Study on the treatment of organic wastewater from soil thermal desorption by Fenton method

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Abstract. Fenton's reagent has been widely used as a high-grade oxidation technology in the treatment of refractory, high-concentration, toxic and harmful organic wastewater, and has achieved remarkable results. The organic wastewater generated by thermal desorption of soil has the characteristics of high pollutant content, complex composition and large fluctuation of water quality. Generally, the organic wastewater components produced by thermal desorption of soil mainly include polycyclic aromatic hydrocarbons, polychlorinated biphenyls, chlorobenzene and the like.

1. Introduction
The main sources of chlorobenzene compounds in the soil are: discharge of chlorobenzene-containing wastewater, leakage of chlorobenzene-containing solid waste, waste incineration, and atmospheric deposition over long distances. The chlorobenzene-contaminated soil is mainly distributed in the chlorobenzene chemical production plant, the disassembly point of the chlorobenzene capacitor, the waste chlorobenzene power equipment storage site and its surrounding areas. Due to the strong volatility of chlorobenzene, chlorobenzene is rapidly distributed in the soil and water and diffuses into the air. Therefore, water and soil contaminated with chlorobenzene can be quickly recovered.

2. Main experimental reagent
The Fenton reagent used in the experiment consisted of hydrogen peroxide and ferrous sulfate. The purity of hydrogen peroxide was 30%, which was purchased from Sinopharm Chemical Reagent Co., Ltd. Ferrous sulfate has a purity of more than 99% and is purchased from Sinopharm Chemical Reagent Co., Ltd.

| Table 1. The properties of hydrogen peroxide and ferrous sulfate used in the experiment |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Compound                        | Chemical formula | Molecular weight | Relative density | purity          |
| Hydrogen peroxide               | $H_2O_2$         | 34.01            | 1.13g/mL         | 33%             |
| Ferrous sulfate                 | $FeSO_4$         | 152              | 1.897g/mL        | $\geq 99\%$    |

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3. **Determination of composition and background concentration of organic wastewater from thermal desorption of soil**

To determine the effect of Fenton's reagents on the removal of chlorobenzene under different conditions, it is first necessary to determine the composition and background concentration of the organic wastewater from the thermal desorption of contaminated soil. From the plastic bucket storing the water sample, take 5 0.2ml samples from the liquid gun and put them into 10ml saturated NaCl solution. The experiment is carried out by GC/MS analysis to determine the organic wastewater generated by thermal desorption of soil by quantitative analysis. The composition of the pollutants, and then use the set line to calculate the content of the pollutants. The value of the content can be found by means of Fig. 1.

![Figure 1. GC/MS composition analysis diagram of organic wastewater](image1)

The comparison of Soil and Sediment Volatile Organic Compounds (release) determines that the main pollutant in organic wastewater is chlorobenzene. At the same time, it can be calculated from the standard curve diagram 2 that the average concentration of chlorobenzene in the organic wastewater is 220 mg/L.

![Figure 2. Standard curve of GC/MS analysis](image2)

4. **Effect of different dosages of Fenton reagent on the removal of chlorobenzene**

In this experiment, the same batch of water samples were taken. Under the condition that the optimal drug dosage ratio was 1:1.6, different dosages were set for testing. The setting of the dosage was as shown in Table 2.
Table 2. Dosage amount set by the experiment

| Dosing amount (ml) | FeSO₄ (g) |
|--------------------|-----------|
| 0.05               | 0.09      |
| 0.10               | 0.18      |
| 0.20               | 0.36      |
| 0.30               | 0.53      |
| 0.40               | 0.7       |
| 0.50               | 0.89      |
| 0.60               | 1.07      |
| 0.70               | 1.24      |
| 0.90               | 1.6       |
| 1.10               | 1.95      |

Figure 3. Removal rate of chlorobenzene at different dosage

The removal rate of chlorobenzene was calculated based on the amount of chlorobenzene removed, as shown in FIG. With the increase of the dosage of hydrogen peroxide, the removal rate of chlorobenzene gradually increased. After the dosage of hydrogen peroxide reached 0.30ml, the removal rate of chlorobenzene reached the maximum value, and the removal rate did not increase with the increase of the dosage. Significant changes occur again, tending to be flat. It is indicated that after the dosage of hydrogen peroxide reaches 0.3ml, the chlorophyll group in the solution has been removed, and the reaction in the solution has basically stopped. Later, as the dosage is increased, the chlorobenzene organic substance in the solution is basically reflected, and the reagent is the free radicals released by iron ions catalysing the hydrogen peroxide are no longer combined with the chlorobenzene in the solution. When the dosage of hydrogen peroxide was 0.1ml and 0.4ml respectively, the removal rate decreased. According to the data of the parallel sample, the reason for the decrease of the removal rate of the two groups was analysed. Chlorobenzene was insoluble in water and the volatile property, while the density of chlorobenzene is 1.11g/cm³, which is greater than the density of water. If it is not mixed in time during the sampling process, the chlorobenzene in the solution is easily precipitated to the bottom of the sample bottle after sampling. This leads to uneven distribution of chlorobenzene in the solution, which affects the sampling and accuracy of the data of subsequent reactions. It can be seen from the above data analysis that the removal effect of chlorobenzene is significantly increased with the
increase of the dosage of Fenton reagent when the dosage ratio is unchanged. However, the dosage of Fenton reagent is too high, and the removal effect of chlorobenzene No significant changes have occurred, so moderate dosage can effectively improve the efficiency of chlorobenzene removal, while also reducing the cost of chlorobenzene removal.

5. Effect of different pH environments on the removal of chlorobenzene
In this experiment, the same batch of water samples were selected. After the first three factors were investigated, the pH values of different reflecting environments were set under the condition that the dosage ratio, dosage and reaction time were optimal, so as to examine different pH environments. The effect of Fenton's reagent on the removal of chlorobenzene. The pH setting is shown in Table 3.

| Dosing amount(ml) | FeSO₄(g) | Reaction time(min) | Environmental pH |
|-------------------|----------|--------------------|-------------------|
| 0.30              | 0.53     | 10min              | 1                 |
| 0.30              | 0.53     | 10min              | 2                 |
| 0.30              | 0.53     | 10min              | 3                 |
| 0.30              | 0.53     | 10min              | 5                 |
| 0.30              | 0.53     | 10min              | 7                 |
| 0.30              | 0.53     | 10min              | 9                 |
| 0.30              | 0.53     | 10min              | 11                |

During the experiment, the set pH environment should be adjusted in turn in the water sample to be tested, adjusted with diluted 1% hydrochloric acid or sodium bicarbonate, and read with a pH meter, then Fenton reagent is added. After the reaction was sampled, the amount of chlorobenzene removed by GC/MS analysis is shown in Fig. 4.

![Removal amount](image)

**Figure 4.** Removal of chlorobenzene under different pH conditions

It can be seen from Fig. 4 that the removal effect of Fenton's reagent on chlorobenzene in different pH solutions is different under the premise of other experimental conditions. During the specified reaction time (10 min), the effect of Fenton's reagent to remove chlorobenzene gradually increased with the decrease of the pH of the solution environment; however, when the pH in the solution environment
decreased to a certain value, the removal effect of chlorobenzene no longer occurred. Obvious changes, the curve of the removal amount gradually becomes flat.

![Removal rate](image)

**Figure 5.** Removal rate of chlorobenzene under different pH conditions

Based on the obtained removal amount data, the removal rate of available chlorobenzene is calculated, as shown in FIG. With the decrease of the pH of the solution environment, the removal rate of chlorobenzene gradually increased. After the pH value of the solution was lower than 3, the removal rate of chlorobenzene gradually decreased. When the pH of the solution environment reaches 1, the removal rate of chlorobenzene reaches a maximum. The analysis curve shows that when the pH value adjusted to the solution environment is lower than 4, the removal effect of chlorobenzene does not change substantially, indicating that the removal effect of chlorobenzene reaches the ideal result in the solution environment with pH below 4. At the same time, we can also see that under acidic conditions, the effect of Fenton's reagent to remove chlorobenzene is better than that in alkaline environment. Therefore, appropriately changing the pH of the reaction environment is beneficial to the removal of chlorobenzene from the organic wastewater by Fenton's reagent, and improving the efficiency of the removal of chlorobenzene by Fenton's reagent.

In the course of exploring the pH conditions, we should pay attention to the change of the reactants in the solution as the acidity increases. Excessively strong acid will cause the ferrous sulfate in the Fenton reagent to become iron persulfate. At the same time, if the removal efficiency of chlorobenzene is simply pursued, and the pH of the treated solution is adjusted to a level that is difficult to recover, it is also impractical to use Fenton's reagent for the treatment of wastewater in practical use. Therefore, under acidic conditions, a suitable range of pH values facilitates the removal of chlorobenzene from organic wastewater by Fenton's reagent.

6. Conclusion

In this exploratory experimental study, the effects of different conditions on the removal of chlorobenzene from organic wastewater by Fenton's reagent were investigated. The experimental samples with chlorobenzene concentration of 220 mg/L in organic wastewater were selected and tested under various conditions. Finally got the correct conclusion.

References

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