Using Fenton Oxidation Method to Advanced Treatment of Landfill Leachate

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Abstract: Hydrogen peroxide and ferrous sulfate were used to advanced treatment of landfill leachate effluent from biochemical tanks. Some influences on removing COD and chroma including the pH value of solution, the dosage of ferrous sulfate, the dosage of hydrogen peroxide and reaction time were investigated. The test results showed that for removal of COD and chroma the optimal pH was 3.0, the best ferrous sulfate and hydrogen peroxide dosage was 1500mg/L, 20mL/L respectively, and the optimal reaction time was 60min. Under optimal conditions, COD and chroma removal rate could reach 79.7% and 95.2% respectively.

Keywords: Ferrous sulfate, hydrogen peroxide, landfill leachate.

1. INTRODUCTION

This work involves the subsequent processing technology of landfill leachate effluent from biochemical tanks. Common landfill leachate treatment technologies are combination of biological methods and chemical methods [1]. Biological methods can be anaerobic-aerobic combined methods, but in an anaerobic-aerobic process, some materials are difficult to biologically degradation, and BOD can't meet discharging standard. The oxidation system of Fenton reagent is consisted of hydrogen peroxide and catalyst ferrous ions. Hydrogen peroxide produces two kinds of active hydroxyl radicals under the effect of catalyst ferrous ions. Ferrous ions can trigger and spread free radical chain reaction, and accelerate the oxidation rate of organic matter. Fenton reagent can oxidize organic compounds which have benzene, hydroxy, substituent group such as carboxyl group and sulfo group [2]. The advantages of Fenton oxidation are quickly reaction, moderate temperature and pressure,and no secondary pollution. In recent years, some scholars used Fenton reagent to treat landfill leachate effluent, due to different garbage sources and landfills, the leachate treating methods are different. Fenton method treating landfill leachate effluent has not used in a large scale. In this study, landfill leachate effluent from biochemical process was treated by Fenton reagent, and the effects of solution pH value, the dosage of ferrous sulfate, the dosage of hydrogen peroxide and reaction time on effluent COD and chroma removal were investigated [3].

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2. EXPERIMENTAL

The COD of landfill leachate effluent from biochemical process was 925.3mg/L, and the BOD was 342.8 mg/L, the solution pH value was 8.01 and chroma was 650. In this experiment 1000 ml beakers were used as reaction devices, which were placed on six league blender with heating chassis for chemical reaction, and agitator certain rotational speed could be adjusted. Reaction reagent were ferrous sulfate (chemical pure) and hydrogen peroxide (industrial, content was 30%). H_2SO_4 and NaOH were used to adjusted pH value. After a period of reaction time, the beakers were removed and settled for 45 minutes. Water effluent COD, chroma and pH value were determined [4].

3. RESULTS AND DISCUSSION

3.1. The Effects of Initial pH Value on Effluent COD and Chroma Removal

The initial pH value of landfill leachate effluent has important influence on efficiency of Fenton reaction. Different pH value made different iron form in solution. Fe^{2+} could catalyze H_2O_2 and produce·OH under acid condition, but could not play a catalytic under neutral and alkalinity conditions. The researchers generally agreed that when pH value was 2～4,wastewater treatment effect was better [5].

In this experiment initial pH were adjusted from 2.0 to 4.5, ferrous sulfate was 500mg/L and hydrogen peroxide was 20mL/L, mixing reaction time was 30 minutes, and settled time was 45 minutes. The effluent COD and chroma results were shown in Figs. (**1** and **2**).

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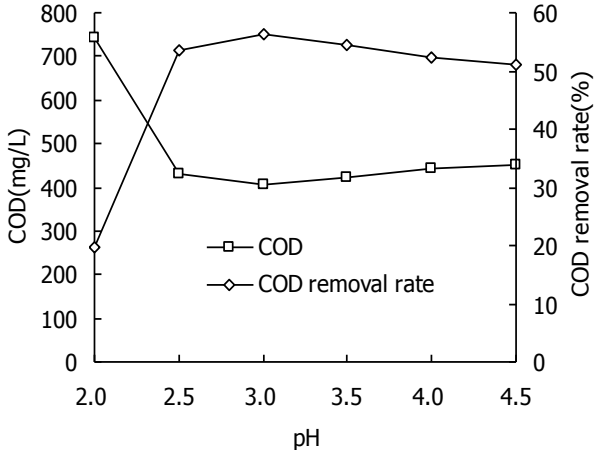

Fig. (1). The effect of pH value on COD removal.

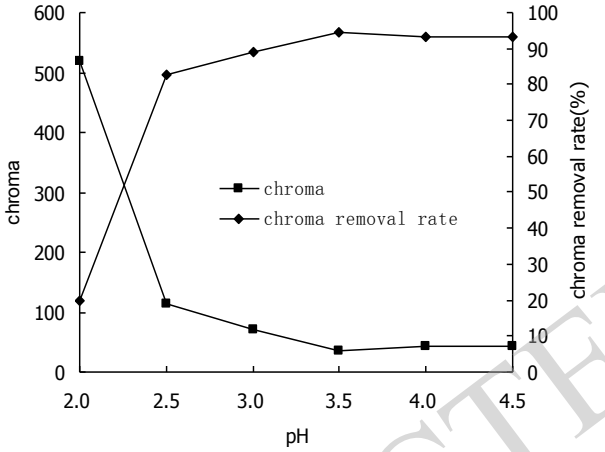

Fig. (2). The effect of pH value on chroma removal.

As shown in Fig. (**1**), when the solution pH value increased from 2.0 to 3.0 ,COD decreased soon after reaction, COD removal rate increased from 19.6% to 56.2%.When pH value increased from 3.0 to 4.0,COD increasing became slowly, and COD removal rate dropped from 56.2% to 51.1%. Fig. (**1**) showed that when pH value was 3.0, removal efficiency was a point, and the pH value of 2.0-3.0 for COD removal efficiency were the best. This suggested that too high or too low pH value were undesirable. When pH value was less than 2, Fe^{3+} could not be successfully reduced to Fe^{2+}, catalytic reaction was inhibited, thereby the hydroxyl radical generation became slow, and the oxidation ability was reduced. When the pH value was greater than 3, The stability of hydrogen peroxide was decreased, and Hydrogen peroxide decomposition speed was accelerated, and inhibit the hydroxyl radical production was inhibited, thus the treatment effect was affected.

The effects of initial pH value on effluent COD and chroma removal were shown in Fig. (**2**). When the solution pH value increased from 2.0 to 3.0, chroma decreased soon after reaction, chroma removal rate increased from 20.0% to 94.7%. With the pH value increasing from 3.5 to 4.5, the removal rate of the chroma had little change after reaction. This showed that for the chroma removal, the best pH value was 3.5. From Fig. (**1**), for the removal of COD, pH value of 3 was appropriate. Therefore, the optimum pH value was considered as 3.0.

3.2. The Effects of $FeSO_4$ Dosage on Effluent COD and Chroma Removal

In Fenton reactions, Fe^{2+}used as a catalyst could catalyze H_2O_2 ,produce hydroxyl radical, and decomposed pollutants. The less Fe^{2+}, the less radical and the lower speed, the catalytic process was restrained. Excessive Fe^{2+}could reduced H_2O_2. Fe^{2+} was oxidized as ferric ion and made solution chroma increasing.

In Fig. (**3**), with the $FeSO_4$ dosage increased from 500 mg/L to 1500 mg/L , COD removal rate increased from 37.2% to 78.2%,then with $FeSO_4$ dosage increased to 2500 mg/L, COD removal rate drop from 78.2% to 65.5% .Therefore, the amount of $FeSO_4$ was not the more the better.Because the excessive Fe^{2+}will reduced of H_2O_2 and affect the removal effect of COD. For the COD removal, the best $FeSO_4$ dosage was 1500mg/L.

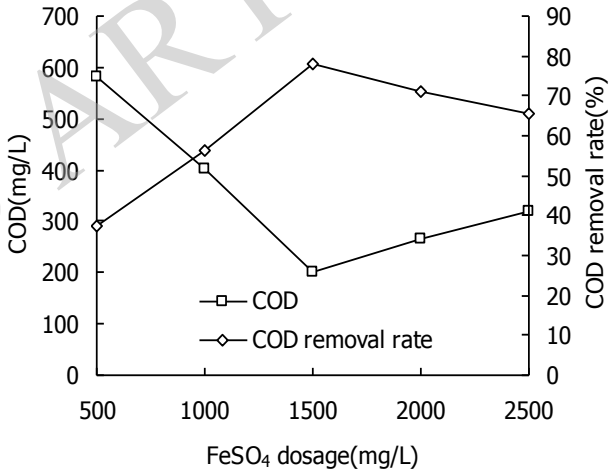

Fig. (3). The effect of $FeSO_4$ dosage on COD removal.

In Fig. (**4**), with the $FeSO_4$ dosage increased from 500 mg/L to 1500 mg/L ,chroma was declined, chroma removal rate increased from 72.1% to 90.3%,then with $FeSO_4$ dosage increased to 2500 mg/L, COD removal rate dropped from 90.3% to 60.4% . Therefore, $FeSO_4$ dosage was not the more the better for chroma removal. Because excessive Fe^{2+} could oxidize Fe^{2+} to Fe^{3+} and increased the chroma of the solution. The experiment testified the best $FeSO_4$ dosage was 1500 mg/L.

3.3. The Effects of H_2O_2 Dosage on Effluent COD and Chroma Removal

The mechanism of Fenton reagent removing organic contaminants were that hydrogen peroxide produced two kinds of active hydroxyl radicals that trigger and spread free radical chain reaction, and accelerate the oxidation rate of organic matter and reduced substances [6]. H_2O_2 dosage had important influence on COD and chroma removal. H_2O_2 dosage also involved in the cost of water treatment. Under

the conditions of pH 3.0, strring time 30 minutes ,$FeSO_4$ 1500 mg/L, hydrogen peroxide quantity from 10mL/L-50 mL/L, the experiment results were shown in Figs. (**5** and **6**).

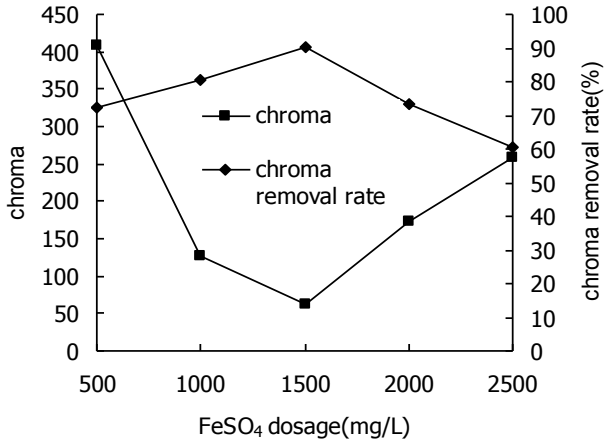

Fig. (4). The effect of $FeSO_4$ dosage on chroma removal.

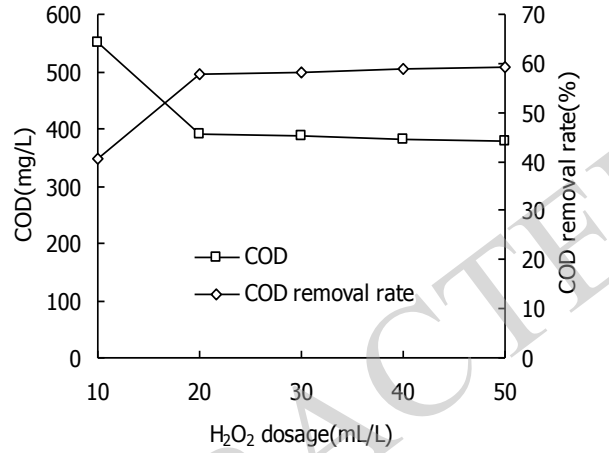

Fig. (5). The effect of hydrogen peroxide dosage on COD removal.

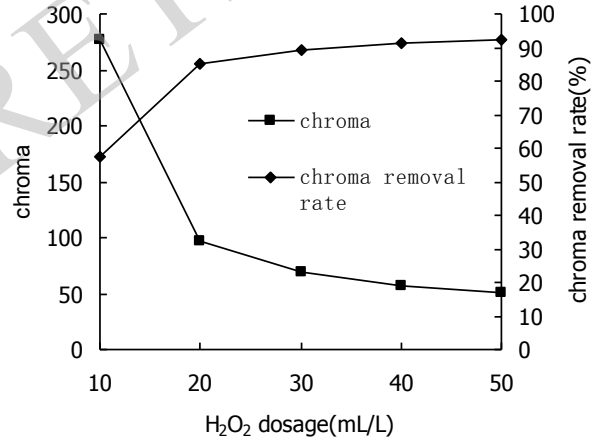

Fig. (6). The effect of hydrogen peroxide dosage on chroma removal.

In Fig. (**5**), the hydrogen peroxide dosage increased from 10 mL/L to 20 mL/L ,COD was decreased soon, COD removal rate increased from 40.5% to 57.8%,then with the hydrogen peroxide dosage increased to 50 mL/L, COD removal rate increased from 57.8% to 59.1% .Although the hydrogen peroxide dosage increased, COD removal increasing became slow. This means that the hydrogen peroxide as a oxidant was not the more the better. When hydrogen peroxide increased to a certain extent, hydrogen peroxide decomposed and released oxygen to inhibit the COD removal efficiency [7]. This experiment testified the best hydrogen peroxide dosage was 20 mL/L for COD removal.

In Fig. (**6**), when the hydrogen peroxide dosage increased from 10 mL/L to 20 mL/L ,chroma was declined, and chroma removal rate increased from 57.5% to 85.2%.Then with hydrogen peroxide dosage increased to 50 mL/L, COD removal rate increased from 85.2% to 92.1% . Although the hydrogen peroxide dosage increased, chroma removal increasing became slow. This testified that the hydrogen peroxide as a oxidant was not the more the better. Because of hydrogen peroxide increased to a certain extent, hydrogen peroxide was decomposed and released oxygen to inhibit the chroma removal efficiency. This experiment testified the best hydrogen peroxide dosage also was 20 mL/L for chroma removal.

3.4. The Effect of Reaction Time on COD and Chroma Removal

Fenton reagent for degradation of organic matter mainly relied on hydrogen peroxide to produce hydroxyl radicals with organic chemical reaction, the generation rate of hydroxyl and the reaction rate of the organic matter directly determined the reaction time required. Reaction time was very important for wastewater treatment [8, 9]. Under the condition of pH 3.0, $FeSO_4$ 1500 mg/L, hydrogen peroxide 20 mL/L, the results were shown in Figs. (**7** and **8**).

In Fig. (**7**), with reaction time increased from 30 minutes to 150 minutes, COD decreased, COD removal rate increased from 57.8% to 85.3%. When the reaction time reached 60 minutes, removal rate reached 79.7%. Therefore, the best reaction time was 60 minutes from the perspective of cost.

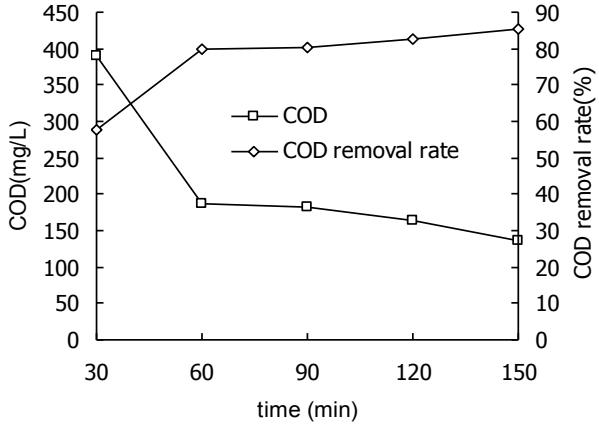

Fig. (7). The effect of reaction time on COD removal.

In Fig. (**8**), With reaction time increased from 30 minutes to 60 minutes, chroma decreased, chroma removal rate increased from 72.1% to 95.2%, then increasing the reaction time ,removal rate of chroma had little change in a stable state. This experiment testified the best reaction time was 60 minutes for chroma [10].

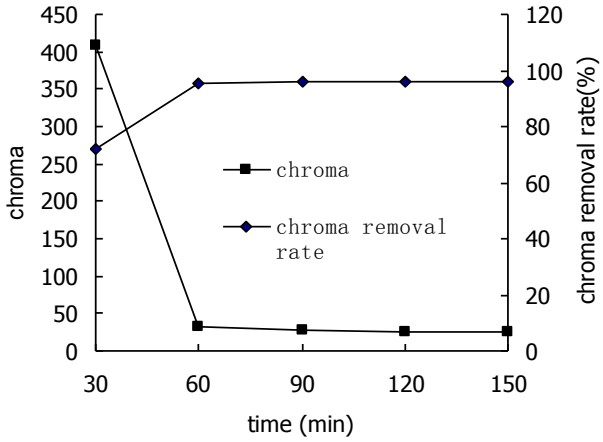

Fig. (8). The effect of reaction time on chroma removal.

CONCLUSION

(1) The pH value of landfill leachate effluent had important influence on Fenton reagent oxidation. pH value was too high or too low, the COD removal decreased, and the best pH value was 3.0.

(2) In Fenton, Fe^{2+}as a catalyst, the dosage have important influence on reaction. Test showed that excessive Fe^{2+} was not good, and the best $FeSO_4$ dosage was 1500 mg/L in the experiments.

(3) H_2O_2 as an oxidant whose dosage determined the reaction effect and the best hydrogen peroxide was 20 mL/L.

(4) Reaction time was also one of the important factors on reaction effects. When reaction time was 60 minutes, Fenton reagent can achieve good effect.

(5) Fenton reagent consisted of H_2O_2 and $FeSO_4$ could effectively treat landfill leachate effluent. The best pH value was 3.0, the best dosage of ferrous sulfate was 1500mg/L, the best dosage of hydrogen peroxide was 20mL/L and the best reaction time was 60minutes.Under the best conditions, COD removal rate could reach 79.7% and the chroma removal rate could reach 95.2%.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

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