ISSN: 2414-1895 DOI: 10.6919/ICJE.202003_6(3).0005

Experimental Study on Polyvinyl Alcohol Wastewater Treatment by Electrocoagulation Technology

Jiangtao Lv[a], Ruihua Zhao[b]*, Xiaoyu Wang[c], Yuehao Shen[d], Chongyang Wang[e]

College of Marine and Environmental Sciences, Tianjin University of Science & Technology, Tianjin 300457, China.

[a]jtaolv@163.com, [b]zhchen@tust.edu.cn, [c]wxy_tjzx@163.com

[d]1037039695@qq.com, [e]228378547@qq.com.

Abstract

Polyvinyl alcohol (PVA) is a kind of refractory organic matter with poor biodegradability. PVA wastewater drained into water body will cause serious environmental problems. Simulated wastewater containing PVA was treated by electrocoagulation technology in the paper. The effects of current density and electrolyte concentration on removal rate of COD and energy consumption were discussed. The optimum values of the three factors were respectively 5mA/cm2 and 0.012mol/L through experiments.

Keywords

Polyvinyl alcohol; Electrocoagulation; Removal rate of COD; Electrical energy consumption.

1. Introduction

PVA is fibrous powder with white or yellow color. PVA is widely applied in textile, chemical, food, paper, medicine and other industries. Otherwise, PVA can enhance the activity of heavy metals in sediment of river, lake and ocean, which causes more serious environmental problems [1]. Therefore, PVA must be degraded before discharged to prevent environmental pollution.

It is hard to degrade PVA with general biological treatment technology. Electrocoagulation is a kind of wastewater treatment technology with the characters of small equipment volume and occupation, flexible operation [2]. The electrocoagulation experiment for PVA solution was studied with RuO_2/Ti as anode [3]. The result showed that the removal rates of PVA and COD were respectively 70.18 % and 27.47%. One of the main reasons restricting the development of electric flocculation technology is high energy consumption. In this paper, PVA simulated wastewater is treated to find the effects of factors to removal rate of COD and electrical energy consumption.

2. Methods

2.1 Experimental procedure

The oxide layer on the electrode surface was removed by sandpaper before experiment. Then these electrodes were cleaned with deionized water. Iron plate was used as anode and aluminium plate was used as cathode with distance between electrode plates of 20mm. There was a magnetic stirrer apparatus at the bottom of the equipment. During the experiment, 1L simulated wastewater of 200mg/L was poured into the equipment and electrodes were installed in the equipment. Then magnetic stirrer apparatus was opened with stirring speed of 200r/min with experiment temperature of 298K. In the experiment, electrolyte concentration and current density were regulated. The samples were collected every 20 minutes, then COD of sample was measured.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202003_6(3).0005

2.2 Calculation method of removal rate of COD

The calculation method of removal rate (RE,%) of COD is formula (1).

$$RE(\%)=\frac{COD_0V_0-COD_tV_t}{COD_0V_0}\times 100 \tag{1}$$

In the formula, COD_0 is the initial concentration of COD, and COD_t is the concentration of COD at the moment of t point, and the units are mg/L. V_0 is the initial volume of wastewater, and V_t is the wastewater volume at the moment of t point, and the units are L.

2.3 Calculation method of electrical energy consumption

The calculation method of electrical energy consumption (EEC, kWh/kg) is formula (2) [4].

$$EEC=\frac{\int U\times Idt}{(COD_0V_0-COD_tV_t)\times 3.6}=\frac{I\int Udt}{(COD_0V_0-COD_tV_t)\times 3.6} \tag{2}$$

In the formula, U, I and t are respectively voltage, current and reaction time, and the units are respectively V, A and min.

3. Result and discussion

3.1 Effect of current density

In the experiment, current density was respectively adjusted to 1.25, 2.5, 5 and 7.5 mA/cm^2 . The effect of current density on removal rate of COD was showed in figure 1. Removal rate of COD increased gradually with the increase of current density. This is because poor flocculation effect is not enough to destabilize the formed metal hydroxide when the current density is 1.25mA/cm^2. With the increase of current density, metal ions from anode increase, then the metal hydroxides increase because of hydrolysis of metal ions. These metal hydroxides promote flocculation and improve removal rate of COD. But the removal rate of COD is not obvious when the current density increases from 5 to 7.5mA/cm^2. This is because electrode is easily polarized and deactivated if current density is enough excessive, which will cause reduction of removal rate of COD and more side effects, such as excessive hydrogen evolution from cathode and poor flocculation effect [5].

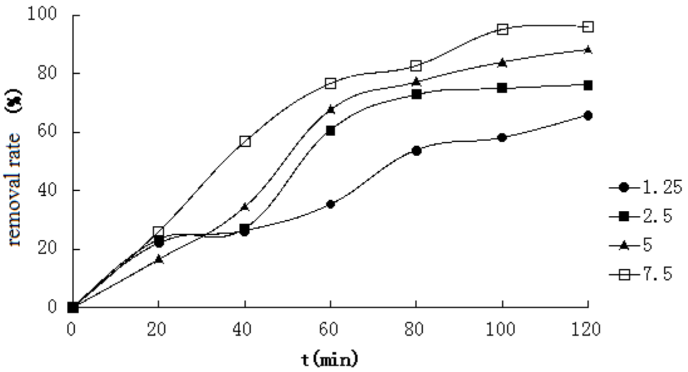

Fig.1 Effect of current density on removal rate of COD

When the reaction time was 60 minutes, the effect of current density on electric energy consumption was showed in figure 2. Removal rate of COD and electric energy consumption increased with increase of current density. Removal rate of COD increased from 35.3% to 67.8% when current density increased from 1.25 to 5mA/cm^2, at the same time, electric energy consumption had a slow increase. However, removal rate of COD was almost no increase when current density continued to increase, but there was twice increase of electric energy consumption. This is because current increase when current density increases, which also cause electric energy consumption increases. Nevertheless, the electrode polarization is serious and electrode passivation is obvious when current density is too high, which causes higher electric energy consumption. So the optimum current density is 5mA/cm^2 for electrocoagulation treatment of PVA wastewater.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202003_6(3).0005

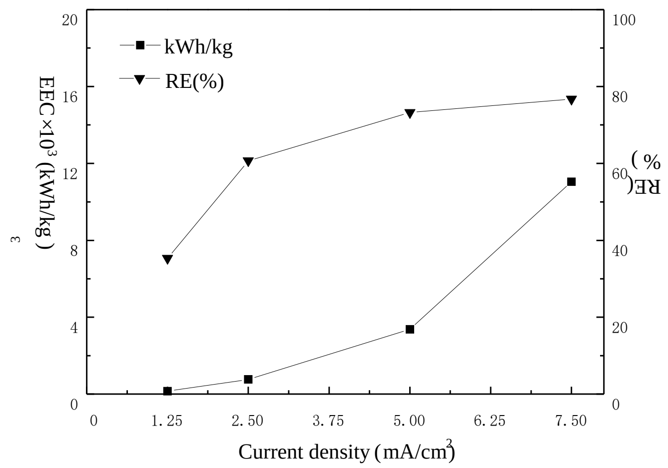

Fig. 2 Effect of current density on electric energy consumption

3.2 Effect of electrolyte concentration

In the experiment, electrolyte concentration was respectively adjusted to 0.004, 0.008, 0.012 and 0.015 mol/L. The effect of electrolyte concentration on removal rate of COD was showed in figure 3. Removal rate of COD was respectively 74.4%, 88.3%, 90.4% and 92.1% at the end of the reaction. This is because Cl_2 and HClO which can degradate organic compounds will produce when there are chlorine ions in waste water. Meanwhile, passivation film on the electrode surface can be perforated and broken by chlorine ion, which accelerates the dissolution of metal passivation layer and more metal hydroxides are formed, therefore, removal rate of COD increases.

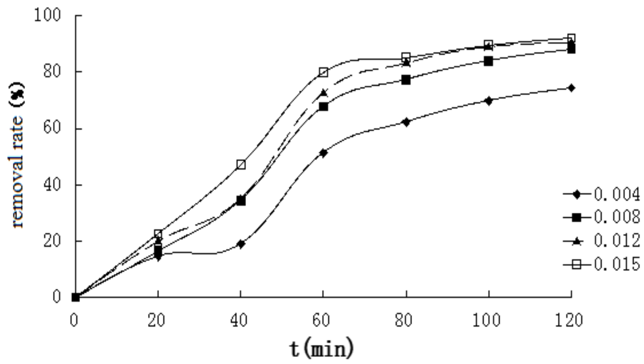

Fig.3 Effect of electrolyte concentration on removal rate of COD

When the reaction time was 60 minutes, the effect of electrolyte concentration on removal rate of COD and electric energy consumption was showed in figure 4. Removal rate of COD and electric energy consumption reduced with increase of electrolyte concentration. Removal rate of COD increased from 51.2% to 79.8% when electrolyte concentration increased from 0.004 to 0.015 mol/L, besides, electric energy consumption reduced by nearly 80%. This is because conductivity of wastewater increases and voltage reduces when electrolyte concentration increases, thus electric energy consumption reduces. But there is no significant change in COD removal rate and electric energy consumption when electrolyte concentration exceeds 0.012mol/L. Therefore, the optimum electrolyte concentration is 0.012mol/L for electrocoagulation treatment of PVA wastewater.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202003_6(3).0005

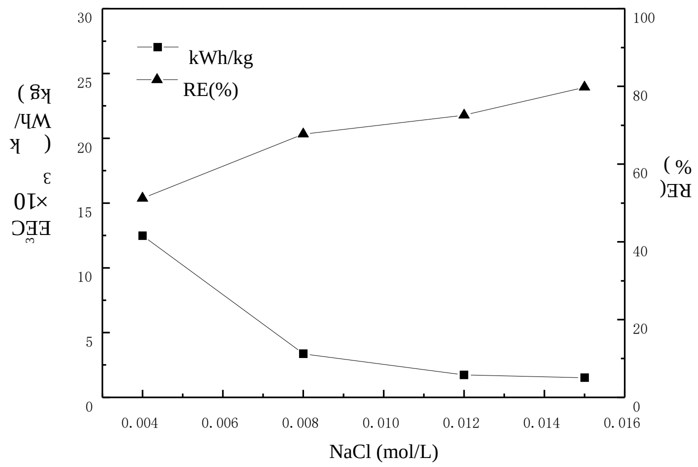

Fig. 4 Effect of electrolyte concentration on electric energy consumption

4. Summary

Effects of current density and electrolyte concentration on removal rate of COD and electric energy consumption are discussed for electrocoagulation treatment of PVA wastewater in this paper. The optimum current density is 5mA/cm^2 and the optimum electrolyte concentration is 0.012mol/L for electrocoagulation treatment of PVA wastewater. The results show that it is practicable for electrocoagulation technology to treat PVA wastewater.

Acknowledgments

This research was financially supported by innovation and entrepreneurship training program for college students（201910057116）.

References

[1] Oh S.Y., Kim H.W., Park J.M., et al. Oxidation of polyvinyl alcohol by persulfate activated with heat, Fe 2+, and zero-valent iron. Journal of Hazardous Materials, Vol. 168(2009), No.1, p. 346-351.

[2] M.Panizza, G.Cerisola. Applicability of electrochemical methods to carwash wastewaters for reuse. Part2: Electrocoagulation and anodic oxidation integrated process. Journal of Electroanalytical Chemistry, Vol. 638 (2010), No.2, p. 236-240.

[3] Sangyong Kim, Tak-Hyun Kim, Chulhwan Park. Electrochemical oxidation of polyvinyl alcohol using a RuO2/Ti anode. Desalination, Vol. 155(2003), No.1, p. 49-57.

[4] American Public Health Association (APHA). Standard Methods for the Examination of water and wastewater.21th ED., APHA: Washington, DC, 2005, p.9.

[5] Daneshvar N., Oladegaragoze A., Djafarzadeh N. Decolorization of basic dye solutions by electrocoagulation: An investigation of the effect of operational parameters [J]. Journal of Hazardous Materials, Vol. 129(2006), No.1, p.116-122.