Factors Affecting Biofouling in Membrane Coupled Sequencing Batch Reactor

Chung-Hak Lee*
School of Chemical Engineering, Seoul National University, Seoul 151-742, Korea
Tel.: +82-2-880-7075; e-mail: leech@snu.ac.kr

ABSTRACT

Factors affecting filtration performance were investigated in a Sequencing Batch Reactor (SBR) coupled with a submerged microfiltration module. Special bioreactors for aerobic and anoxic phases, respectively, were specifically designed in order to differentiate the effect of Dissolved oxygen (DO) from that of mixing intensity on membrane filterability. DO concentration as well as mixing intensity proved to have a major influence on the membrane performance regardless of the SBR phase. A higher DO concentration resulted in a slower rise in TMP, corresponding to less membrane fouling.

INTRODUCTION

Sequencing Batch Reactor (SBR) processes offer several advantages over other types of activated sludge reactors. The cycle format can be easily modified at any time to offset changes in process conditions, influent characteristics or effluent objectives (Pavelj et al., 2001). However, SBR has a potential risk in that poor clarification and a turbid effluent are associated with it. Combining a membrane process with SBR (MSBR), which incorporates a membrane separation in place of sludge settling, provides procedural advantages for both processes. This allows for a very high treatment capacity for a membrane coupled SBR (MSBR) (Jörg Krampe et al., 2000). In a membrane coupled SBR (MSBR) system, it would be very important, but also difficult, to select the most appropriate SBR phase in which membrane filtration could be performed at its best. The efficiency of membrane process in MSBR would certainly be dependent on the physicochemical and biological conditions of each SBR phase, as well as the type and cycle format of the SBR. However, little information is available on comparison of membrane filtration characteristics between various SBR phases in MSBR. In this study, factors affecting filtration performance in MSBR was investigated in terms of DO, mixing intensity, cycle format, etc.

EXPERIMENT

The SBR system was run parallel with the MSBR. The SBR was operated at 4-hour / cycle (6 cycles per day) under the following sequence: (1) filling, (2) aerobic, (3) mixed anoxic, (4) settling and (5) drawing. The exchange rate was 50% of the full reactor liquid volume. In case of the MSBR a hollow fiber membrane module was immersed in the bioreactor having a 7L working volume. The hollow fiber microfilters used in the study were made of polyethylene with a pore size of 0.1μm (Mitsubishi Rayon Co., Ltd., Japan) and a membrane area of 1440 cm^2. During filtration, the membrane permeate was withdrawn by a peristaltic pump under a constant flux of 20 or 40 LMH(L/m^2/hr), and the TMP build-up was constantly monitored.

The influent COD was 250 mg/L. Sodium bicarbonate was added to the synthetic wastewater to maintain the pH of the mixed liquor in the range of 6.7-7.3.

RESULTS AND DISCUSSION

Filtration characteristics at each SBR phase

In order to compare the membrane performance at each SBR phase, submerged microfiltration was performed at each individual SBR phase under a constant flux of 20 LMH with being recycled all permeate to the reactor (Fig.1). A much better filtration performance at aerobic conditions than for anaerobic conditions was assumed to be related to both DO concentration and the degree of mixing, or turbulence in the SBR. In this context, the effects of these two parameters on the membrane performance were further studied in order to elucidate the differences in the rise of TMP for the aerobic and anoxic phases.

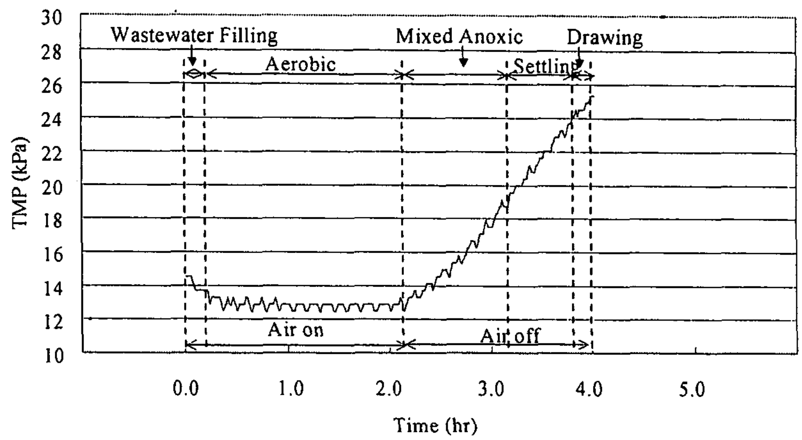


Fig.1. Variations in the TMP profile at each SBR phase during submerged microfiltration.

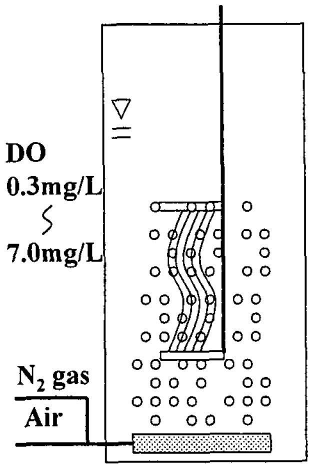
Effect of DO on TMP profile

Because the mixing intensity, as well as DO, affects membrane permeability, it became necessary to further investigate the effect of only DO on membrane filterability while fixing the mixing intensity. For this purpose a modified MSBR was devised in which the DO can be controlled easily with no variation in turbulence (Fig. 2a). The TMP variations during the submerged microfiltration of mixed liquors at three different DO concentrations (0.3, 1.7 and 7.0 mg/L) were monitored under constant flux of 40 LMH and the results are depicted in Fig. 2b. The rate of TMP rise for anoxic conditions (0.3 mg/L of DO) was 3 times higher than that of the highest DO (7.0 mg/L).

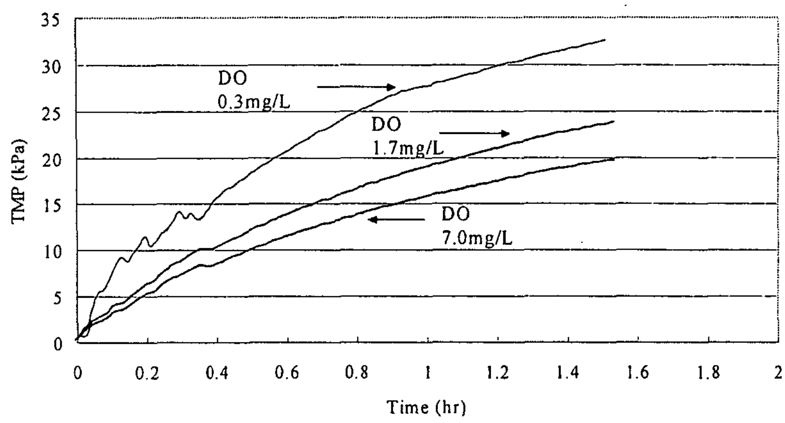
Resistance and Adhesion strength of Biofilm layer

In order to investigate in depth the role of DO in membrane biofouling for the MSBR system, specific cake resistance (Lee et al., 2001) was conducted after each filtration of mixed liquor with DO concentrations of ~0, 1, 2, 3, 4, and 5 mg/L. As can be seen in Fig. 3, the specific cake resistance of the mixed liquor with a

DO of 5 mg/L was about one order of magnitude lower than that with a DO of ~0 mg/L.



(a)



(b)

Fig. 2. (a) MSBR with various DO concentrations under constant pneumatic mixing intensity (b) TMP profiles at DO concentrations of 0.3, 1.7 and 7.0 mg/L.

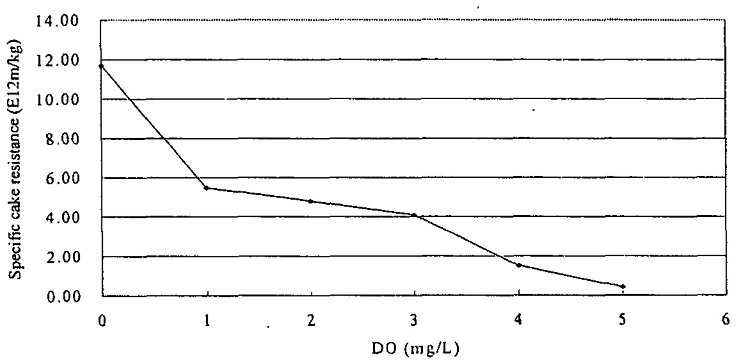


Fig. 3. Specific cake resistance as a function of DO concentration.

According to the Carman-Kozeny equation, the particle size and the porosity of the cake layer are two key parameters, which determine the specific cake resistance. Therefore, the particle sizes of the mixed liquors were measured as a function of the DO. The average particle sizes in the mixed liquors with a DO of 0.3 mg/L were much smaller (13±2 μm) than that with that DO of 7.0 mg/L (30±4 μm). Willén et. al. (1999) reported that there was a trend towards larger flocs at higher DO concentrations. They also reported that activated sludge flocs deflocculated under anaerobic conditions and reflocculated under aerobic condition (Willén et. al., 2000).

Fig. 4 illustrates that the activated sludge in the mixed liquor of the MSBR(A/O/-) has about 3 times of adhesion strength than that in the mixed liquor of MSBR(-/O/-). In other words, the activated sludge in the MSBR(A/O/-) can be deposited on the membrane surface more firmly, and thus is more difficult to be taken off under turbulence.

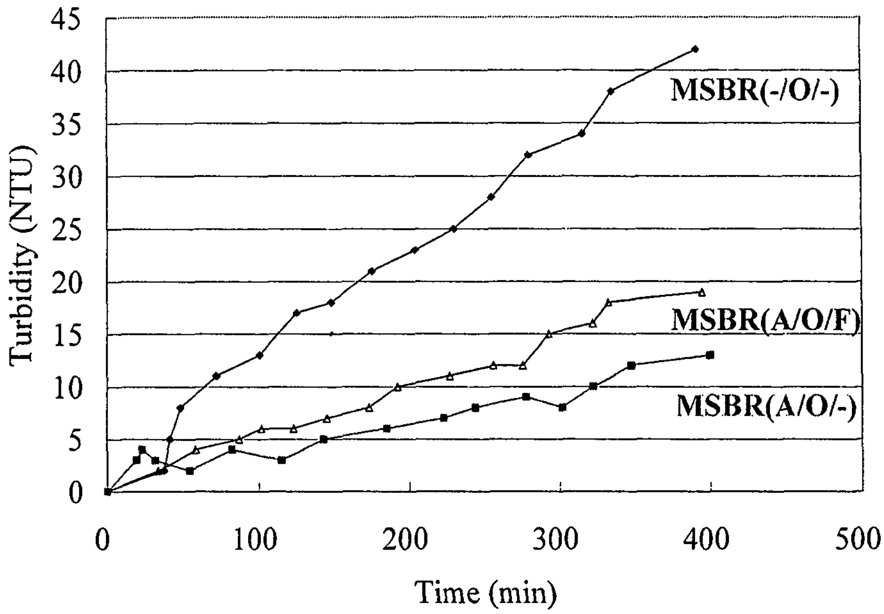


Fig. 4. Variations in turbidity in the evaluation of adhesion strength of activated sludge.

CONCLUSIONS

In a membrane coupled SBR (MSBR) system, membrane filtration characteristics were investigated as a function of the SBR phase and operating parameters. The filtration performance was strongly dependent on DO concentration and the turbulency of the mixed liquor, regardless of the SBR phase. The higher DO and the greater mixing intensity, the better is the filterability, for both aerobic and anoxic phases. Biofilm in MSBR with anoxic/aerobic phase showed greater adhesion strength on the membrane than with aerobic phase only, which accelerates the accumulation of Biofilm on the membrane.

REFERENCES

Jörg Krampe and Karlheinz Krauth (2000) Sequencing batch reactor with submerged hollow fiber membranes for the biomass separation, *In Preceedings of 2nd International Symposium on Sequencing Batch Reactor Technology*, Vol.2, 109-115.

Lee J., Ahn W.Y. and Lee C.H. (2001) Comparison of the Filtration Characteristics between Suspended and Attached Growth Microorganisms in Submerged Membrane Bioreactor, *Wat. Res.* **35** (10), 7-16.

Pavelj N., Hvala N., Kocijan J., Ro M., Ubelj M., Mui G. and Strmnik S. (2001) Experimental design of an optimal phase duration control strategy used in batch biological wastewater treatment, ISA Transactions, 40(1), 41-56.

Willén B. M., Keiding K. and Nielsen P. H. (2000) Anaerobic deflocculation and aerobic reflocculation of activated sludge. *Wat. Sci. Tech.* **34**(16), 3933-3942.