Preparation of Polyaluminium Chloride from Kaolin and Its Application in Phosphorus-Containing Wastewater

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Abstract. In this paper, PAC was prepared from kaolin. The control experiment was carried out by controlling a single variable to find the most suitable conditions for processing simulation. The main reference indicators were pretreatment ratio, calcination temperature, calcination time, acid dissolution time, and acid dissolution ratio, acid. Specific parameters such as solution temperature, and then complete data to process polyaluminum chloride products with a certain degree of alkalinity. On this basis, this paper uses the experimentally prepared polyaluminum chloride product for coagulation experiments to test the treatment of P element in wastewater by PAC.

1. Introduction

There are many ways to prepare polyaluminium chloride in industrial production, but in many aspects such as economic concept, value-effective cost performance, etc., only the acid-soluble one-step method, the acid leaching neutralization two-step method, and the gel method have been reused. [1-3] However, it is not said that it has been directly promoted. The relevant technology of this academic is still in the relative research and development state, and the corresponding technology of this academic is gradually maturing in continuous research.[4-8] The purpose of this paper is to study the high concentration of phosphorus-containing wastewater by studying polyaluminium chloride, so that the effluent water quality meets certain emission standards.[9].

2. Test plan for preparing polyaluminum chloride

The production of polyaluminium chloride must take into account the impact of six different process parameters on the test results. Five different values are selected for each process parameter to more precisely optimize individual process parameters. In order to study the impact of different parameters on the extensive analysis of test results, the development of a very reasonable test procedure is an important part of the experimental work. In the case of problems with orthogonal design, the number of experiments can be significantly reduced. We can solve problems scientifically and achieve the desired results. Because orthogonal experiments are scientific methods for studying multiple levels and multiple factors. Orthogonal testing is an ideal test method if the factors and levels to be studied are high.

According to the orthogonal design method, the number of factors included in the test is six, that is, the pretreatment ratio, calcination temperature, calcination time, acid dissolution time, acid dissolution ratio and acid solution temperature should be investigated in each factor. Indicators, the factors and level indicators are shown in Table 1:

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Table 1. Kaolin preparation test plan

No	Factor					
	A	B	C	D	E	F
	Pretreatment ratio (g/ml)	Calcination temperature (°C)	Roasting time (hour)	Acid dissolution time (hour)	Acid soluble ratio (ml/g)	Acid solution temperature (°C)
1	1.8	600	0.5	1.0	2.5	65
2	2.0	650	1.0	1.5	3.0	75
3	2.2	700	1.5	2.0	3.5	85
4	2.4	750	2.0	2.5	4.0	95
5	2.6	800	2.5	3.0	4.5	105

3. Determination of optimum process parameters

The preparation of each batch of liquid sample was carried out in accordance with the established test protocol.

As a flocculant, its coagulation performance is one of the important indicators to measure product quality. Therefore, the optimum process parameters can be determined by comparing the coagulation properties of these products. The investigation of the coagulation performance can be carried out by comparing the turbidity of the effluent after coagulation.

According to the $L_{25}(5^6)$ orthogonal design scheme, the formula for calculating the dispersion R is as follows:

$$R = \left(\mathrm{I}/5 - T/25\right)^2 + \left(\mathrm{II}/5 - T/25\right)^2 + \left(\mathrm{III}/5 - T/25\right)^2 + \left(\mathrm{IV}/5 - T/25\right)^2 + \left(\mathrm{V}/5 - T/25\right)^2 = \left(\mathrm{I}/5 - \mu\right)^2 + \left(\mathrm{II}/5 - \mu\right)^2 + \left(\mathrm{III}/5 - \mu\right)^2 + \left(\mathrm{IV}/5 - \mu\right)^2 + \left(\mathrm{V}/5 - \mu\right)^2 \quad (1)$$

Among them: R - dispersion, the magnitude of the impact of various factors on the test indicators.

Ⅰ， Ⅱ，Ⅲ，Ⅳ， Ⅴ—Corresponds to the sum of the five levels of data in each column.

T —Sum of data

$\mu = \left(T/25\right)$—The average of the sum of the data, the total average.

It can be seen from Table 1 that the order of importance of each factor to the test evaluation index is: E(acid solution ratio)>A(pretreatment ratio)>B(baking temperature)>F(acid solution temperature)>C (baking time)>D(acid dissolution time), therefore, the optimal level is: $E_4A_5B_4F_3D_5C_5$, ie the pretreatment ratio is 2.6g/ml, the calcination temperature is 750°C; the calcination time is 3.5h; the acid dissolution time is 3h; the acid dissolution ratio is 4.0ml / g; female acid temperature is 85°C.

4. Comparative Test

In the above experiment, the homogeneous wastewater coagulation test with the best process parameters was obtained, and domestic sewage treatment was carried out at the same time to check which flocculant was better in water treatment. The test results are shown in Table 2.

Table 2. Comparison test results

Coagulant	Raw water turbidity (NTU)	Effluent turbidity (NTU)	Turbidity removal rate (%)
Homemade PAC	67.3	1.84	97.26
Commodity PAC	67.3	2.68	96.01

As can be seen from Table 2, the PAC product prepared with kaolin is slightly superior to the commercial PAC in coagulation performance.

5. Treatment of High Concentration Phosphorus Containing Wastewater by Polyaluminium Chloride

Through the detection of the sample water, we found that the total phosphorus content was 40mg/L, and we found that the turbidity was around 30.14NTU by other technical means.

a). The effect of PAC dosage on the treatment of water samples

At the beginning of the experiment, we used the use of the measuring cylinder to weigh six equal-quality (200ml) water samples into six beakers with elevations of 1, 2, 3, 4, 5, and 6, respectively. Among them, 1 ml, 2 ml, 3 ml, 4 ml, and 5 ml of polyaluminum chloride of the same concentration (3%) were added (not added in the first beaker, followed by sequential arrangement). After the above operation procedure, we use JJ-4 six-connected electric mixer to mix and process it. This part is divided into two periods. The first period of time is high, but the action time is short, and the second period is low. But the time is relatively long. After removing and performing the static treatment, we took the supernatant for testing. After testing, we obtained the corresponding total phosphorus value and turbidity, as shown in Figure 1 below:

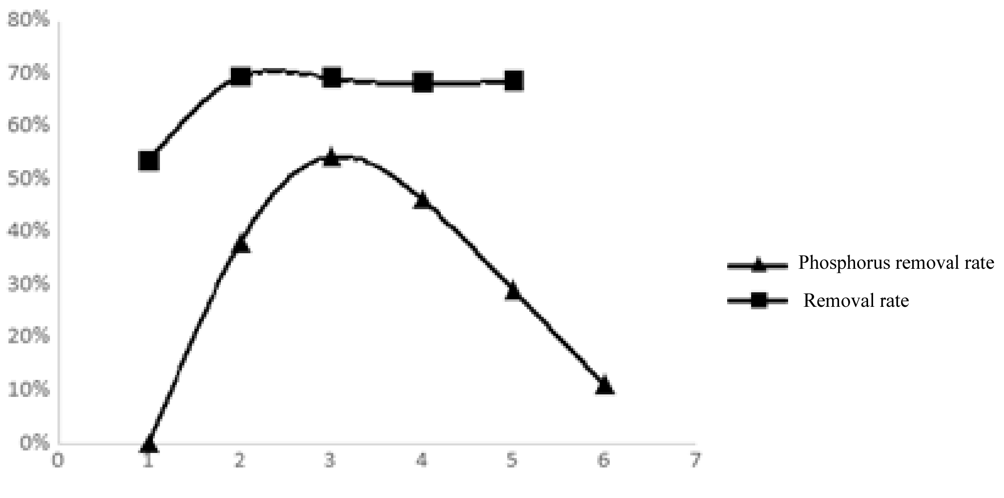

Figure 1. Effect of PAC dosage on total phosphorus and turbidity removal rate

According to Figure 1, we can see that the removal effect of P element is the overall trend of rising first and then falling. The overall change is 3ml as a base point. Before it, it is obvious that the removal rate is proportional to the applied amount. After the amount reached 3 ml, the effect gradually became stable and gradually deteriorated as the applied amount increased. According to the illustration, we can conclude that the removal of P element is best when the application amount is 3ml, and the turbidity removal effect is also very good. It is not the optimal value but also within the floating range. The total value is 18.34 mg / L. Through other technical means, we have detected that the turbidity is around 9.14 NTU.

b). Effect of reaction time on the treatment effect of water sample

In the second stage of the experiment, we used the use of the measuring cylinder to weigh six equal mass (200ml) water samples into six beakers with elevations of 1, 2, 3, 4, 5 and 6, respectively. 2 ml of the same concentration (3%) of polyaluminum chloride was sequentially added thereto. After the above operation procedure, we use JJ-4 six-connected electric mixer to mix and process it. This part is divided into two periods. The first period of time is high, but the action time is short, and the second period is low. However, the time is relatively long. The variable we control is the mixing time of the second period. The time of the six groups of experimental items is 10, 15, 20, 25, 30 min. After removing and performing the static treatment, we took the supernatant for detection. After testing, we obtained the corresponding total phosphorus value and turbidity, as shown in Figure 2 below:

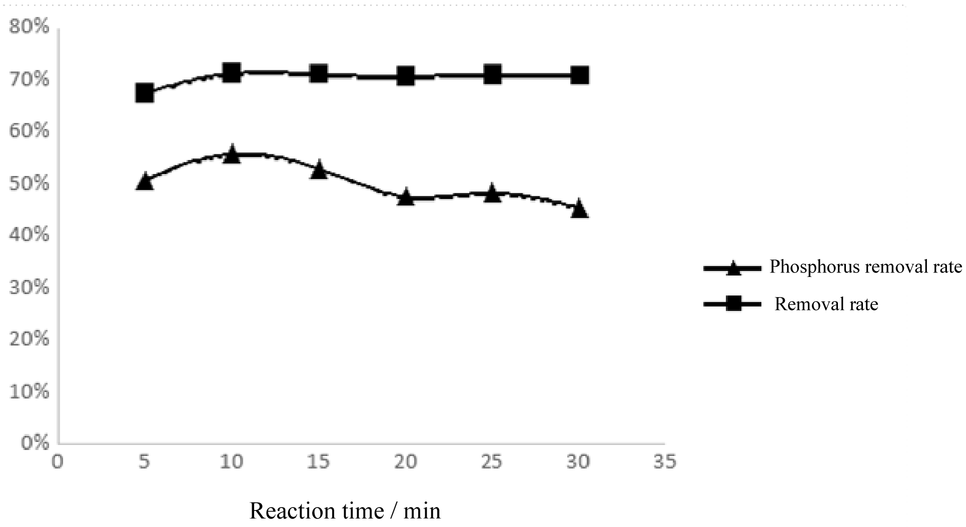

Figure 2. Effect of reaction time on total phosphorus and turbidity removal rate

According to the comparison of six groups of experiments, we can see that the removal degree of P element and the removal degree of turbidity are different from the reaction time. The removal rate of turbidity is obviously stabilized at a certain proportion after rising. However, the removal rate of phosphorus is first increased and then decreased. After finishing the data, we found that the removal effect of P element and the removal effect of the overall turbidity were relatively good at 10 min. At this time, the total value of phosphorus was 17.52 mg/L, and we detected it by other technical means. The degree is around 8.75 NTU.

6. Orthogonal test

In the design of this experiment, because there are many factors that have mutual cooperation and superposition, we need to consider the comprehensiveness when designing the experimental project, so as to prevent the time-consuming and laborious situation, but still face the difference of experimental data. The experimental design should follow a simplified operational design concept that minimizes the cost of the experiment with the simplest experimental design procedures and streamlined operational procedures. In the early stage of the experimental design process, we can refer to the reference method is the orthogonal experimental design, the specific design is as follows.

Orthogonal experimental design: (a). Evaluation index: value of total phosphorus (b). The selection of orthogonal tables and experimental design.

First, it was confirmed that the experiment was a 4-level experiment. The experiment orthogonally selected five factors of PAC dosage, PAM dosage, pH value, sedimentation time and magnetic powder dosage, and the $L_{16}(4^5)$ orthogonal table was selected.

The experimental water sample prepared in this experiment has a phosphorus content of 40 mg/L; PAC dosage: 1.50 ml, 1.75 ml, 2.0 ml, 2.25 ml; PAM dosage: 0.2 ml, 0.3 ml, 0.4 ml, 0.5 ml; Settling time: 5 min, 10 min, 15 min, 20 min; PH value: 6, 6.5, 7, 7.5; magnetic powder dosage: 0.05 g, 0.10 g, 0.15 g, 0.20 g.

This experiment does not consider the interaction effect, so the header can be designed by itself. First, fill in the factor level according to the $L_{16}(4^5)$ orthogonal table, and then calculate the total phosphorus removal rate based on the experimental calculation results, and finally fill in the orthogonal table, as shown in the following table.

a). From the difference of the factors in the table, the factors affecting the total phosphorus removal rate are PAC dosage, reaction time, pH value and sedimentation time.

b). From the average of the horizontal values of the various factors in the table, it can be concluded that the PAC dosage is 2 ml, the reaction time is 12.5 min, the PH value is 6.5, the sedimentation time is 15 min, and the removal rate will be higher.

7. Summary

In this paper, the treatment of high-concentration phosphorus-containing wastewater by polyaluminum chloride was carried out, and the removal rate of total phosphorus and turbidity was used as reference. The single factor experiment of the water samples was carried out by studying the dosage of PAC, reaction time, pH and sedimentation time. After comparison, it is not difficult to find that the PAC prepared by kaolin is better than the PAC sedimentation coagulation effect sold in the market.

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