пражњења (DBD), при чему је један слој диелектрика танак слој третиране воде који се константно обнавља (проточни тип реактора). Почетна концентрација боје у третираном раствору је била 40,0 mg L^{-1}. Проучаван је утицај различитих високих концентрација неорганских соли (NaCl, Na$_2$SO$_4$ и Na$_2$CO$_3$) на степен обезбојења. Раствор боје је седам пута рециркулисан кроз DBD реактор, што одговара примењеној густини енергије од 45 до 315 kJ L^{-1}. Проценат обезбојења раствора боје је мерен после 5 min и после 24 h од третмана плазмом. Обезбојавање боје је праћено помоћу спектрофотометријског мерења. После сваке рециркулације раствора боје мерене су промена pH вредности и проводљивост раствора. Најефикасније обезбојење од преко 90 % добијено је у систему са додатком 50 g L^{-1} NaCl, при примењеној густини енергије од 45 kJ L^{-1} и после 24 сата од плазма третмана. Обезбојења раствора боје који садрже неорганске соли Na$_2$SO$_4$ и Na$_2$CO$_3$ била су нижа него код раствора боје без додатка соли.

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