Fabrication of a composite catalytic material for efficient removal of chroma, ammonia nitrogen and phosphorus

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Abstract: The problems like eutrophication and high chroma of surface water has aroused the attention of lots of people. Nowadays, the study on the treatment of chroma, ammonia nitrogen and phosphorus is mature. But, these technologies are always single and independent. In this study, we synthetize a material for decolorization and efficient removal of ammonia nitrogen and phosphorus. The results showed that the novel material can remove 48.34% and 55.50% methylene blue after 10 hours, and activated carbon particles can adsorb 17.88%. This material can also remove 17.02% NH_3-N and 17.21% TP besides the loss rate after 24 hours.

Introduction

As the activities of human beings, plenty of growth elements like nitrogen, phosphorus were discharged into rivers and lakes [1]. If the self-purification of water body can't transform and consume these elements, alga and plankton will be excessive growth and reproduction, resulting in the deterioration of water quality and the increasing of turbidity and chroma [2, 3]. Currently, the problem of eutrophication, a major global environmental issue, has been the central point [4].

To overcome this difficulty, a lot of investigators have done much research and offered many measures [5]. Slow filter can remove 88% turbidity and 65% chroma [6]. As a strong oxidizer, Fenton reagents can reduce 93.11% color [7]. Christina [8] tested the adsorption ability of constructed wetland substrate, and found that kerogen shale can remove about 71% P. Zeolite modified by 1mol/L NaOH can absorb 650.68mg/kg ammonia nitrogen, that is 2.82 times of the natural zeolite [9]. Oyster shell can remove about 87% P and plants absorb only 7% [10]. But, these treatment of decolorization, ammonia nitrogen and phosphorus are exclusive and independent.

The main objective of this study was to fabricate a novel multiple material. A new material was prepared via tube furnace for treating the chroma and removing ammonia nitrogen and phosphorus. Ferrous sulfate is completely oxidized to ferric via burning high temperature, resulting in the composite material having a magnetic which makes it easy to collect and disposal after treatment.

Material and Methods

A. Chemicals and Preparation of materials

A guaranteed grade of reagents Phenolic resin, Powder zeolite, $FeSO_4$, TiO_2, CaO and Ethanol were prepared without further purification.

Phenolic resin, Powder zeolite, $FeSO_4$, TiO_2 and CaO were dissolved in Ethanol with the proportion of 3:4:3:1:1. The mixed solution was put into the drying device for drying 24h. After that, the dried materials were heated in a tube furnace for 2h with nitrogen as the fluidising gas. Last, the prepared hybrid materials need to be ground with a mortar before use.

B. Synthetic water and Analytical Methods

Methylene blue was chosen as the target pollutants for decolorization experiments, and the dye solution was prepared containing 10mg/L methylene blue. Here methylene blue was measured by spectrophotometric method.

The synthetic water containing 0.03821 g/L NH_4Cl (NH_3-N: 10mg/L) and 0.00877g/L KH_2PO_4 (P:

2mg/L) was used to test the performance of the removal experiments with ammonia nitrogen and phosphorus as target compound. Ammonia nitrogen concentration was measured by Nessler's Reagent Spectrophotometry. Total total phosphorus was determined with ammonium molybdate spectrophotometric method.

Result and Discussion

The SEM images of the synthetic materials with or without treatment experiments are showing in Figure.1. Those images are taken in 2 µm. SEM image (Fig.1 a) shows that the surface of crystal structure of the material is level and smooth. Crystals are distributed evenly and have a certain degree of agglomeration. Fig. 1 b shows that the surface of the material with decolorization experiment is rough and has lots of small cavities with dispersion and independence state. Fig.1 c shows that a small part of the crystal turns into miniaturization and granulation. The degree of roughness and quantities of fine particle and pore are concerned with the activities of catalytic oxidation reaction.

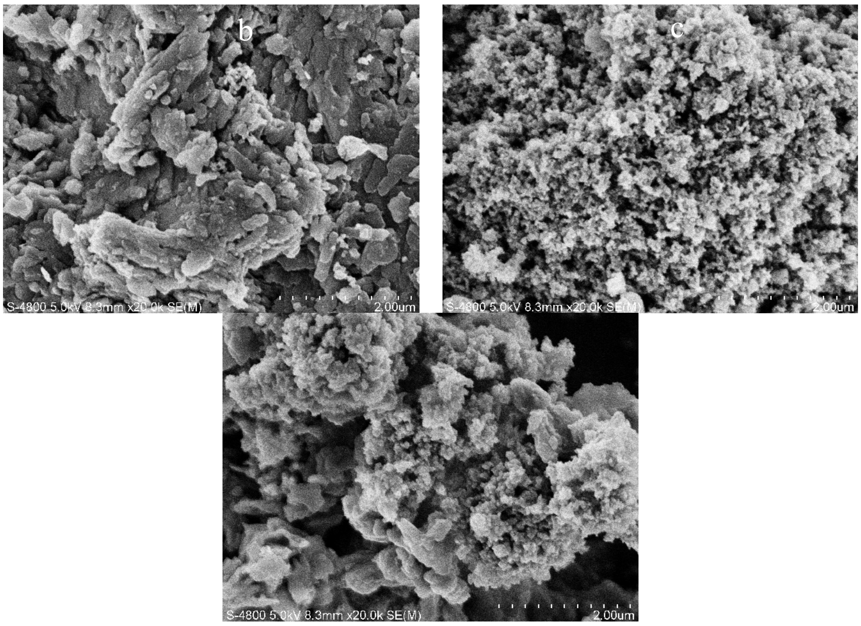

Figure.1 SEM images of the synthetic materials. a: the synthetic material without treatment experiment; b: the synthetic material with decolorization experimensts; c: the synthetic material with experiments on removal of N and P.

A 2L sample of dye solution with the initial concentration 10.00mg/L, was added to 1g composite materials and the concentration of dye in the solution was monitored at different times, namely 0.5, 1, 1.5, 2.5, 3.5, 4.5, 5, 5.5, 6, 7, 8, 9 and 10 h. The results such as methylene blue are shown in Fig.2. The concentration of methylene blue decreased during 10 hours.

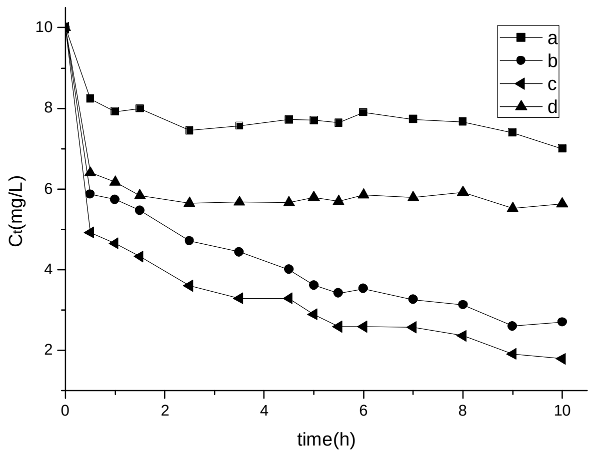

Fig.2 Effect of time on the removal of methylene blue. a: blank; b: 1g novel material; c: 1g novel material (5h adding ultraviolet light); d: 1g activated carbon particles

After the reaction start-up, as light degradation and catalytic oxidation, the concentration of dye solutions decreased significantly. From line a and line d, the concentration of dye was stable from 2.5h to 10h, because equilibrium is reached. According to line b and line c, the trend of decrease of experiments was almost alike, even that the group c was added ultraviolet light When the time reached 5 hours. Therefore, one can conclude that ultraviolet light has no effect on the novel material. After 10 hours, 25.59% methylene blue can be degraded because of the light. For the removal of two materials, activated carbon particles can adsorb 17.88% methylene blue, and the novel material can remove 48.34% and 55.50% methylene blue because of catalytic oxidation process.

A 1L sample of prepared synthetic water was added to 0.1g adsorption materials and the concentration of synthetic water in the solution was monitored at different times, namely 0, 10, 30, 60, 120, 240, 360, 480, 1440 and 2880 min. The results are shown in Fig.3 and Fig.4.

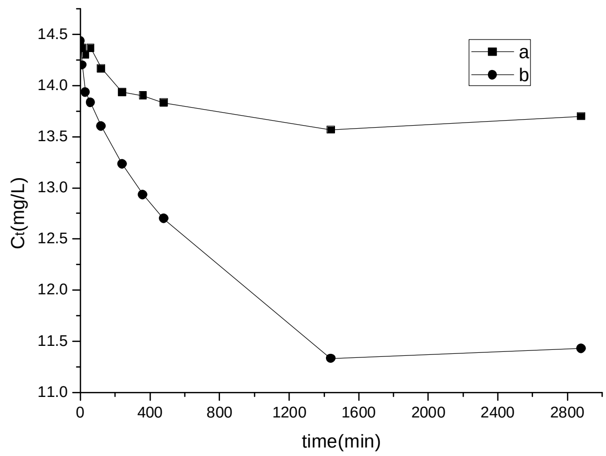

Fig.3 Effect of time on the adsorption of ammonia nitrogen. a: blank; b: 0.1g novel material

According to Fig.2, in the view of line b, the concentration of ammonia nitrogen was decreased apparently compared to line a. The mean value of blank group is 13.76mg/L during the equilibrium time from 240 min to 2880 min and the loss rate was 4.46%. After 1440 minutes, the concentration of ammonia nitrogen was down to 11.33mg/L and the removal rate was 17.02% besides the loss.

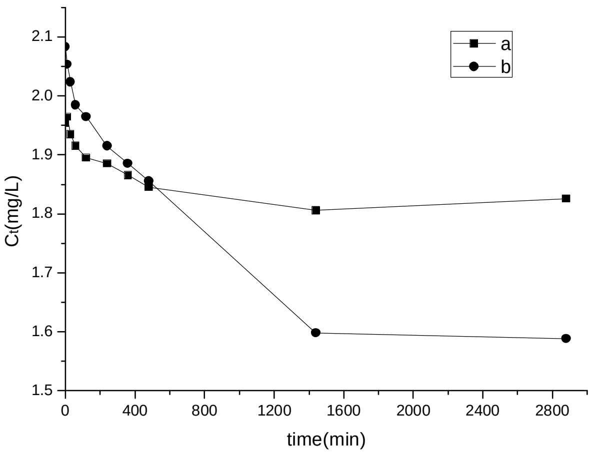

Fig.4 Effect of time on the adsorption of total phosphorus. a: blank; b: 0.1g novel material

According to Fig.3, as we can see from line a, the blank group concentration was steady from 360 min to 2880 min and the mean value was 1.836mg/L. The concentration of total phosphorus was fallen from 2.08mg/L to 1.60mg/L after 1440 minutes. The removal rate of total phosphorus was 17.21% besides the loss rate 6.08% according to the blank group.

Conclusions

Results of this study demonstrate that this composite material can be used to decoloration and removal of ammonia nitrogen and phosphorus.From the SEM images of the materials, we can see that the surface turns to be rough and has lots of cavities compared to the blank group after experiment treatments, and the degree of roughness and quantities of fine particle and pore are concerned with the activities of catalytic oxidation reaction. For decolorization experiments, the novel material can remove 48.34% and 55.50% methylene blue besides 25.59% light degradation because of the catalytic oxidation of titanium dioxide and ferric oxide [11,12], and the activated carbon particles can only adsorb 17.88% methylene blue. In addition, a conclusion can be drown that ultraviolet light has no effect on the novel material for decolorization, which means that this novel material can simplify technological conditions and reduce production costs for application in engineering. For removal experiments of ammonia nitrogen and phosphorus, the novel material can remove 17.02% NH_3-N and 17.21% TP besides the loss rate.

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