Proceedings of Basic and Applied Sciences
ISSN 1857-8179 (paper). ISSN 1857-8187 (online). http://www.anglisticum.mk
Proceedings of the 1st International Conference on New Horizons in Basic and Applied Science, Hurghada – Egypt, Vol 1(1), 2013.

Treatment of B-Naphthols from Waste Water by Electrocoagulation

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Abstract: *The release of poly aromatic hydrocarbons specially β-Naphthols from industrial plants, especially in wastewater effluents discharged from desizing processes in the textile industry, causes many ecological problems that must be solved. These highly contaminated wastewaters contain considerable amounts of dissolved organic carbon, causing a high chemical oxygen demand. Various techniques have been investigated for the removal of these organic pollutants hydrocarbons from contaminated water, including biodegradation, adsorption onto activated carbon, membrane processes, and advanced oxidation processes. These techniques suffer from several technical and economic disadvantages. Although biodegradation is an environmentally friendly process, the rate of hydrocarbon biodegradation is considerably slow and thus requires long reaction times in the range. Electrocoagulation is an important water treatment technology that has been widely used for removing heavy metals and organic pollutants. In the present study, several factors were studied first of them is the EC process parameters such as current density ,pH, electrolysis time ,electrolyte concentration and initial compound concentration were investigated in terms of their effects on the removal efficiencies of poly aromatic hydrocarbons specially β-Naphthols. The optimum conditions for the removal of β-Naphthols were achieved at current density = 20mA/cm^2, pH = 7, NaCl concentration = 1 g/l and temperature of 25°C.*

Keywords*: Organic pollutants, waste water, treatment, electro coagulation.*

Introduction

Alfa and beta Naphtols can be considered the derivative of Naphthalene which is the simplest Poly aromatic hydrocarbons (PAHs). PAHs are composed of "two or more fused aromatic (benzene) rings. However, most people consider the most important criteria in classifying PAHs to be whether or not two benzene rings are present in the chemical structure. However “fused aromatic rings” is probably the best definition. One can also use “carbocyclic systems” in describing some types of compounds [1].PAHs are to a certain degree resistant to biodegradation and are sometimes included in a class of persistent organic pollutants (POPs) [2]. PAHs are hydrophobic compounds and their persistence in the environment is also linked to their low water solubility and electro-chemical stability Of the over 900 agents compiled by the International Agency for Research on Cancer (IARC), 400 have been classified as carcinogenic (this includes PAHs) (IARC, 2009).Electrocoagulation is an effective primary treatment for highly polluted industrial wastewater. It has been used successfully for the treatment of various industrial effluents including effluent issues from food industries [3,4], tanneries [5,6], heavy metals [7–10], mechanical workshop (soluble oil) [11,12], polymerization manufactures, and textile industries [13–16]. Its application for the treatment of textile wastewaters is of a primary interest for two main reasons. The first one is that this treatment is very efficient and adapted for wastewaters containing high level of various types of pollutants (organic, mineral, heavy metals, and dyes…). Secondly electrocoagulation is known for its high efficiency in decolorization. Numerous papers are therefore devoted to decolorization of solutions prepared with specific dyestuffs as illustrated by the general review recently published by Martĩnez-Huitle and Brillas[17]. The process dependent on the effects of various operating parameters e.g. pH, initial concentration, current density, time, electrode gap on the removal efficiency have been investigated, in particular regarding the COD level and the absorbance at the maximum wavelength.Naphthalene derivatives[18]are organic pollutants present in the

Selection and peer-review under responsibility of ICNHBAS, 2013 http://www.nhbas2013.com

environment as a result of various processes such as industrial, biogeochemical and as pesticide degradation productsTherefore, the determination of α- and β naphtholis of great importance in quality controland in environmental chemistry.The large quantity of aqueous waste generated by petrochemical and textile industries has becomes a significant environmental problem. Nowadays α- and β naphthol are the environmental priority pollutants and are becoming one of the most serious environmental problems. So these toxic α- and β naphthol should be removed from the wastewater to protect the people and the environmental. Many methods that are being used to remove α- and β naphthol include chemical coagulation, activated carbon,adsorption, chemical precipitation, ion-exchange, ultrafiltration, membrane filtration ozonation and electrocoagulation(EC) .

The objective of this study is to remove β naphthol which is very dangerous to people and environmental. The removal technique done in this work is electrocoagulation method. The main objective of this work is to examine the different parameters which affect on the percentage removal. These parameters are initial concentration of the solution, dosage of electrolyte, pH of the solution, contact time and current density.

Electrocoagulation Technology:

A host of very promising techniques based on electrochemical technology are being developed and existing ones improved that do not require chemical additions. These include electrocoagulation[19], electroflotation[20], electrodecantation[21], and others[22]. Even though one of these, electrocoagulation, has reached profitable commercialization, it has received very little scientific attention. This process has the potential to extensively eliminate the disadvantages of the classical treatment techniques. Moreover, the mechanisms of EC are yet to be clearly understood and there has been very little consideration of the factors that influence the effective removal of ionic species, particularly metal ions, from wastewater by this technique. In this brief review, we wish to address these issues. Coagulation is a phenomenon in which the charged particles in colloidal suspension are neutralized by mutual collision with counter ions and are agglomerated, followed by sedimentation. The coagulant is added in the form of suitable chemical substances. Alum [Al2(SO4)3·18H2O] is such a chemical substance which has been widely used for ages for wastewater treatment. The mechanism of coagulation has been the subject of continual review [23,24]. It is generally accepted that coagulation is brought about primarily by the reduction of the net surface charge to a point where the colloidal particles, previously stabilized by electrostatic repulsion, can approach closely enough for van der Waal's forces to hold them together and allow aggregation. The reduction of the surface charge is a consequence of the decrease of the repulsive potential of the electrical double layer by the presence of an electrolyte having opposite charge. In the EC process, the coagulant is generated in situ by electrolytic oxidation of an appropriate anode material. In this process, charged ionic species—metals or otherwise—are removed from wastewater by allowing it to react (i) with an ion having opposite charge, or (ii) with floc of metallic hydroxides generated within the effluent. The EC technology offers an alternative to the use of metal salts or polymers and polyelectrolyte addition for breaking stable emulsions and suspensions. The technology removes metals, colloidal solids and particles, and soluble inorganic pollutants from aqueous media by introducing highly charged polymeric metal hydroxide species. These species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase. The treatment prompts the precipitation of certain metals and salts. The advantages of EC technology are discussed below. There are many advantages of electrocoagulation process such as: it requires simple equipment and is easy to operate with sufficient operational latitude to handle most problems encountered on running, Wastewater treated by EC gives palatable, clear, colorless and odorless water, EC produces effluent with less total dissolved solids (TDS) content as compared with chemical treatments. If this water is reused, the low TDS level contributes to a lower water recovery cost, The EC process avoids uses of chemicals, and so there is no problem of neutralizing excess chemicals and no possibility of secondary pollution caused by chemical substances added at high concentration as when chemical coagulation of wastewater is used, The EC technique can be conveniently used in rural areas where electricity is not available, since a solar panel attached to the unit may be sufficient to carry out the process.

Experimental Part

Experimental Set-up

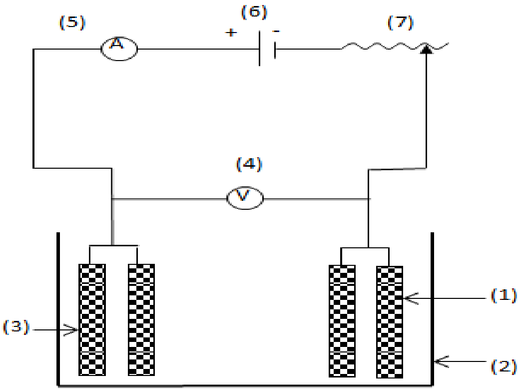
The experimental set-up used in the present work is schematically shown in Fig. (1). The EC cell consisted mainly of a rectangular vessel made of plexi-glass with dimensions 10 × 10 cm square base and a height of 20 cm (Fig.2). Perforated aluminum sheets (10 × 20 cm) (Fig.3) which are placed in plexi-glass rectangular vessel which include two plates one at the right side operate as a cathode and another perforated aluminum sheet at the lift side which operate as anode ,the anode is connected by wire to the negative charge of power supply and the cathode is connected by wire to the positive charge of the power supply . The anode-cathode distance was kept at 4 cm. The electrical circuit consisted of power supply (10V, 5A) with a voltage regulator and multi range ammeter, all connected in series with the cell, a voltmeter was connected in parallel with the cell to measure its voltage. Fig (3) shows the perforated anode.

Electrocoagulation Procedure

For each run 1.5 L of synthetic waste solution mixed with the appropriate amount of sodium chloride which used as a conductor. The solutions were placed into the electrolytic cylinder cell. The pH was adjusted by the addition of NaOH and/or HCl solutions. Direct current from the D.C power supply was passed through the solution via the two electrodes during 120 minutes of electrolysis run; 10 ml of the solution was drawn at interval time during the run. The location of the drawn samples was kept constant for each run. Samples were filtered and centrifuged, and then taken for absorbance measurements at an appropriate wave length of the maximum absorption for each beta compounds. The measured absorbance was then converted to the residual concentration of the compound using a calibration curve obtained from a plot between the absorbance versus the known concentration for each compound .The electrodes were washed with HCl solution (15% w/v) before each run in order to remove any adhering scales or oxides. Following each run, the electrodes were washed with distilled water, dried until the second use.

Variables studied

(1) Effect of current density, (2.5,5,10,15 and 20 mA/cm^2).
(2) Effect of initial concentration, (20,40,60,80,100 ppm).
(3) Effect of pH, (1, 5, 7, 9 , 11).
(4) Effect of sodium chloride concentration, (0.5, 1, 2, 3 g/l).
(5) Effect of time, (30,60,90,120,180).



Figure(1) Schematic diagram of the experimental set-up

1) Perforated Al anode
2) plexi-glass tank
3) Perforated Al Cathode
4) Voltammeter
5) Ammeter
6) Power supply
7) Resistance

Figure (2) Plexi-glass cell

Figure(3) perforated aluminum sheet

Results and discussion:

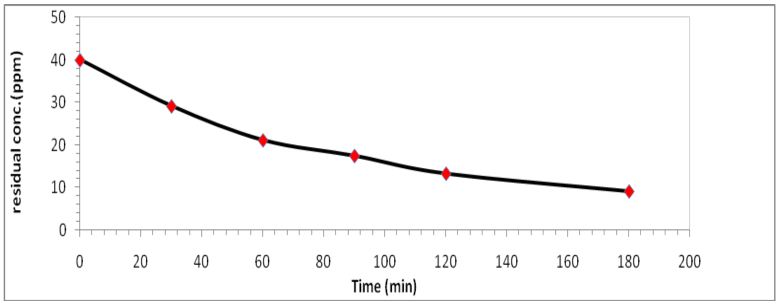
Effect of electrolysis time

Figure (4) shows the effect of electrolysis time on the residual concentration of β Naphthols at a current density of 15 mA /cm^2.As the duration of the electrolysis treatment increased, comparable decreased on the residual concentration of β Naphthols was observed. It was also observed that as the reaction time increases from 30 mins to 180 mins the residual concentration decreased from 40 ppm to 9.16 ppm , This is due to as the time of electrolysis increases the time of mixing and reaction increases.[25] In the following sections, all EC experiments were conducted using 180 mins of electrolysis.

Fig(4) Effect of electrolysis time on the residual concentration, (Current density =20 mA/cm^2, Initial pH=7,Initial concentration=40 ppm ,NaCl Concentration **=**1 g/l, and Temperature =25°C).

Effect of Current Density

Another important parameter influencing the performance and the economy of the electrogoagulation process is the density of current applied at the electrodes [26].To study the effect of current density on the efficiency of electrocoagulation in Residual concentration of β-Naphthols the experiments carried out at range from 2.5 mA/Cm^2 to 20 mA/Cm^2. From Figure (5) it was observed that as the current density increased from 2.5 mA/Cm^2 to 20 mA/Cm^2 the residual concentration decreased from 40 ppm to 8.33 ppm .This trend was observed due to that as the current density increased the formation of flocs of aluminium hydroxide at the anode of the cell increased and this enhance the rate of adsorption of β-Naphthols on the flocs of Aluminum hydroxide.



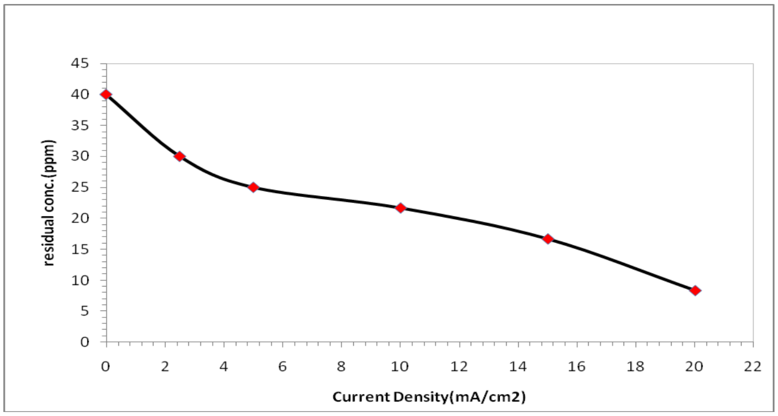


Fig (5) Effect of Current Density on the residual concentration
(Initial pH=7, **Initial** concentration=40 ppm, NaCl Concentration **=**1 g/l, **Temperature** =25°C, Time =120min)

Effect of initial concentration of β-Naphthols

The variation of percentage removal of different initial concentrations of β-Naphthols was shown in Fig(6). It can be seen that with increasing initial concentration, removal efficiency of β-Naphthols increased linearly. The reason for this is the lack of flocs for adsorption of excess β-Naphthols in high concentrations. It is necessary to mention that the total amount of flocs is constant for all concentrations. [27]

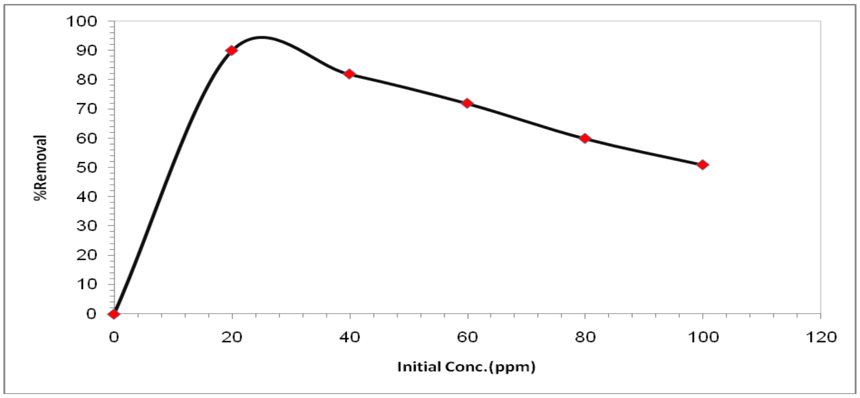


Fig (6) Effect of initial Conc. on the removal efficiency
(Current density =20 mA/cm^2, Initial pH=7, NaCl Concentration =1 g/l, Temperature =25°C, Time =120min)

Effect of pH

Solution pH is one of main factors affecting electrochemical processes. Therefore, pH (in the range of 1 to 11) was examined as one of the main variables affecting electrocoagulation removal of β-Naphthols from waste water. The results were shown in Fig.(7). The residual concentration decreased from 28.3 ppm to 13 ppm for cell no.1, when the pH was increased from 1 to 7. Then the removal percentage decreased for a pH between9 and 11. This finding support that electrocoagulation efficiency is a function of pH and these results are in accordance with other researchers who have reported the maximum performance for the ECP at pHs between 7 and 8 when using Fe or St as the sacrificial electrode.[28-30]

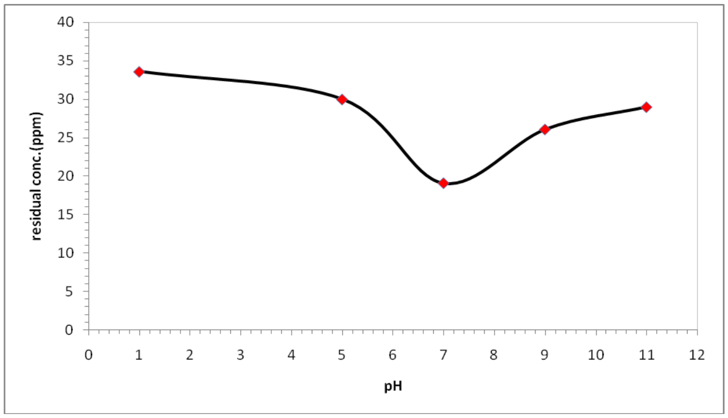


Fig. (7) Effect of pH on the residual concentration
(Current density =20 mA/cm^2 , Initial concentration=40 ppm NaCl Concentration =1 g/l, Temperature =25°C,Time =120min.)

Effect of Sodium chloride concentration

Table salt is usually employed to increase the conductivity of the water or wastewater to be treated. Besides its ionic contribution in carrying the electric charge, it was found that chloride ions could significantly reduce the adverse effect of other anions such as HCO_3^-,SO_4^{2-} .The existence of the carbonate or sulfate ions would lead to the precipitation of Ca 2+ or Mg 2+ ions that forms an insulating layer on the surface of the electrodes. This insulating layer would sharply increase the potential between electrodes and result in a significant decrease in the current efficiency. It is therefore recommended that among the anions present, there should be 20% Cl − to ensure a normal operation of electrocoagulation in water treatment. The addition of NaCl would also lead to the decrease in power consumption because of the increase in conductivity [31,32].From fig. (8).It was observed that with increasing initial concentration of Nacl from (0.5 g to 5 g) the residual concentration decreased from 40 ppm to 7.5 ppm, but it was observed also that there is a slight change in results beyond 1 g/L of NacL so the optimum amount of the electrolyte was taken to be 1 g/l.

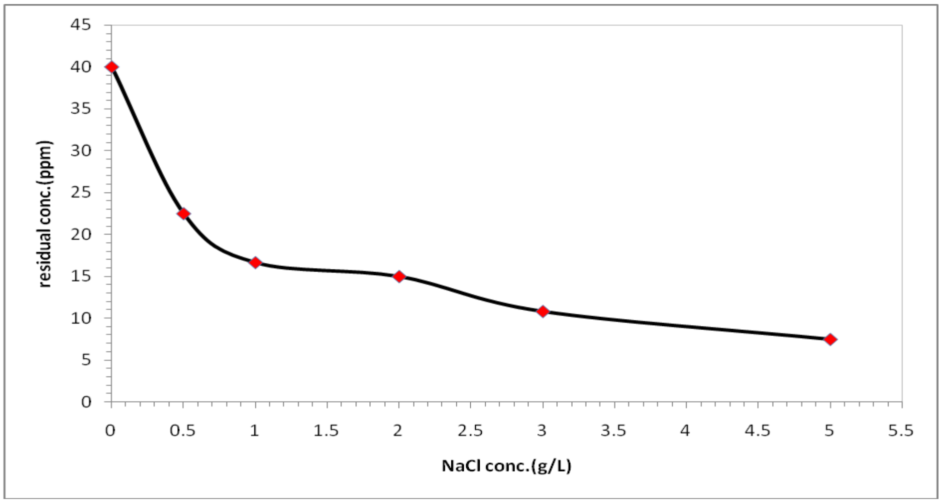


Fig (8) Effect of NaCl Conc. on the residual concentration

(Current density =20 mA/cm^2, Initial pH=7, Initial concentration=40 ppm ,Temperature =25°C, Time =120min)

Conclusions

The following conclusions can be drawn based on this investigation:

1. Experimental parameters such as current density, electrolysis time, pH, electrolyte concentration, and initial β Naphthols concentration were investigated for β Naphthols compound removal in batch mode apparatus.
2. Increase in the current density and NaCl concentration resulted in an decrease residual concentration of β-Naphthols.
3. Maximum removal of(β-Naphthols) was attained at current density=20mA/cm^2, initial pH=7,initial concentration=40ppm,treated volume=1.5liters NaCl concentration = 1 g/l and temperature of 25°C.

References

1. J.-S. Do, M.-L. Chen, Journal of Applied Electrochemistry 24 (1994) 785-790.
2. H.L. Sheng, L.C. Peng, Water Research 28 (2) (1994) 277-282.
3. X. Chen, G. Chen, P.L. Yue, Separation of pollutants from restaurant wastewater by electrocoagulation, Sep. Purif. Technol. 19 (2000) 65–76.
4. H. Inan, A. Dimoglo, H. Simsek, M. Karpuzcu, Olive oil mill wastewater treatment by means of electrocoagulation, Sep. Purif. Technol. 36 (2004) 23–31.
5. A.K. Golder, A.N. Samantha, S. Ray, Removal of Cr3+ by electrocoagulation with multiple electrodes: bipolar and monopolar configurations, J. Hazard. Mater. 141 (2007) 653–661.
6. I. Heidman, W. Calmano, Removal of Cr (VI) from model wastewaters by electrocoagulation with Fe electrode, Sep. Purif. Technol. 61 (2007) 15–21.
7. B. Merzouk, K. Madani, A. Sekki, Treatment characteristics of textile wastewater and removal of heavy metals using the electroflotation technique,Desalination 228 (2008) 245254.
8. B. Merzouk, B. Gourich, A. Sekki, K. Madani, M. Chibane, Removal turbidity and separation of heavy metals using electrocoagulation–electroflotation technique. A case study, J.Hazard.Mater. 164 (2009) 215–222.
9. N. Meunier, P. Drogui, C. Montané, R. Hausler, G. Mercier, J.-F.Blais, Comparison between electrocoagulation and chemical precipitation for metals removal from acidic soil leachate, J. Hazard. Mater. 137 (1) (2006) 581–590.

10 I. Heidmann, W. Calmano, Removal of Zn(II), Cu(II), Ni(II), Ag(I) and Cr(VI) present in aqueous solutions by aluminium electrocoagulation, J. Hazard. Mater. 152 (3) (2008) 934– 941.

11 P. Cañizares, F. Martĩnez, C. Jiménez, C. Sáez, M.A. Rodrigo, Coagulation and electrocoagulation of oil-in-water emulsions, J. Hazard. Mater. 151 (1) (2007) 44–51.

12 M. Khemis, G. Tanguy, J.P. Leclerc, G. Valentin, F. Lapicque, Electrocoagulation for the treatment of oil suspensions: relation between the electrode generations and the waste content, Process Saf. Environ. Prot. 83 (B1) (2005) 50–57.

13 M. Kobya, O. Taner Can, M. Bayramoglu, Treatment of textile wastewaters by electrocoagulation using iron and aluminium electrodes, J. Hazard. Mater. B 100 (2003) 163–178.

14 A. Alinsafi, M. Khemis, M.N. Pons, J.P. Leclerc, A. Yaacoubi, A. Benhammou, A. Nejmeddine, Electrocoagulation of reactive textile dyes and textile wastewaters, Chem. Eng. Process. 44 (2005) 461–470.

15 B. Merzouk, B. Gourich, A. Sekki, K. Madani, Ch. Vial, M. Barkaoui, Studies on the decolorization of textile dye wastewater by continuous electrocoagulation process, Chem.Eng. J. 149 (2009) 207–214.

16 I. Zongo, A. Maïga, J. Wéthé, G. Valentin, G. Paternotte, J.-P. Leclerc, F. Lapicque, Electrocoagulation for the treatment of textile wastewaters with Al or Fe electrodes:compared variations of COD levels, turbidity and absorbance, J. Hazard.Mater. 169 (2009) ,70–76.

17 C.A. Martĩnez-Huitle, E. Brillas, Decontamination of wastewaters containing synthetic organic dyes by electrochemical methods: a general review, Appl. Catal., B 87 (2009) 105– 145.

18 M.C. Pietrogrande, G. Blo, C. Bighi, J. Chromatogr. 349 (1) (1985) 63.

19 K. Rajeshwar, J.G. Ibanez, G.M. Swain, J. Appl. Electrochem. 24 (1994) 1077.

20 P. Stamberger, J. Colloid Interface 1 (1946) 93.

21 H. Svensson, Adv. Protein Chem. 4 (1948) 251.

22 M. Bier, in: M. Bier (Ed.), Electrophoresis: Theory, Methods and Applications, Academic Press,New York, 1959, p. 270

23 J.Th.G. Overbeek, J. Colloid Interface Sci. 58 (1973) 408.

24 J. Lyklema, in: J. Goodwin (Ed.), Colloidal Dispersion, Royal Society of Chemistry, London, 1981, p. 47

25 B. Fleet, Evolution of electrochemical reactor systems for metal recovery and pollution control, in: J.T. Stock, M.V. Orna (Eds.), Electrochemistry, Past and Present, America Chemical Society, Washington, DC, 1989.

26 W. Balla, A.H. Essadki, B. Gourich, A. Dassaa, H. Chenik, M. Azzi, Electrocoagulation/electroflotation of reactive, disperse and mixture dyes in an external-loop airlift reactor, J. Hazard. Mater. 184 (2010) 710–716.

27 Ehssan.Nassef,"Treatment of phenolic compounds from petrochemical waste by electrochemical technique" PhD,Thesis,Chemical Departement,Faculty of Engineering, Alexandria University.2010.

28 Linares-Hernández, C. Barrera-Díaz, G. Roa-Morales, B. Bilyeu, F. Ureña-Núñez, Influence of the anodic material on electrocoagulation performance, Chem. Eng. J. 148 (2009) 97–105.

29 N. Daneshvar, A. Oladegaragoze, N. Djafarzadeh, Decolorization of basic dye solutions by electrocoagulation: an investigation of the effect of operational parameters, J. Hazard. Mater. B129 (2006) 116–122.

30 M. Kobya, S. Delipinar, Treatment of the baker's yeast wastewater by electro-coagulation, J. Hazard. Mater. 154 (2008) 1133–1140.

31 M. Kobya, S. Delipinar, Treatment of the baker's yeast wastewater by electro-coagulation, J. Hazard. Mater. 154 (2008) 1133–1140.

32 H.M. Wong, C. Shang, Y.K. Cheung, G. Chen, Chloridem Assisted Electrochemical Disinfection, in: Proceedings of the Eighth Mainland-Taiwan Environmental Protection Conference, Tsin Chu, Taiwan, 2002.