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Sludge Bulking Property of Membrane Bio-reactor in Albumen Wqastewater Treatment

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Abstract: Albumen wastewater was treated by Membrane Bio-reactor. Sludge bulking property of Membrane Bio-Reactor was investigated in this study through contrast research. When the sludge bulking appeared, the removal efficiency of COD in Membrane Bio-reactor increased slightly under the function of filamentous bacteria. However, the negative effects of the higher net water-head differential pressures, the higher block rate of membrane pore and the great quantity of filamentous bacteria at the external surface presented at the same time. Thus, plenty of methods should be performed to control sludge bulking once it happened in Membrane Bio-reactor.

Key words: Membrane Bio-reactor; Sludge bulking property; Membrane fouling

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1 Introduction

The membrane bioreactor (MBR), a technological combination of biological treatment with a membrane separation device, is a new biochemical reaction system. The study on its applications in treating various types of waste streams, such as domestic wastewater, industrial wastewater and human excrement has therefore attracted great attention [1,2]. Microorganisms were all retained within the bioreactor due to the efficient interception performance of the membrane. Hence there was no problem about mass lapse of the microorganisms as a result of sludge bulking, and it was well known that an advantage of a MBR was its good resistance to sludge bulking [3,4]. The effect of sludge bulking to a MBR has seldom been reported since MBRs came forth. The purpose of this study is, therefore, to elucidate the influence of sludge bulking to a submerged membrane bioreactor (MBR).

2 Material and methods

2.1 Apparatus

The schematic diagram of the experimental set-up is shown in Fig.1. A new hollow fiber membrane module (Hangzhou Zheda Hyflux Hualu Membrane Tec. Co., Ltd.) was immersed in the cylindrical bioreactor, whose effective diameter was 18.8cm, with a 20.8L working volume. The membrane with a pore size 0.1 μm was made of polyethylene, and its molecular weight cut-off (MWCO) was approximately 100kDa. The membrane module half a metre in length had a filtration area of 2m^2. The temperature of the bioreactor was maintained in the range 20～25℃.

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2.2 Albumen Wastewater

MBR was fed with albumen wastewater, which was made of soybean powder solution with 18% fat, 49% protein, 27% polyose and 6% minerals.

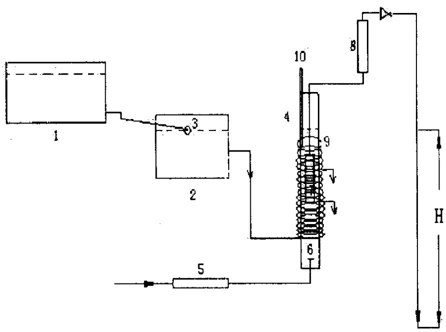


Fig.1 Schematic diagram of the MBR

1. Highly placed water tank; 2. Water level balance tank; 3. Ball cock; 4. Bioreactor; 5. Gas flowmeter; 6. Aeration device; 7. Hollow fibre membrane module; 8. Backwashing obturator; 9. Strip heater; 10. Thermometer

2.3 Operating Conditions

The albumen wastewater was pumped up to the highly placed water tank. The water level of the MBR was controlled by the ball cock, which kept the balance of influent and effluent with the variety of the effluent, in the water level balance tank.

2.3.1 Sludge Bulking Period (SBP)

The surplus sludge in the secondary clarifier of Harbin Refinery and the surplus sludge used in the last trial were incubated together directly in the reactor with intermittent aeration. Clear solution was taken out of the MBR every day. A new membrane module was immersed in the bioreactor two weeks later. The pressure-head showed as H in Fig. 1 was 10kPa at the beginning of the trial. The gas flow flux was adjusted between 0.1 and 0.2 m^3/h using a gas flowmeter. DO concentration maintained in the range 1~2 mg/L in the bioreactor.

The filtration flux decreased from 103mL/min of the initial flux of a new membrane module (HRT was 3.37h) to 51mL/min on the 2nd day, and to 38mL/min on the 4th day, and to 32mL/min on the 6th day (HRT was 10.8h).

1L mixed liquid was taken out of the MBR as sampling every other day; hence the SRT was 42 days. The membrane was without backwashing from 1st to 6th day during the operation period. From 7th day on, about 1L water was used everyday for backwashing, and the pressure-head showed as H in Fig.1 was adjust everyday in order to maintain the filtration flux at a constant value of 57mL/min (HRT was 6.08h).

The sludge settlability decreased in the first week of the operation obviously. The activated sludge floc was big and the filamentous bacteria were dominant in the microscopic field, which indicates the bulking state of sludge. The trial went on for other two weeks without changing the operation conditions.

2.3.2 Comparative Trial Period (CTP)

The source of the sludge and the way in which the sludge was incubated were the same during the CTP as those during the SBP. A new membrane module was also used. But the gas flow flux, which was adjusted between 0.4 and 0.6m^3/h using a gas flowmeter, and the organic loading rate were much higher during the CTP than those during the SBP. DO concentration maintained in the range 3.5~4.5 mg/L in the bioreactor.

The filtration flux decreased from 106mL/min of the initial flux of a new membrane module (HRT was 3.27h) to 53 mL/min on the 2nd day and to 45 mL/min on the 4th day, and to 40 mL/min on the 6th day (HRT was 8.67h).

The SRT, the backwashing and operation conditions during the CTP were all the same as those during the SBP.

3 Results and Discussion

3.1 Comparison of the Effect of COD Removal during the two different periods

COD concentration in influent fluctuated between 516.5 and 691.3mg/L during the SBP, while it undulated between 858.2 and 1021.4mg/L during the CTP.

The organic loading rate (N_s) was adjusted to increase abruptly on the 8th day during both the SBP and the CTP (Fig. 2). Because MLSS increased differently, N_s decreased during both of the periods and

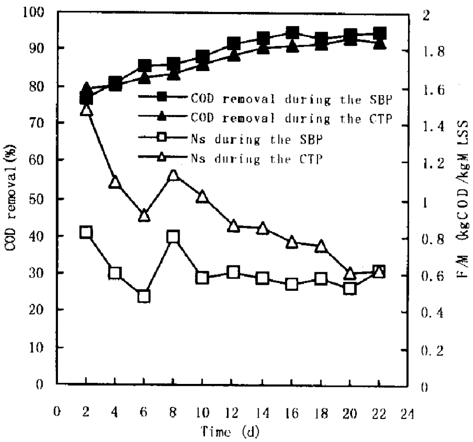


Fig. 2 Effect of COD removal and variation of N_s in MBR during the two different periods

there was a greater downtrend during the CTP as a whole.

The filamentous bacteria with an strong affinity for nutriment in the soy protein wastewater had a highly competitive ability to the nutriment, thus the water quality of effluent was good. Therefore the effect of COD removal during the SBP was a little better than that during the CTP, and F/M was much lower all along.

3.2 Comparison of the Variation of SVI During the Two Different Periods

There is no consensus of the various references that above which value of SVI, which is used to describe the compressibility of sludge, will be, when sludge bulking occurs. It is generally accepted that the sludge status was good if SVI is below 100mL/g. Generally, sludge bulking happens in factual engineering, when SVI is above 150 (or 200) mL/g. During the SBP, the SVI was 152mL/g on the 4th day, and achieved 234mL/g on the 6th day, and climbed up to 299mL/g on the 8th day, and then declined a bit, but was still beyond 200mL/g, which showed the bulking state of sludge (Fig. 3). During the steady-state SBP, the SVI stood around 100mL/g all along, which suggested that the sludge status was good.

3.3 Comparison of the Variation of Pressure-Head during the Two Different Periods

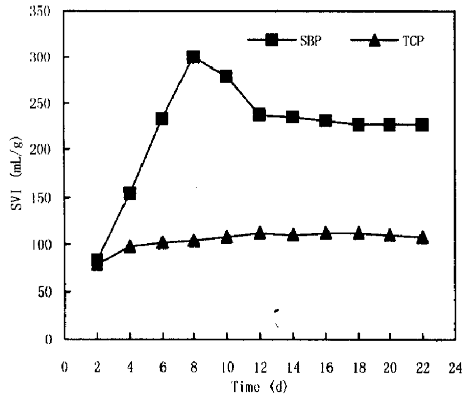


Fig. 3 Variation of SVI in MBR during the two different periods

The pressure-head showed as H in Fig. 1 was regulated to 10kpa everyday from 1st to 6th day. From Fig. 4 it can be seen that H rose during both of the two different periods as time went by. The increasing amplitude of H during the SBP was especially larger than that during the CTP, that is, in order to satisfy the filtration flux need, a higher value of H was required during the SBP, which reflected indirectly that fouling was much heavier. It was caused by two reasons, one was the big mass-surface ratio of the filamentous bacteria, and the other was the physiological and biochemical characteristic of the bacterial slime secreted by the filamentous bacteria.

Now, many researchers believe that MBR can counteract the effect of sludge bulking very well. But the trial results above showed that a bad fouling was the fatal wound of MBR during its SBP. So the most dominant factor of the MBR development is the fouling control.

3.4 Comparison of the Scanned Pictures by the Electron Microscope of the Internal Membrane Surface during the SBP

The membrane surface was scanned by the electron microscope (KYKY-1000B) at the end of the SBP, and the microcosmic status of the membrane surface was presented

There were a mass of filamentous bacteria on and in the external membrane surface at the end of the SBP (Fig. 5a), which confirmed the bulking state of s-

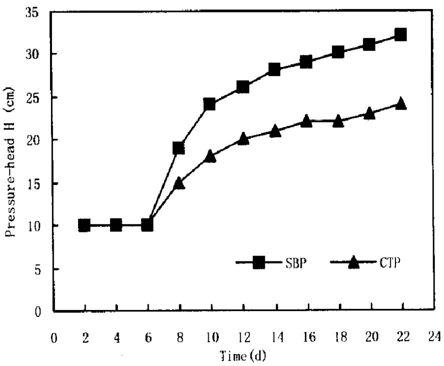
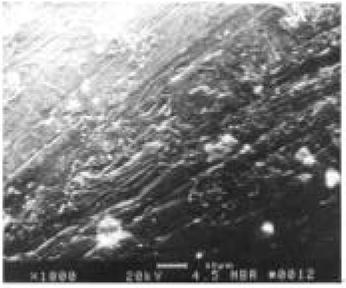
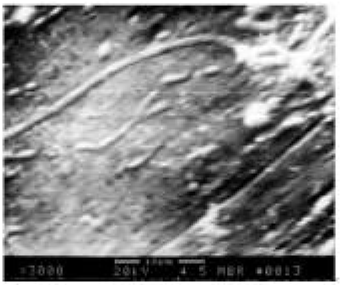


Fig. 4 Variation of pressure-head in MBR during the two different periods

ludge. Fig. 5b shows the shape of the filamentous bacteria more evidently.



(a) Magnified 1000 times



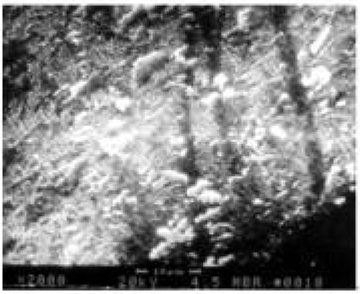
(b) Magnified 3000 times

Fig. 5 Scanned pictures of the external membrane surface at the end of the SBP by the electron microscope

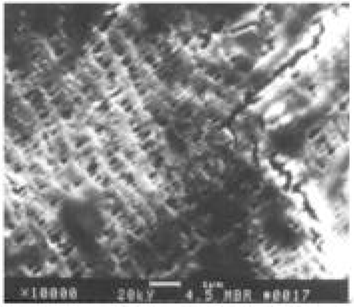
From Fig. 6a it can be seen clearly that there were large numbers of contamination on and in the internal membrane surface at the end of the SBP. The membrane pore size average was 0.1 μm, which was smaller than the bacteria size 0.5 ~2.0 μm, in theory, all bacteria should be retained within the bioreactor, but the trial above showed that bacteria could stick to the internal membrane surface. It resulted from the inhomogeneity of the membrane pore size and the allotypical division of bacteria.

A bad fouling on and in the external membrane surface (Fig. 6) caused the active area of the membrane pores on and in the external membrane surface decreased during the SBP. The pressure-head was adjust to increase constantly in order to maintain a constant HRT, and the membrane pore size was uneven; therefore the filtering velocity of the big membrane pores enhanced, as a result, Thus it was much more possible that the filamentous bacteria stuck to the internal membrane surface rapidly and led fouling during the SBP of the trial.

Fig. 6b obviously shows the clogging and fouling status and the inhomogeneity of the membrane pores.



(a) Magnified 2000 times



(b) Magnified 10000 times

Fig. 6 Scanned pictures of the internal membrane surface at the end of the SBP by the electron microscope

4 Conclusion

(1) The effect of COD removal during the SBP was a little better than that during the CTP, because the filamentous bacteria with an strong affinity for nutriment in the soy protein wastewater had a highly competitive ability to the nutriment, thus the water quality of effluent was good.

(2) In order to satisfy the filtration flux need, a higher value of pressure-head was required during the SBP, which reflected indirectly that fouling was much heavier. It was caused by the big mass-surface ratio of the filamentous bacteria.

(3) Since there were a mass of filamentous bacteria on and in the external membrane surface, and large numbers of contamination on and in the internal membrane surface and during the SBP, a bad fouling was the fatal wound of MBR during its SBP. A little better removal effect can not make up for the minus effect of the fouling during the SBP. Essential control was demanded once the sludge bulking occurs for the sake of efficient and steady operation of MBR.

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