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Flocculation Efficiency of Sludge Bioflocculant for Treating Two Kinds of Simulated Wastewater

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Abstract. Sludge bioflocculant was prepared from excess biological sludge by extraction method with dilute hydrochloric acid. A series of experiments were performed to investigate the flocculation efficiency of sludge bioflocculant towards starch and oily wastewater. The results indicated that the sludge bioflocculant had good efficiency towards starch and oily wastewater. More than 90% of flocculating rates were attained for the two kinds of wastewater. From the above study not only sludge could be recycled, a cheaper and readily available flocculant was attained from biological sludge, but also some kinds of wastewater could be treated with the sludge flocculant.

Introduction

Excess biological sludge is an aggregate of microorganisms organism and inorganism which are discharged from wastewater processing system [1, 2]. Thus excess biological sludge is supposed to be a source of bioflocculants and could be recycled to prepare bioflocculant. In the previous work, we successfully extracted flocculation active ingredient from sludge and 98% of flocculation efficiency for kaolin suspension was attained [3].

Nowadays various kinds of sewage are generated with the rapid development of industry and agriculture which brings risk for human health and environment [4]. Directly emitted starch wastewater can consume the dissolved oxygen in the water, leads to the deterioration of the environment. Therefore, to improve the quality of starch wastewater treatment and comprehensive recycling, environmental scientists pay more attention to it [5, 6]. Oily wastewater is also one of the priority control pollutants. Therefore, an effective and economical flocculant, which is capable of dealing with the ever increasing demand, is desirable for industrial application.

In this paper, hydrochloric acid was applied to disintegrate excess biological sludge to extract flocculating activity ingredients which was defined as sludge bioflocculant (SBF). The flocculation conditions for wastewater treatment with SBF were researched. From the above study not only a cheaper and readily available flocculant was attained, but also some kinds of wastewater could be disposed of with the sludge flocculant.

Materials And Methods

Preparation of SBF

Before extracting sludge bioflocculants, 100.0mL sodium hydroxide solution (4%, w/w) was used to soak 30.0g dewatered sludge. During the soaking time, the mixed system was stirred by a magnetism mixer at 400rpm for 40min and then centrifuged at 8000 rpm for 15 min. The sediment was washed to neutral with deionized water and centrifuged at the same speed. The rest sediment was defined as one piece of neutral sludge.

Hydrochloric acid (3%, w/w) 60.0mL was mixed with one piece of neutral sludge, and then the sludge suspension was stirred with magnetic stirrers at 400 rpm for 15 min. The suspension was centrifuged at 8000 rpm for 15 min. The supernatant liquor was diluted to 150.0mL with deionized water. This supernatant liquor was defined as crude bioflocculant. The crude bioflocculant was fractional precipitated by increasing supernatant liquor pH to 9.0 with sodium hydroxide solution (4%, w/w) and the sediment was got by centrifugation at 8000rpm for 15 min. The above sediment was feed into dialysis bags which molecular weight cut off was 10,000Da. After dialysis, this kind of purified sludge bioflocculants were evaporated 2h for dryness then the dry solid were defined as SBF.

Flocculation Experiments

To evaluate the flocculation effect of the prepared SBF, flocculation experiments were carried out. Starch suspension and oily wastewater were tested. Selected properties of the tested solutions were summarized in table1. The experimental procedures were as follows: different dosage of SBF was added to the beaker. The above flocculating system solution was diluted to 300.0mL. Afterwards, the flocculating system was stirred with a magnetic stirrer for 30 s at 400 rpm, slowly stirred at 100 rpm for 5 min and then kept still for over 20 min. The supernatant sample was collected for further analysis. The flocculating rate was defined and calculated using the following equation.

Table 1 Selected property for tested solutions

Solution	pH	OD
Starch suspension	6.0-7.0	550
Oily wastewater	6.0-7.0	268

$$\text{Flocculating rate (\%)} = (A-B)/A \times 100 \quad (1)$$

Where A and B were OD of the blank control and the bulk solution, respectively.

Analytical Methods

Starch suspension absorbance, with 722 type spectrophotometer was measured under 550 nm wave lengths. The turbidity removal rate is the flocculating rate. COD was measured by fast digestion spectrophotometric method. The oil contents after flocculation were analyzed by ethyl acetate extraction test, and the oil contents of extracting agent were also analyzed by UV-VIS spectrophotometry. Each sample was read three times to get the average value.

Results and Discussion

In order to optimize the flocculation performance of wastewater using SBF which involves more than one mechanism, it is important to consider the influence factors which have effects on the flocculation mechanisms. In this section, the effect of some these factors, for example, the concentration of simulated wastewater (C_0), dosage of flocculant (V), solution pH and settling time (t) on the flocculation efficiency of SBF was investigated.

Starch Wastewater Treatment Using the Sludge Bioflocculant

The pH of a flocculating mixture containing starch suspension and a certain amount of the SBF was adjusted with 0.01mol/L HCl and 0.01 mol/L sodium hydroxide solution before flocculating. Fig.1 shows the flocculation efficiencies of the starch wastewater at different pH, using 2.0mL SBF in 300.0mL of 4.0g/L starch solution. The turbidity of the supernatant was measured to calculate the flocculating rates after standing for 10 min. According to Fig.1, with the increase of the initial pH the removal rate appears increasing at first and then not changes significantly after reaching the peak value. The flocculating rates were all over 90% in the range of pH 6.0-12.0, which was just the pH of the practical starch wastewater, so pH adjustment was not necessary any more in actual application.

The effect of SBF dosage on flocculation efficiency of starch wastewater was shown in Fig.2. Flocculating system pH was all adjusted to 6.0. Flocculating rate was more than 95.0% in a flocculant dosage range of 2.0-12.0mL. The maximum flocculating rate 99.5% was observed when the flocculant dosage was 8.0mL. When the flocculant dosage increases, the flocculating rate increased overall.

It can be seen from the above experimental results that SBF has a better flocculation effect on starch granules. The surface of the starch granules contains a large number of hydrophilic groups. After being in the water, starch granules have been swelling. Some hydroxyl groups on the surface of the particles ionization. It makes starch granules negatively charged, at the same time the surface forms the hydration layer. After adding the flocculating agent, positively charged flocculant quickly combined with starch granules, which can break the particles hydration layer. When particles lost stability, collision probability will be increased. Because the SBF attracted to each other at the same time, the larger particles of stable flocs can exist and settle down.

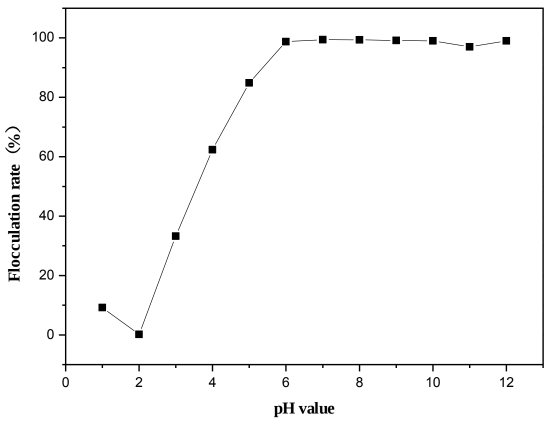

Fig. 1 The Relationship between PH Value of Starch Solution and Flocculation Activities

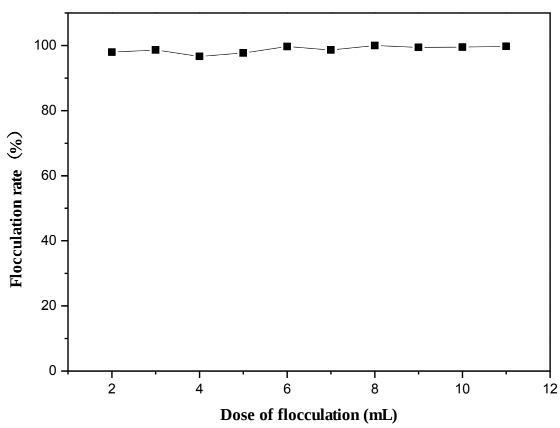

Fig. 2 The Relationship between Flocculant Dosage and The Rate of Starch Flocculation

Oily Wastewater Treatment Using the Sludge Bioflocculant

Chitosan, a natural cationic polyelectrolyte, and other similar coagulants were used in the treatment of an olive oil water suspension as a model for the processing wastewater. At optimum conditions of coagulation and flotation stages, the COD of the olive oil emulsion could be reduced by 95% [7]. In this study, we also found that SBF had specifically adsorption ability to tested oil wastewater. Oily wastewater pH is one of the main factors influencing the treatment effect of oily wastewater. The dosage of SBF was 4.0mL for 300mL oily wastewater. The oil-water mixture was stirred for 10 min by a magnetic stirrer at ambient temperature. After sedimentation for 30 min the middle part of the mixture was taken for measuring the absorbance under 268 nm wavelength with spectrophotometer of UV-VIS.

It can be seen from Fig.3, the flocculating rate increased first from pH 1.0-5.0 and then decreased from 5.0-9.0. When the pH was 5.0 the flocculation efficiency presented peak, flocculation efficiency reached 92.0%. Therefore, the best range of pH for oily wastewater is 4.0-6.0. However when the pH was 12.0 the flocculating rate was negative. The concentration of the oil in wastewater had been significantly decreased when the pH value reach 12.0. In neutral water, the absorbance of oil absorbency was 1.3, but in strong alkaline solution, that was 0.1. It shows that the oil is broken. Experiments had shown that the clarity of oily wastewater before flocculating is low and oil had been dispersed evenly by stirring in the water. However, after the flocculating, the oil droplets gathered on the liquid surface which can be recycled. The spare liquor is clear and transparent. The oil removal efficiency can reach 91.0%. Therefore the above experiment results show that the SBF has good oil and water separation capability. The SBF is a microbial flocculant which has many hydrophilic group and lipophilic group in the molecular structure [8]. So the interaction between lipophilic group and oil droplets can disrupt the hydration layer of oil and water. At the same time, it also can make a lot of oil droplets gathering to become thick oil layer that easily can be separated from water.

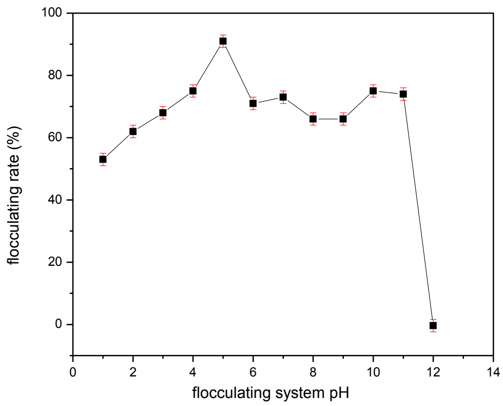

Fig. 3 The Relationship between PH Value of Oily Wastewater and Flocculation Activity

Summary

Excess biological sludge could be used as resources to prepare bioflocculants. Sludge bioflocculant had a good flocculation effect on starch granules. The flocculation efficiency reached 99.5%. The SBF has a certain oil-water separation capability which can make the dispersed oil bead quickly gathering and stratification. The flocculation efficiency could reach 92.0%. From the above study not only sludge could be recycled, a cheaper and readily available flocculant was attained from biological sludge, but also some kinds of wastewater could be disposed of with the sludge flocculant.

Acknowledgement

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