

Study the Effect of Process Parameters during Electrochemical Treatment of Wastewater

Sachin N. Golani¹, Savan R. Ghelani², Shivamsinh V. Jadav³, Kishan M. Kaneria⁴,
Prof. Baddi Prasad⁵ and Prof. Vishal Kumar Sandhwar⁶

^{1,2,3,4}B.Tech. Chemical Engineering, Parul University

^{5,6}Asst. Prof., Department of Chemical Engineering, Parul University, Vadodara, Gujarat, India

Abstract - Disposal of industrial effluent wastewater containing hazardous components like phenol and/or phenolic compounds, unreacted dyes, iron sulphide, bacteria, lactic acid, dissolved salt and other toxic compounds. We have to remove these pollutants to reuse wastewater for industrial purpose. There are so many methods to treat the effluent from industries, but here we use most efficient method electrochemical treatment. In present study, we will take the sample of effluent from textile industries and also select the electrodes that have remarkable binding characteristics to remove pollutants, so special interest was devoted for optimizing its uptake and studying its selectivity properties under static and dynamic conditions. Also, we will study the process parameters such as, effect of pH, conductivity, electrolysis concentration, current density, etc. By using electrochemical method, the pollutants of effluent wastewater are mostly removed.

Key Words: EC treatment, wastewater, pH, type of electrode, distance between electrodes, current density, treatment time

1. INTRODUCTION

Today, the industrial wastewater is a major problem in nowadays. It may contain hazardous pollutants like phenol and/or phenolic compounds, suspended solids, bacteria, dyes, etc. Because of their poor biodegradability and high toxicity, it must be treated before we discharge or reuse. The Environmental Protection agency (EPA) decided that, the quantity of phenol in the effluent wastewater is must be less than 1 mg/L.

There are so many methods to treat wastewater such as biological treatment, activated carbon adsorption, extraction, oxidation and electrochemical methods. These methods have problems such as high cost, low efficiency, generation of toxic compounds. Biological and electrochemical methods are eco friendly methods means no harmful to environment.

The electrochemical treatment consists of electro-oxidation, electrocoagulation, electroflotation, etc. Comparing to other methods, it requires less space. It has the advantage of removing the smallest colloidal particles; the smallest charged particles have a greater probability of being coagulated because of the electric field that sets them in

motion. It has also the advantage of producing a relatively low amount of sludge.

In the present work, the removal of phenol from aqueous solution was investigated using aluminum electrodes. Several parameters, namely initial pH, conductivity, current density, phenol concentration, NaCl concentration and electrolysis time, were investigated for their effects on the removal efficiency.

2. EC TREATMENT

Electrocoagulation neutralizes the electrostatic charge on colloidal particles and facilitates coagulation and then separates it from the solution. This treatment also prompts precipitation of some of the metal sand salts. It involves the situ generation of coagulants by dissolving electrically either aluminum or iron ions from aluminum or iron electrodes, respectively. The metal ions generation takes place at the anode; hydrogen gas released from the cathode. The hydrogen gas would also help to float flocculated particles out of the water. In this process $Al(OH)_3$ and $Fe(OH)_2$ were formed.

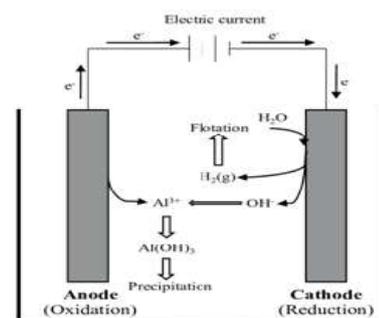


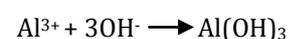
Fig. 2 Electrocoagulation cell

The chemical reaction taking place at the anode are given as follows

For aluminum anode:



At alkaline conditions



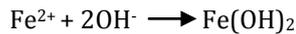
At acidic conditions



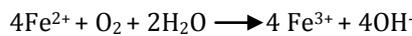
For iron anode:



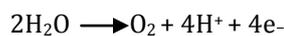
At alkaline conditions



At acidic conditions



In addition, there is oxygen evolution reaction



The reaction at the cathode is



The Al^{3+} or Fe^{2+} ions are very efficient coagulants for particulates flocculating. The hydrolyzed aluminum ions can form large networks of Al-O-Al-OH that can chemically adsorb pollutants such as F. Aluminum is usually used for water treatment and iron for wastewater treatment. The advantages of electrocoagulation include high particulate removal efficiency, compact treatment facility, relatively low cost and possibility of complete automation.

3. EXPERIMENTAL DETAILS

3.1 Experimental Set up

The batch experimental setup is schematically shown in fig. 3.1. The EC unit with monopolar electrodes in parallel connection consists of an EC cell, a DC power supply and electrodes. The aluminum cathode and aluminum anode separated by a space of 2 cm and dipped in the wastewater. The wastewater contains 300 mg/L phenol in water. The electrolyte, 1 g NaCl was added to the phenol solution. The EC treatment of wastewater was carried out in the glass reactor. The volume of the reactor was 991.85 cm³ [9.5 cm(dia.)*14 cm (h)]. There were four electrodes connected in a monopolar mode in the electrochemical reactor, each one with dimensions of 9.5 cm*2.5 cm*0.3 cm. Total area submerged into the solution of the electrode is 53.95 cm².



Fig. 3.1 Electrochemical cell

3.2 Experimental method

At the beginning of a run, the wastewater was fed into the reactor and the pH adjusted to a desired value. The electrodes were placed into the reactor. The reaction starts, when the DC power supply was switched on. Because of adding salt, aluminum salts reaction causes a 50% increase in treatment time and power requirements. Eliminating the salt formation at the anode could reduce this effect. We performed no. of experiments by adjusting parameters pH and treatment time. The cell was cleaned after each experiment. Also, the electrodes were rinsed in the diluted HCl solution after the each experiment to clean them. Samples (10ml volume) were collected at pH = 3.2, 7.0 and 9.1 at different time intervals 30 min, 60 min, 90 min and 120 min respectively.

We can find % removal of phenol by

$$\% \text{ Removal of phenol} = (C_i - C_f) * 100 / C_i$$

Where, C_i is the initial phenol concentration (mg/L) and C_f is the final phenol concentration (mg/L).

4. RESULT AND DISSCUSSION

4.1 Effect of pH

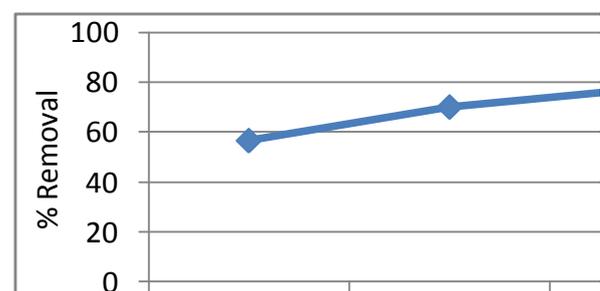


Fig. 4.1 Effect of pH on phenol removal efficiency

It has been established that the pH is an important operating factor influencing the performance of electrochemical process, current efficiency as well as the solubility of metal hydroxide. To know this effect, pH of the phenol solution was adjusted by using 1N NaOH and 1N H₂SO₄. During the experimental work phenol removal

efficiency was determined at different pH 3.2, 7.0 and 9.1. The results are shown in fig. 4.1 in which the variation of removal efficiency of phenol with the solution initial pH could be clearly identified. As the pH increases, the phenol removal efficiency is increase.

4.2 Effect of treatment time

The treatment time is also an important parameter for electrochemical treatment. It depends on the electrode material and type of electrolyte. Here, in this experiment, as the time increase, the amount of Al^{3+} ions released from the electrodes will also increase, means more amt. of phenol will be remove.

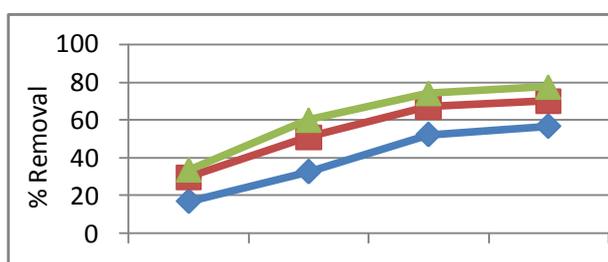


Fig. 4.2 Effect of treatment time on phenol removal efficiency

CONCLUSION

Electrocoagulation of wastewater using Al electrodes seems very effective method as relevant by present study. At constant inner electrode distance and concentration of phenol, as we increase the pH the rate of removal efficiency of phenol will also increase. At pH = 9.1, the rate of phenol removal is 77.7 %, which means we get high removal efficiency at high pH. As the time increase, the rate of removal of phenol will also increase. Also, the removal efficiency of phenol is different at different types of electrode materials.

ACKNOWLEDGEMENT

We are thankful to Prof. Baddi Prasad (Asst. Prof. of chemical engineering, Parul University) and Prof. Vishal Kumar Sandhwar (Asst. Prof. of chemical engineering, Parul University) for their valuable advice during preparation of the paper.

REFERENCES

- [1] E. Diaz, A.F. Mohedano, L. Calvo, M.A. Gilarranz, J.A. Casas, J.J. Rodriguez, 2007, Hydrogenation of phenol in aqueous phase with palladium on activated carbon catalysts, Chem. Eng. J. 131, pp. 65-71.
- [2] F. Benyahia, M. Abdulkarim, A. Embaby, M. Rao, 2006, The 7th Annual U.A.E. University Research Conference, Al Ain, UAE.

- [3] A.K. Basu, 1975, Characteristics of distillery wastewater, Water Pollut. Control Fed. 47, pp. 2184-2190.
- [4] W.W. Eckenfelder, 1996, Industrial Water Pollution Control, second ed., McGraw-Hill, NY.
- [5] B. Demirel, O. Yenigun, T.T. Onay, 2005, Anaerobic treatment of dairy wastewaters: a review, Process Biochem. 4 (8), pp. 2583-2595.
- [6] M. Perle, S. Kimchie, G. Shelef, 1995, Some biochemical aspects of the anaerobic degradation of dairy wastewater, Water Res. 29, pp. 1549-1954.
- [7] K. Baskaran, L.M. Palmowski, B.M. Watson, 2000, Wastewater reuse and treatment options for the dairy industry, Water Sci. Technol. 3, pp. 85-91.
- [8] Garg, A., Mishra, I.M., and Chand, S., January 2007, "Catalytic wet oxidation of the pretreated synthetic pulp and paper mill effluent under moderate conditions", Chemosphere, 66(9), pp. 1799-1805.
- [9] Pokhrel, D. and Viraraghavan, T., October 2004, Treatment of paper and pulp mill wastewater a review, Science of the Total Environment, 333 (1-3), pp. 37-58.
- [10] Kalyani, K.S.P., Balasubramanian, N. and Srinivasakannan, C, August 2009, "Decolorization and COD reduction of paper industrial effluent using electro-coagulation," Chemical Engineering Journal, 151 (1-3), pp. 97-104.
- [11] Gnusin N. P., Vithulskhaya., Zabolotskaya L. I., Belobrow I. A., 1997, Appl. Chem.. (USSR) 50.
- [12] Abou-Mesalam, M. M., 2003, "Sorption kinetics of copper, zinc, cadmium and nickel ions on synthesized silico-antimonate ion exchanger." Colloids Surfaces A, 225(1-3), pp. 85-94.
- [13] American Public Health Association (APHA), 2003, Standard methods for the examination of water and wastewater, Washington, DC.
- [14] Boehm, H. P., 1996, "Chemical identification of functional groups." Advances in catalysis, Academic, New York.
- [15] Banu R and Kaliappan S., 2007, Treatment of tannery wastewater using hybrid upflow anaerobic sludge blanket reactor, J. Environ. Eng. Sci., 6, pp. 415-421.
- [16] D.H.F. Liu, B.G. Liptak, 1996, Environmental Engineers Handbook, Lewis Publishers, NY.