International Journal of Computational Intelligence Systems and Applications. Volume 4, Issue 1, (2016) 73-78
http://www.cayley-nielson.com/ijcisa/

Experimental Research on the Treatment of Souse Industrial Organic Wastewater by Electrolysis

Yang Guangjun[1], Yang Lei[2], Shan Yu[1], Shen Yang[1], Chai Tianyu[1], Wang min[1], Liu kun[1], Xie Yuanhua[1], Zhu tong[1,*]

[1]School of Mechanical Engineering and Automation, Northeastern University, Shenyang 110004, China

[2] Technical Center for Safety of Industrial Products, Tianjin Entry-Exit Inspection and Quarantine Bureau, Tianjin 300308, China

Abstract

In order to explore the effect of electrolysis in the treatment of souse industrial organic wastewater, the wastewater with different original pH value and current density was electrolyzed respectively. The electrolytic wastewater's chemical oxygen demand (COD) removal rate and instantaneous current efficiency (ICE) were chosen as indicators to evaluate the effectiveness of wastewater treatment. The experimental results showed that wastewater treatment effect under initial acidic pH was better than that of neutral and alkaline conditions. The greater the current density, the higher the removal rate of wastewater COD. Oversize current density led to excessive energy consumption and small ICE. When the initial pH was 4.9 and the current density was 7.48A/dm^2, ICE could reach up to 140.00%, and the effect was better.

Keywords: Electrolysis process; organic wastewater; current efficiency; removal efficiency.

1. Introduction

With the development of the souse industry in China, the treatment of souse wastewater becomes cannot be ignored. Souse wastewater has high salinity, high chemical oxygen demand (COD) and other characteristics, the effluent water salinity is about 20000mg/L, COD is about 3000~6000mg/L[1].

At present, the common methods to deal with the souse industry wastewater can be summarized as the physical and chemical method, chemical method, biological method [2-4]. Electrolysis is a kind of chemical method; its principle is the use of applied current to produce a series of chemical reactions in the wastewater, so that the harmful substances in wastewater are converted into harmless substances [5]. Duan Weiyu et al. [6] through the exploration of the electrolytic product of souse wastewater proved that the electrolysis method can degrade the organics into water and carbon dioxide. Cheng Yulai et al. [7] made a series of experiments on the electrolysis of Slaughter Wastewater, which proves that increasing the electrolytic current and time can significantly improve the electrolytic effect. Han Fengxia et al. [8] further proves the effect of electrolytic current and time on the electrolysis effect, and puts forward the relationship between energy consumption and current.

In this paper, the Pt-Ir/Ti electrode is used to electrolyze souse industrial organic wastewater containing NaCl, and taking COD removal rate and instantaneous current efficiency (ICE) as the index, investigating the optimal pH initial value and electrolytic current density of the reaction, and explore the relationship between energy consumption and processing efficiency.

ISSN 2331-1924 / Copyright © 2016 CAYLEY NIELSON PRESS, INC.
April, 2016

2. Materials and methods

2.1. Experiment materials and apparatus

Electrolysis wastewater is a high concentration organic wastewater, the original COD is about 10800mg/L, pH is 4.09, and when regulating pH to neutral or alkaline, the COD is about 7000mg/L.

The experimental apparatus is shown in Fig.1, DC power supply (PMC18-5, KIKUSUI, Japan) provide 7.48A/dm^2 and 14.96A/dm^2 current density. Electrodes are coated with platinum and iridium on a titanium substrate (Pt-Ir/Ti electrode), the electrode area is 0.25dm^2, and the distance between the two electrodes is 3mm, which is placed in parallel.

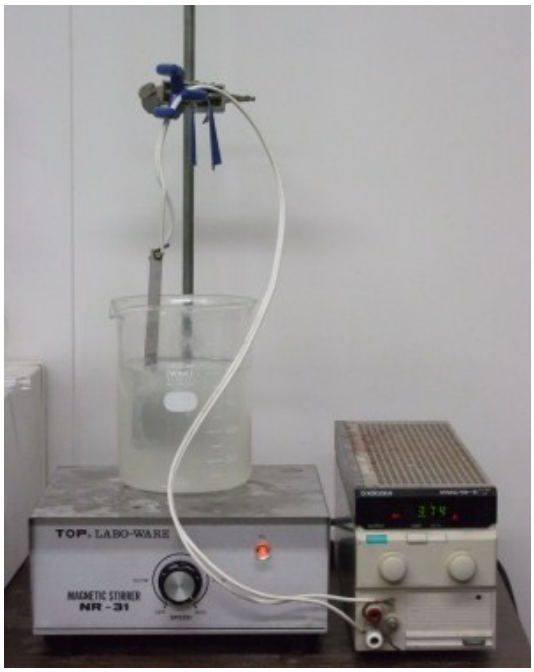

Fig.1 Photo of experiment equipment

2.2. Analysis items and methods

The determination of COD adopts potassium dichromate method. In order to consider the problem of energy consumption, the concept of ICE is introduced, and the relationship between the current intensity, the COD removal rate and the energy consumption is established,

ICE calculation is as follows:

$$\mathrm{ICE} = \frac{[(\mathrm{COD})_t - (\mathrm{COD})_{t+\Delta t}]}{8I\Delta t} F * V \tag{1}$$

Where, （COD）t——when time is t, the value of COD，g/L;

（COD）t+Δt——when time is t+Δt , the value of COD, g/L;

I——Current intensity, A;

F——Faraday constant, 96487g/mol;

V——Electrolyte volume, L;

Δt——time interval, s.

2.3. Operation methods

(1) The effect of initial pH on the processing efficiency

Add 30g NaCl to 1L wastewater[9], Regulating current density is 7.48A/dm^2, electrolysis time is 26h, the water samples are taken from 0, 2, 4, 6, 10, 14, 8, 18, 22, 26h, respectively,， testing the value of COD[10].The initial value of pH of wastewater was adjusted to 8.00 and 10.00 respectively, repeating the above steps.

(2) The effect of current density on processing efficiency

Under the initial pH condition, repeating step (1)， investigating the effect of current density (7.48A/dm^2 and 14.96A/dm^2) on the treatment effect.

(3) Relationship between energy consumption and treatment efficiency

Based on the effect of current density on the treatment effect, ICE parameter is introduced to discuss the relationship between energy consumption and wastewater treatment efficiency.

3. Results and discussion

3.1. Effect of initial pH on the processing efficiency

When the current density is 7.48A/dm^2, the change of COD under different initial pH is shown in Fig.2. At the starting stage in the electrolysis of souse wastewater, COD all has a short rise phenomenon, which can be interpreted as the beginning stage of electrolysis, long chain organics is broken and decomposed into a large number of short chain organics, so COD slightly increased.

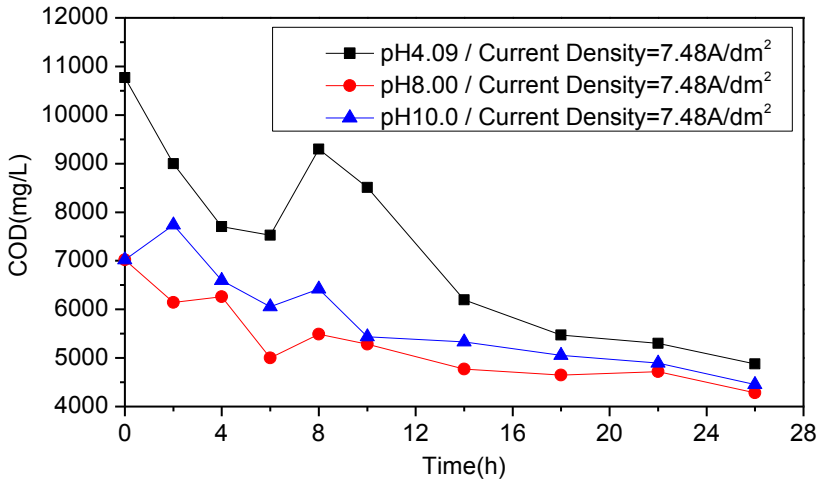

Fig.2 Change of COD under different initial pH and current density of 7.48A/dm^2

When the initial value of pH is 8.00 and 10.00, electrolysis on wastewater COD removal effect is not obvious. This is mainly because the value of wastewater pH is higher, the polymerization product which is not soluble in water can be formed on the surface of the anode in the process of electrolytic anodic oxidation, finally form a layer of thin film, which will hinder the reaction, and resulting in wastewater COD removal is not obvious.

When the initial value of pH is about 4, electrolysis effect is relatively good, and COD removal rate is the highest. The reason is under low pH condition, it is favorable for the generation of H_2O_2, which is conducive to the cathode produce •OH and the removal of organics. At the same time under the

condition of high potential, electrolysis in acidic aqueous solution is more conducive to the formation of ozone, and promotes the oxidation of organics.

3.2. Effect of current density on processing efficiency

When the initial pH is 4.09, the current density is 7.48A/dm^2 and 14.96A/dm^2, the change of wastewater COD is shown in Fig.3. When the current density is 14.96A/dm^2, the removal rate of COD is higher than that of 7.48A/dm^2.

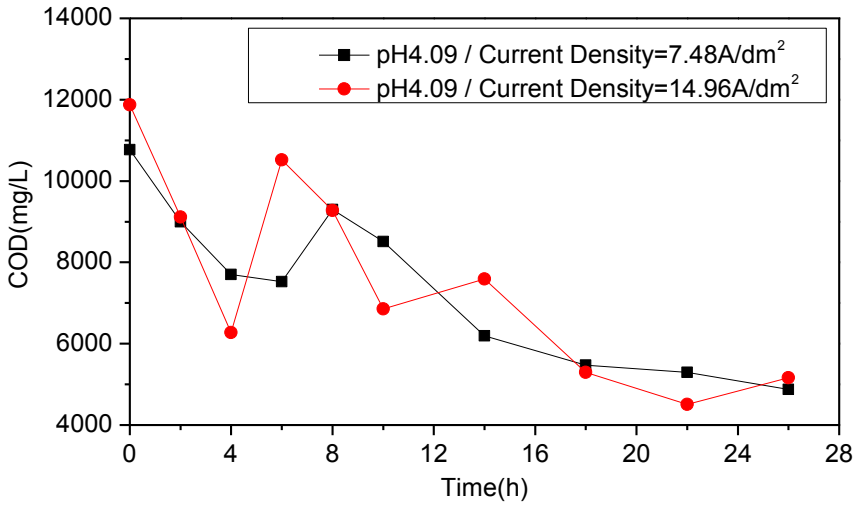

Fig.3 Change of COD under different current density and initial pH of 4.09

When the current density is large, the COD removal rate is fast and high in the same electrolysis time. Due to the increase of current density, the current share of oxygen evolution will be reduced accordingly, which is equivalent to increasing the current efficiency of oxygen. Therefore, the amount of Cl_2 generated on the anode plate can be increased, the concentration of ClO^- is increased, and the oxidation resistance of the solution is enhanced. And the greater the current density, the more energy is provided, resulting in more molecular bond of macromolecular organics breaking and degradation of organics, achieving a better treatment effect.

3.3. Relationship between energy consumption and treatment efficiency

When the initial pH is 4.09, the current density is 7.48A/dm^2 and 14.96A/dm^2 respectively, the change of the current efficiency ICE is shown in Fig.4.

From the beginning of the electrolytic to 8h, during this time, ICE first rise and then fall, then increased slightly and gradually balanced. In the former 6h, ICE was the highest, and COD fell the fastest, the reason may be 0~6h stage of the production of intermediate products is relatively easy to be oxidized. When the current density was 7.48A/dm^2, ICE was significantly higher than that of 14.96A/dm^2. So under the same initial pH condition, the higher the current density, the higher the COD removal rate, but the energy consumption is also increased, instead ICE lower. When the initial pH is 4.9, the current density is 7.48A/dm^2, ICE can reach up to 140.00%, and effect is better.

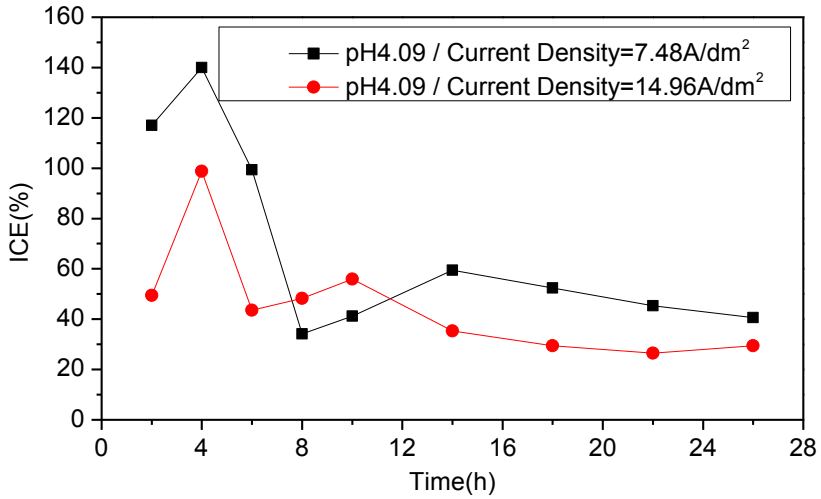

Fig.4 Change of ICE under different current density and initial pH of 4.09

4. Conclusions

(1)The treatment effect of souse industrial organic wastewater by electrolysis in the conditions of acidic is better than that of the neutral and alkaline conditions, the optimal pH initial value range is around 4.

(2)In the range of the initial value of the optimal pH, the greater the current density, the higher the COD removal rate.

(3)When the initial pH is 4.9, the current density is 7.48A/dm^2, ICE can reach up to 140.00%, and wastewater treatment effect is better.

Acknowledgements

This work was supported by National Natural Science Foundation of China (51178089), the Doctoral Scientific Fund Project of China (20130042110009) and the Fundamental Research Funds for the Central Universities of China (N1503040016).

References

[1] Feng Xianghua, Wen Liang qin, Zhu Mingxiong, Ding Shimin. Study on removal of mustard production wastewater COD by Class Fenton oxidation technology. Journal of Environmental Engineering, 2008, 2(11): 1483-1486.

[2] Yang Zhikuan, Wei Jinbao. Pollution Control Chemistry. Wuhan: Wuhan University Press, 1998.

[3] Wei Jie, Yu Xiujuan, Wang Dongtian. Preparation of titanium based oxide electrode and its application in water treatment. Science of Environmental Protection, 2002, 18(112): 10-12.

[4] Ahsan S., Kaneco S., Ohta K., Mizuno T., Kani K. Use of some natural and waste materials for waste water treatment. Water Research, 2001, 35(15): 3738-3742.

[5] Chen Fanzhong, Li Huizhong. Progress in electrochemical technology for purification of wastewater. Chongqing Environmental Science, 1997, 19(6): 19-21.

[6] Duan Weiyu. Study on the mechanism of electrolytic method for the purification of the slaughterhouse wastewater. Shenyang: Shenyang Agricultural University, 2007.

[7] Cheng Yulai, Zhang Haibin. Experimental study on the treatment of the wastewater from slaughterhouse by

electrolysis. Food and machinery, 2007, 23(5): 60-62.

[8] Han Fengxia, Cheng Yulai. Preliminary study on the treatment of organic wastewater by electrolysis. Food and machinery, 2006, 22(1): 22-26.

[9] Qiang Z., Chang J.H., Huang C.P. Electrochemical generation of hydrogen peroxide from dissolved oxygen in acidic solutions. Water Research, 2002, 36(1): 85-94.

[10] Bunce N.J., Chartrand M., Keech P. Electrochemical treatment of acidic aqueous ferrous sulfate and copper sulfate as models for acid mine drainage. Water Research, 2002, 35(18): 4410-4416.