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SBR 및 BS-SBR 처리의 공정변화 연구

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Process variations in SBR and BS-SBR treatment

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국문요약

이 연구에서는 SBR에 Rotating disks를 부착하여 회전하면서 두 원판 사이에서 전단력이 발생하는 BS-SBR을 이용하여 용해성 유기물질 제거율과 슬러지 분리에 대해 비교 검토하였다. BS-SBR 공정에서는 부유성 활성슬러지와 생물학적 고정막에 의해 동시처리 되어 높은 처리효율을 보였다. SCOD 제거율은 SBR보다 높은 97%를 보였다. 처리수의 평균 SS 농도는 4.8mg/ℓ 정도로 나타났고, 1-cycle/d 및 3-cycle/d 모두 10mg/ℓ 이하를 유지하여 매우 효과적임을 알 수 있었다. 슬러지 침전 특성은 SBR과는 상이한 매우 좋은 결과를 보였다. 운전중 슬러지는 진한갈색으로 플록이 잘 형성되었고, 그 크기는 SBR에서 보다 크다는 것이 눈으로 확인할 수 있을 정도였다.

Abstract

The main purpose of this study was to determine effects of BS-SBR compared with SBR on the removal of soluble organics and sludge separation. In the BS-SBR process, soluble organics were removed by suspended activated sludge as well as biological fixed films and these two processes occurred simultaneously in one tank. The removal efficiency of soluble COD in the BS-SBR, approximately 97% in both 1 and 3-cycle/d was higher than for SBR. The BS-SBR process was very efficient for SS removal. The averaged SS concentration were 4.8mg/ℓ over the operation period, the daily SS values were consistently below 10mg/ℓ in both of 1-cycle and 3-cycle a day. The sludge settling characteristics in BS-SBR were totally different from SBR's. The sludge, dark brown, was well flocculated and its floc size was visible larger than the SBR's.

I. INTRODUCTION

The performance of activated sludge could be influenced by a number of factors: organic loading, substrate composition, detention time, pH and other operating parameters. In addition, a successful separation of the biological solids from treated wastewater is a very important factor to operation of activated sludge. Some of suspended organic particles and colloidal material would not be well separated from treated wastewater when filamentous growth occurs in the aeration tank. The most notable problem is due to the filamentous organisms which comes a sludge bulking. In this project, a new attempt was made to improve soluble organic removal efficiency as well as sludge separation by a process compromized between suspended growth process and fixed film process. In this process, soluble organics were removed by suspended activated sludge as well as biological fixed films and these two processes occurred simultaneously in one tank. As activated sludge process, SBR system which has relatively good sludge settling characteristics was employed. For fixed film process, rotating biological disk which is submerged in wastewater was employed. These two systems were combined together and the combined system was operated as a sequencing batch reactor mode. The submerged rotating disks provided shear force to the disk surface and tubulence to the mixed liquor named as BS-SBR. The objective of this experiment was to determine effects of BS-SBR compared with SBR on the removal of soluble organics and sludge separation.

II. MATERIALS AND METHODS

1. Materials

1.1. Sequencing Batch Reactor(SBR)

The SBR was made of clear plexiglass with thickness of 0.25″. The size of reactor was H11″, L12″, W1.375″. The filled reactor volume was 2 ℓ. There were two baffles spaced at equal intervals from side walls. The aeration apparatus consisted of two L12″, Ø0.12″ glass tubes ending in two diffuser stones aerator which had maximum air flowrate of 10 ft^3/hr. A mixing was provided by the aeration and two baffles. A 2 ℓ bottle was used as an influent feed reservoir. The influent flow rate was controlled by feeding control valve.

1.2. BioShear-Sequencing Batch Reactor(BS-SBR)

The difference between BS-SBR and SBR is only rotating disk system added in SBR. Rotating disk system consisted of 5 disks, Ø4.7″, stainless steel sprockets, stainless chain, steel rods coated with polyurethane to prevent from rust. The inside surfaces of front and rear disks and middle disk were overlapped. Overlapped portion of disk was about 30% of surface area. These overlapped portion provided a shear force to disk surface when disks were rotated. The distances between disks were all 0.25 inch. The top of disks was submerged about 2.5″ below the water level. Mixing was provided by aeration and rotating disks. Sketches of the BS-SBR were shown in Figure 1.

2. Experimental method

2.1. Start up operation

In order to build biological films on rotating disks, BS-SBR was operated as Rotating Biological Contactor mode for a week. During this period, 500mℓ of synthetic wastewater(1000mg/ℓ COD) was fed per day, no aeration was provided, and rotating velocity was 48.8 rpm. After a week, a visible biological film was formed on the disk surface.

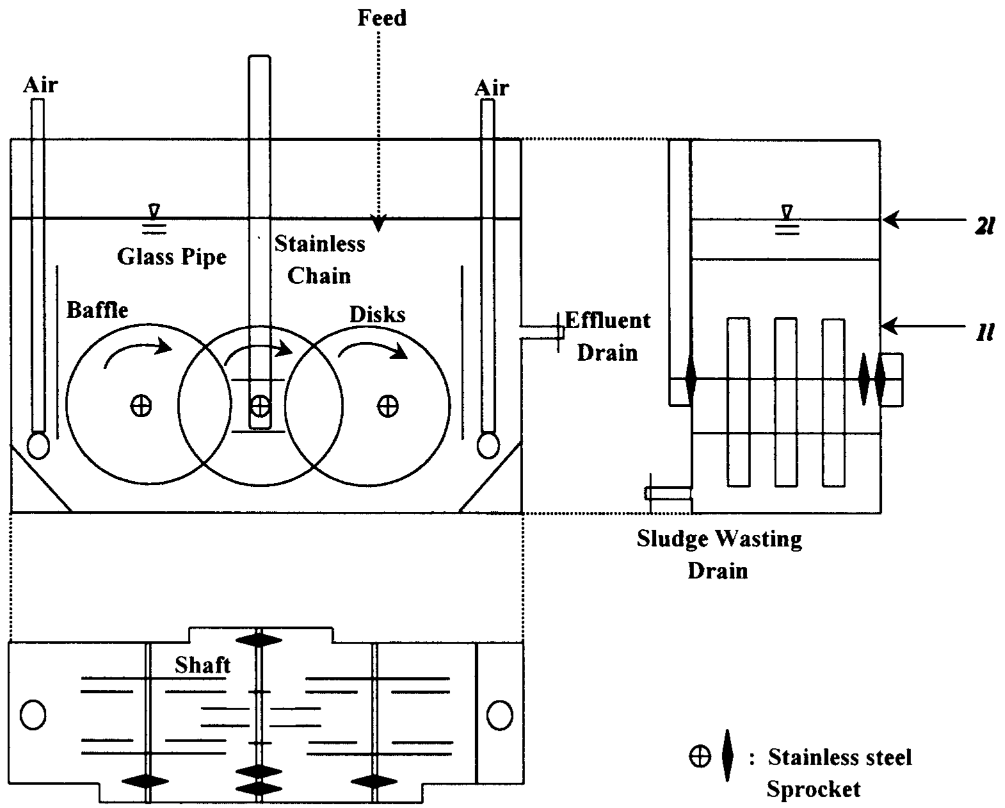

Fig. 1. Configuration of BS-SBR

2.2. Operating system

The SBR system in our experiment has four periods in a one cycle. The periods were 1)React 2)Settle 3)Draw 4)Fill. The first period is react. Twenty three hours a day were given for react in one cycle, and twenty one hours in three cycle. During the react, reactor was aerated and completely mixed by full aeration(10 ft^3 /hr). After react, aeration was shut off for settling. During the fill period, the reactor was reaerated. 1 ℓ of the substrate was filled with even influent flow rate and mixed with activated sludge for solid/liquid contact and uptake of soluble BOD. In the Fill period, it is important to decide the filling time of substrate. We provided 15 minutes, very short fill period or high influent flow rate, for fill period. A high influent flow rate should produce substrate concentration gradient in a plug-flow system. BS-SBR was operated as the same mode and methods with SBR except for the operation of submerged rotating disk.

2.3. Monitoring Parameters

The following parameters were measured during BS-SBR and SBR operation : SS, VSS, Effluent Total and Soluble COD, Influent Total COD, Turbidity, Absorbance, MLSS, MLVSS, pH, SVI, DO. At the last day of the low loading and high loading operation, the Soluble COD reduction during the react period was determined with proper time intervals. Samples were taken from the reactor for pH, SVI, MLSS, and MLVSS measurement at the end of the react period. Total COD, Soluble COD, Turbidity, Absorbance, SS, and VSS were measured from the effluent draw period. In three cycles per day operation, the samples were taken at the second cycle.

2.4. Operating Condition

The BS-SBR and SBR operation were designed to one cycle per day and three cycles per day which were about F/M ratio 0.25 gr-COD/d/gr-MLSS as a low loading and 0.75 gr-COD/d/gr-MLSS as a high loading. Because of difficulties in maintaining the exact MLSS concentration, the actual F/M ratio for SBR was 0.265 gr-COD/d/gr- MLSS in the low loading and 0.619 gr-COD/d/gr-MLSS in the high loading. Actual F/M ratio for BS-SBR was 0.253 gr-COD/d/gr-MLSS and 0.626 gr-COD/d/gr-MLSS in low loading and high loading, respectively. The Temperature of laboratory was 23±2℃ and all same environmental conditions were provided to both SBR and BS-SBR.

The operated condition was shown in table 1.

Table 1. Operated Condition

Parameter \ Loading	Low loading(1-cycle/d)		High loading(3-cycle/d)	
	SBR	BS-SBR	SBR	BS-SBR
F/M(gr-COD/d/gr-MLSS)	0.262	0.253	0.619	0.626
MLSS(mg/ℓ)	1940	2012	2796	2766
MLVSS(mg/ℓ)	1589	1652	2286	2244
pH	6.7	7.0	6.8	7.0
Influent COD(mg/ℓ)	1017	1017	1154	1154
DO(mg/ℓ)	6.0	5.7	5.8	5.3

Table 2. Total and Soluble COD (mg/ℓ)

Run \ cycle/d	1-cycle/day		3-cycle/day	
	T-COD	S-COD	T-COD	S-COD
SBR	82.5	54.9	85.0	50.5
BS-SBR	52.0	31.6	43.3	35.0

III. Results and Dicussion

1. Total and Soluble COD

Over 90% of the influent COD was removed in both run. The highest removal was observed in BS-SBR operated in the high loading. The following percent removal of T-COD were obtained from operation : 92% for SBR in 1-cycle and 3-cycles, 95% for BS-SBR in 1-cycle, 96% for BS-SBR in 3-cycle. The T and S-COD removal by BS-SBR process was better than by SBR process. Averaged effluent T and S-COD were shown in table 2. The daily effluent T and S-COD for SBR and BS-SBR during experiments were plotted in Figure 2.

The lowest effluent COD was observed in BS-SBR of 3-cycle. The percent removal of soluble COD were as follows: 95% for SBR in both cycles, 97% for BS-SBR in both cycles. The daily effluent soluble CODs were plotted in Figure 2.

2. Suspended and Volatile Suspended Solid (SS and VSS)

The BS-SBR process was very efficient for SS removal. Especially in a high loading, SS removal was excellent and the effluent was very clear. The averaged SS concentrations for BS-SBR were 4.8mg/ℓ in 1-cycle and 6.5mg/ℓ in 3-cycle operation over the operation period, the daily SS values for BS-SBR in both cycles were consistently below 10mg/ℓ.

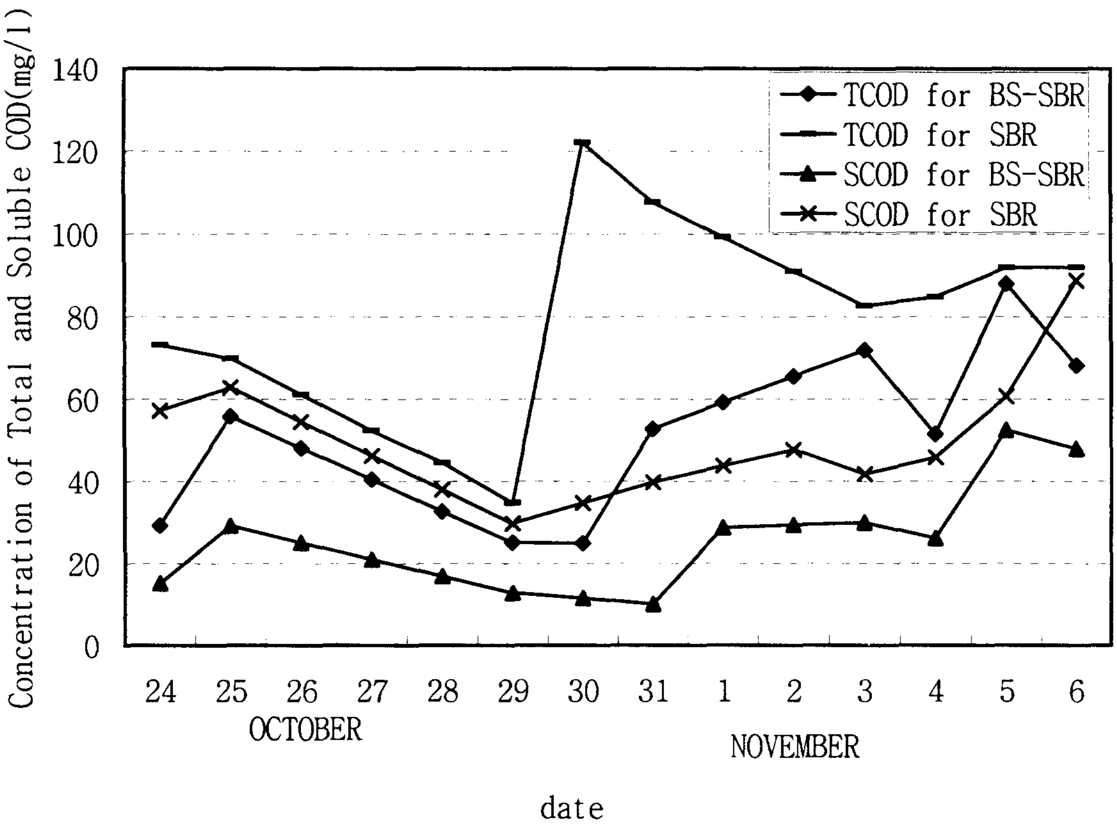

Fig. 2. TCOD and SCOD Profiles for BS-SBR and SBR during 1-cycle/d Operation.

The values were ranged from 4.0 to 8.3 mg/ℓ in the low loading and 4.2 to 5.4 mg/ℓ in the high loading. The effluent SS concentrations for SBR was relatively higher than for BS-SBR. The averaged values were about 27 mg/ℓ in 1 and 3 cycles operation. The daily SS values for SBR were ranged from 11.5mg/ℓ to 35.5mg/ℓ in the low loading and 11.5mg/ℓ to 46mg/ℓ in the high loading. The effluent SS in the SBR operation were not consistent and fluctuated during the operation. The percent of volatile suspended solid to suspended solids in 3 cycle were about 85% and 77% for BS-SBR and SBR, respectively. The daily effluent SS concentrations were plotted in Figure 3.

3. Sludge Characteristics

During the operation, significant differences in the sludge characteristic were observed and BS-SBR showed an excellent sludge settling characteristics. The sludge, dark brown, was well flocculated and similar to the fixed film humus described in the literature review. And its floc size was visible larger than the SBR's and compacted well on the bottom. During the settle period, the

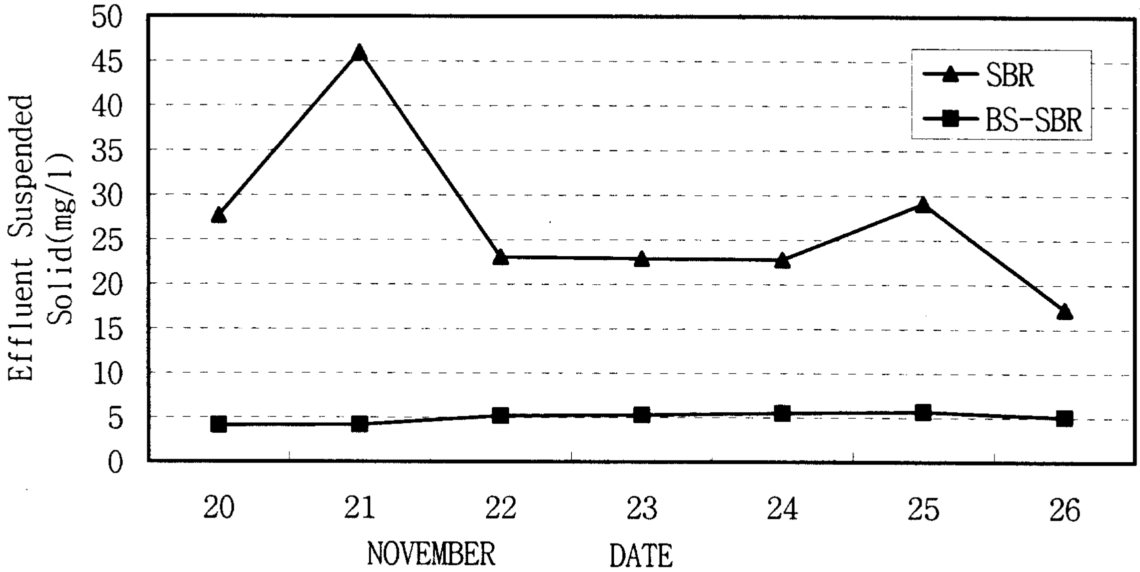

Fig. 3. Effluent SS Profiles for BS-SBR and SBR during 3-cycle/d Operation

interface between solids and supernatant was well defined and very clear supernatant was left above the interface.

4. Absorbance

In both cycles, the averaged effluent absorbances for BS-SBR were lower than for SBR. For both reactors, effluent absorbances in the high loading were lower than in the low loading. The percent transmittances corresponding to absorbances were calculated as 76.7% and 80.5 for SBR in 1 and 3-cycle, and 83.5% and 86.1% for BS-SBR in 1 and 3-cycle, repectively. The effluent absorbance was associated with effluent suspended solid concentration and turbidity. The absorbed absorbances during the operations were plotted in Figure 4.

5. Soluble COD reductions during the react period.

During the react period, the S-COD reduction was determined with proper time intervals. The influent COD was 1198.5 mg/ℓ in 1 cycle and 1180.7 mg/ℓ in 3-cycle operation. The first determination of S-COD was made at the end of the fill period, or beginning of the react period. During the fill period, the S-COD was rapidly removed. The removal rates during this period were as follows : 74% for both reactors in 1-cycle, 66% for SBR in 3-cycle, 73% for BS-SBR in 3-cycle. For 75 min. from the start of the fill period, the removal rates of initial influent COD were as follows: 89% and 83% for SBR in 1 and 3-cycle, and 90% and 94% for BS-SBR in 1 and 3-cycle, repectively. The

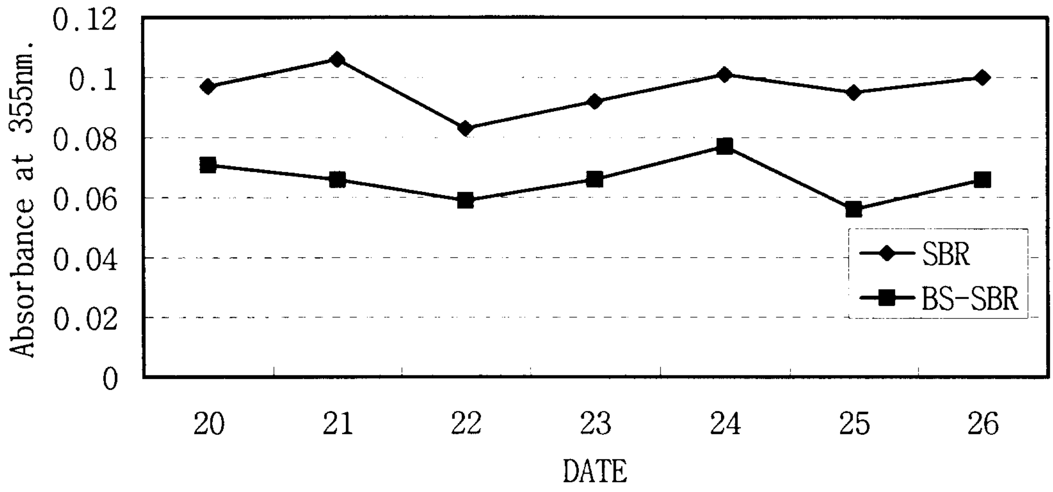

Fig. 4. Absorbance at 355nm. for BS-SBR and SBR during 3-cycle/d Operation

most rapid reduction during the 75 min. occurred in BS-SBR 3-cycle. After the 75 min. the soluble COD for in both cycles and BS-SBR in 1-cycle were removed gradually and then reached end value, however, the soluble COD for BS-SBR in 3-cycle was almost not removed and the values were stuck in around 65 mg/ℓ for 2-hour. After these 2-hour, the COD was dropped rapidly again and reached end

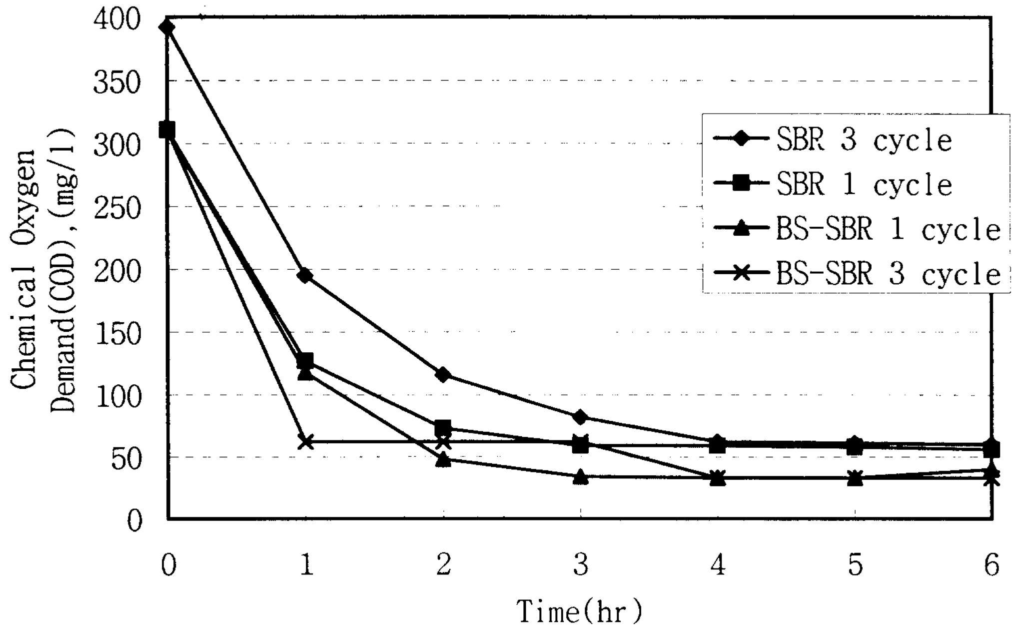

Fig. 5. Soluble COD Reduction for BS-SBR and SBR during the Reaction Period.

value, about 29 mg/ℓ.

The different COD removal behavior for BS-SBR in 3-cycle shown above, could be reasoned by adsorption of S-COD due to the fixed film on rotating disks. In the Figure 5, if the adsorption contributed to the rapid COD drop during the time interval between 0 and 1-hour, and the S-COD material was adsorbed on the biological film up to the its adsorption capacity, no more extraction of S-COD matter from the liquid might be occurred during the time interval between 1 and 3-hour.

At the point of 1-hour, the COD for BS-SBR in 3-cycle was almost same with the end value for SBR in 3-cycle, so that it could be meant that in BS-SBR, there was no significient COD removal by activated sludge during the time interval between 1 and 3-hour. As the adsorbed material was assimilated, the adsorption might be reoccurred during the time interval between 3 and 4-hour.

Ⅳ. CONCLUSION

1. The removal efficiency of S-COD in the BS-SBR, approximately 97% in 1 and 3-cycle/d operations, was higher than for SBR.
2. The BS-SBR process was very efficient for suspended solids removal. The averaged values were 7.5mg/ℓ in 1-cycle/d operation and 4.8mg/ℓ in 3-cycle/d operation.
3. The sludge, dark brown, floc size was visible larger than the SBR's. During the settle period, the interface between solids and supernatant was well defined and very clear supernatant was left above the interface.
4. The BS-SBR process was very efficient for SS removal. The averaged SS concentration of effluent were 4.8mg/ℓ over the operation period, the daily SS values were consistently below 10mg/ℓ in both of 1 and 3-cycle a day.
5. The percent transmittances corresponding to absorbances were calculated as 76.7% and 80.5% for SBR in 1 and 3-cycle, and 83.5% and 86.1% for BS-SBR in 1 and 3-cycle, respectively.

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