Study on the Process of Degradation of Phenolic Compounds in Water by Slot Ultrasonic

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Abstract: The test results show that the degradation rate of phenol decreases with the increase of ultrasonic power. The effect of degradation increases by studying the effects of the power of the ultrasonic, the initial concentration of the phenol sample solution, and the pH of the phenol sample solution. The degradation rate of phenol increases first and then decreases with the increase of initial concentration, and the degradation rate of phenol is up to 31.86%. The ultrasonic degradation technology can provide reference for the application of industrial wastewater treatment.

Water resources are the basis for human survival and an essential resource for economic development. China's water resources are not only severely short, but also geographically unevenly distributed. Water shortages in industrial and agriculturally developed areas are becoming increasingly serious. From the perspective of social development trends, due to social reasons, the demand for water resources is increasing, and the contradiction between supply and demand makes water resources an important factor in the development of the national economy.

Environmental pollution is the biggest problem facing humanity today. Water pollution not only harms the environment, but also directly threatens human health. The discharge of phenolic wastewater into the natural environment would be a highly toxic pollutant. It is one of the 129 pollutants monitored by the US Environmental Protection Agency and one of the key pollutants controlled by China. If the wastewater is not treated and discharged in large quantities, it will cause serious pollution to the environment. Phenol-containing wastewater is a general term for monohydric phenolic wastewater, including phenol substitutes, chlorophenols, nitrophenols, etc. The main sources are coking plants, gas stations, pharmaceutical plants, etc. Table 1 shows the average phenol content of wastewater in chemical enterprises in China.

Phenol, also known as carbolic acid, hydroxybenzene, a weak acid, is a colorless or white crystal at room temperature and is easily oxidized to pink when exposed to air. It is a highly toxic substance that is difficult to degrade protoxins, and its toxicity poses a major hazard to humans and agricultural and sideline crops. Phenol is mainly used in the production of phenolic resins, fungicides, preservatives and important raw materials for drugs. It is highly toxic, can cause proteins to coagulate and degenerate, deactivate cells, cause nervous system diseases such as dizziness and anemia, and is teratogenic, carcinogenic, mutagenic and other potential toxicity. Therefore, the treatment of phenol-containing wastewater has become one of the important topics for the recent degradation of wastewater. Phenolic wastewater containing more than 1000 mg/L can cause acute poisoning or even death, while phenol-containing wastewater with a mass concentration lower than 1000 mg/L can cause cumulative chronic poisoning.

The chemical nature of phenol is that it absorbs moisture from the air and liquefies. It has a special odor and a very dilute solution has a sweet taste. Very corrosive. Strong chemical reaction ability. It reacts with aldehydes and ketones to form phenolic resin, bisphenol A, and acetic anhydride; and salicylic acid reacts to form phenyl acetate and salicylate. Halogenation, hydrogenation, oxidation, alkylation, carboxylation, esterification, etherification, and the like can also be carried out. Phenol is a solid at normal temperature and cannot react smoothly with sodium. If the method is carried out by heating and melting phenol and then adding sodium metal, phenol is easily reduced, and the color of phenol changes during heating, which affects the experimental effect. Some people have taken the following methods in the teaching, the operation is simple, and the satisfactory experimental results have been achieved. Add 2-3 ml of anhydrous ether to a test tube, take a piece of sodium metal in the size of soy bean, use the filter paper to dry the surface of the kerosene, and put it into ether. It can be seen that sodium does not react with ether. Then, a small amount of phenol was added to the test tube and shaken, and it was observed that sodium reacted rapidly in the test tube to generate a large amount of gas. The principle of this experiment is that phenol is

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dissolved in diethyl ether to allow the reaction of phenol and sodium to proceed smoothly.

Phenol was first recovered from coal tar, and most of it is currently synthesized. By the mid-1960s, the technical route for the production of phenol and acetone by the cumene process had been developed, which accounted for half of the world's phenol production. At present, the phenol produced by this process has accounted for more than 90% of the world phenol production. Other production processes include toluene chlorination, chlorobenzene, and sulfonation[9]. China's production methods are cumene and sulfonation. Since the sulfonation method consumes a large amount of sulfuric acid and caustic soda, China will only retain a small number of sulfonation equipment, and gradually produce mainly cumene. Phenol has a strong corrosive effect on skin and mucous membranes, and can inhibit central nervous system or damage liver and kidney function. Acute poisoning: Inhalation of high concentrations of vapor can cause headache, dizziness, fatigue, blurred vision, pulmonary edema, etc. Inadvertently causing burns in the digestive tract, burning pain, exhaled breath with phenolic odor, vomit or large blood, gastrointestinal perforation, shock, pulmonary edema, liver or kidney damage, acute renal failure, Can die of respiratory failure. Eye contact can cause burns. In addition, phenol can also be used as a solvent, an experimental reagent, and a disinfectant. An aqueous solution of phenol can separate proteins on the chromosomes of plant cells from DNA, and facilitate DNA staining.

In this paper, the phenolic substances in wastewater were degraded by trough ultrasonic, and phenol was used as the research object to investigate the influencing factors and process conditions of ultrasonic degradation of phenol.

1 Experimental method

1.1 Preparation of experimental solution

1.1.1 Preparation of phenol standard solution

About 1.0 g of phenol was weighed in water using an analytical balance, transferred to a 1 L volumetric flask, and diluted to the mark. The calibration was performed by an international method to obtain 1000.0 mg/L [19]. The phenol standard solution was diluted 100-fold to obtain a phenol standard intermediate. The phenol standard solution 5 mL was diluted to 1000 mL to obtain a phenol sample solution having a concentration of 5.000 mg/L.

1.1.2 Preparation of buffer (pH about 10)

Weigh 5.4g of ammonium chloride (NH4Cl), add 20mL of water to dissolve, add concentrated ammonia water 35mL, then add water to dilute to 100mL, add stopper, and store in the refrigerator.

1.1.3 Preparation of 2% 4-aminoantipyrine solution

Weigh 4 g of 4-aminoantipyrene dissolved in water, dilute to 100 mL, dilute to volume, and store in a refrigerator.

1.1.4 Preparation of 8% potassium ferricyanide solution

Weigh 8g potassium ferricyanide solution dissolved in water, dilute to 100mL, can be used for one week.

1.2 Drawing of standard curve

Pipette 0.00, 8.00, 11.00, 17.00, 20.00, 23.00, 29.00mL phenol standard intermediate solution into a 50mL volumetric flask, and add water to volume. Add 0.5 mL of buffer, shake well, then add 1.0 mL of 8% potassium ferricyanide solution and 1 mL of 2% 4-aminoantipyrine solution, shake well, place for 10 minutes, measure absorbance at 505 nm wavelength, and draw a standard curve. (Figure 1). After all the data were processed, the standard curve regression equation was obtained as A=0.1232c-0.0176, and the correlation coefficient was r=0.9995. Calculate the degradation rate of phenol according to the following formula:

Phenol degradation rate (%) = (concentration of phenol in water before degradation - concentration of phenol in water after degradation) / concentration of phenol in water before degradation x100%

Fig.1 Standard curve of phenol

2 Trough ultrasonic degradation of phenol in water

This experiment explored the effects of three factors (power, concentration, pH) on the degradation of phenol in ultrasound, and sought the best process parameters for ultrasonic degradation of phenol.

2.1 Influence of ultrasonic power

The measuring tube was used to measure 80 mL of the phenol solution into a custom glass test tube, and ultrasonically irradiated for 20 minutes at 200 W, 240 W, 280 W, 320 W, and 360 W ultrasonic power, respectively. The experimental results are shown in Figure 2.
Fig.2 Ultrasonic power impact

As can be seen from Fig. 2, the degradation rate was 6.20% at a power of 200 W, 5.10% at a power of 240 W, and 2.40% at 360 W. In general, the degradation rate of phenol by slotted ultrasound alone is not high. This may be because at a certain ultrasonic power, the cavitation bubble grows too large, causing the cavitation bubble to be compressed to collapse.

2.2 The effect of initial concentration

The phenol standard intermediate solution was precisely drawn in order to prepare a solution having an initial concentration of 2.00, 4.00, 6.00, 8.00, 10.00 mg/L. A phenol solution of 80 mL was weighed into a custom glass test tube using a measuring cylinder. Ultrasound was performed for 20 min at a power of 200 W for probe-type ultrasound. The result is shown in Figure 3.

As can be seen from Fig.3, the initial concentration does not have a large effect on the degradation rate. The trend of the curve decreases first, then rises and then decreases. When the initial concentration of phenol was 6.00 mg/L, the degradation rate was 5.76%, which was the maximum value. Therefore, the lower the concentration of ultrasonic degradation of phenol, the better the degradation effect.

2.3 Effect of pH

The pH of the solution was adjusted to 2, 4, 6, 8, 10, 12 using H₂SO₄ solution and NaOH solution, and 80 mL of the phenol solution was weighed into a custom glass test tube and degraded at a power of 200 W for 20 min. As shown in Figure 4.

It can be seen from Fig.4 that when pH=2, the degradation rate is 0.47%, pH=4, degradation rate is 1.21%, pH=6, degradation rate is 3.52%, pH=8, degradation rate is 6.72%, pH=10. The degradation rate was 8.31%, pH=12, and the degradation rate was 32.79%.

3 Conclusion

The test results show that the degradation rate of phenol decreases with the increase of ultrasonic power. The effect of degradation increases with increasing pH. The degradation rate of phenol increases first and then decreases with the increase of initial concentration.

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