

Efficiency of Wastewater Treatment Under Electric Field Forming in Bioreactor

Na Byung Kwan, Yoo Yung Sun¹, Sang Byung In² and Park Doo Hyun[†]

Department of Biological Engineering, Seokyeong University, 16-1, Jungneung-dong, Sungbuk-gu, Seoul 136-704

¹*Department of Applied Chemistry, Seokyeong University, 16-1, Jungneung-dong, Sungbuk-gu, Seoul 136-704*

²*Division of water environment and remediation KIST, Hawolgok-dong, Sungbuk-gu, Seoul 136-791, Korea*

Biological wastewater treatment efficiency was compared between under normal environment and under electric field forming in bioreactor. The variation of electric charge forming in electric field between anode and cathode was applied to the wastewater treatment. The electric charge variation was assumed to be a good signal for the bacterial metabolism or activator for bacterial growth. On the basis of this propose, the wastewater treatment system with electric field was designed and tested. The COD consumption, MLSS, HST and SV₃₀ were positively influenced by the charge variation forming in the electric field but TN and TP were not influenced. The electric field forming in the bioreactor for wastewater treatment is thought to be a good signal or an activator for microorganisms living in the wastewater.

Key words: electrode-sensor, modified electrode with metal ion, electrochemistry

1. Introduction

Microbiological wastewater treatment has been dependent on the microflora inhabited in water with high concentration organic compounds.¹⁰⁾ This system is much more safety than the chemical treatment system and does not produce the source for the secondary contamination after treatment.⁴⁾ However, the efficiency of biological treatment is not stable and is lower than that of chemical treatment.⁵⁾ Various systems have been developed for the improvement of biological wastewater treatment efficiency. The rotating biological reactor, filter media, blanket media, fiber media and floating media were applying to the biological treatment system.^{3,7,11)} The baffled reactor was reported to be effective for dye and food waste.⁹⁾ The success of biological wastewater treatment is to a large extent governed by the ability of bacteria to induce metabolic activation, thereby facilitating the consumption of organic compounds from the wastewater.¹²⁾ The bacterial activity was affected by the continuous variation of environment surrounding of bacterial cell in

a way that strongly suggests that the electrochemical stimulation can activate the bacterial metabolism.⁸⁾ At environment standing the electric field, bacterial metabolism may be influenced by the positive and negative charged compounds, and at condition with continuous changed charges the bacterial growth may be inhibited by the fluctuating variation of signals. The increasing electrolytes concentration was reported to make bacterial flocks stable.^{1,6)} Most of bacterial cell under environment with abundant organic compounds have to produce more energy for overcoming the inhibition factors. In this research, we tested and compared the wastewater treatment efficiency under electric field forming bioreactor.

2. Experimental

2.1. Bioreactor

The bioreactor was creatively designed and made in our laboratory as shown in Fig. 1. The electric voltage between anode and cathode in the reactor was adjusted to DC 4 volt or DC 8 volt and the reactor with electrode

[†]To whom correspondence should be addressed.

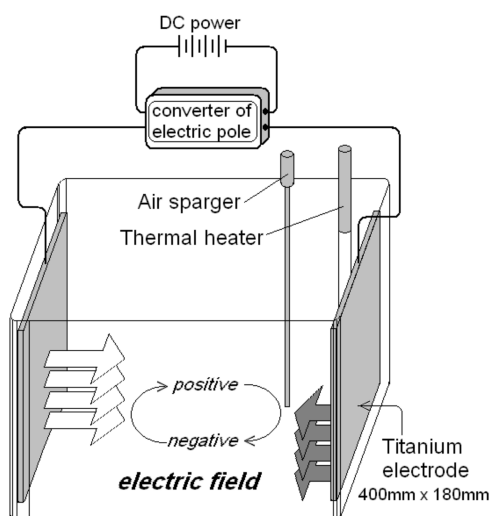


Fig. 1. Schematic structure of bioreactor with electrodes, by which electric field was constructed between two electrodes. The electric pole was periodically converted from negative to positive or from positive to negative at interval of 15 min. The distance between two electrodes was 320 mm and depth of reactor was 400mm. Reactor volume, aeration speed and temperature were adjusted to 18 liter, 15 liter per minute and 20°C, respectively. The charged chemicals may move through the electric field from anode to cathode or reverse direction.

but without supply of electric energy was used as a control. The description about operation condition was explained in figure legend. The bacterial seed was obtained from the Jungnang terminal wastewater treatment plant located in Jangan-dong, Dongdaemungu, Seoul, and wastewater was made in laboratory by mixing of 5 g/L soluble starch, 5 g/L soy protein concentrate, 5 g/L yeast extract and trace mineral.

2.2. Measurement of COD

Chemical oxygen demand was measured with HAAK (DR-2100 model, German) COD measurement system and reagent, all procedure for pretreatment of samples was being done in accordance with Standard Method.²⁾

2.3. Measurement of TN

Total nitrogen concentration was measured with HAAK (DR-2100 model, German) TN measurement system and reagent, all procedure for pretreatment of samples was being done in accordance with Standard Method.

2.4. Measurement of TP

Chemical oxygen demand was measured with HAAK (DR-2100 model, German) TP measurement system and reagent, all procedure for pretreatment of samples was being done in accordance with Standard Method.

2.5. Measurement of MLSS

Mixed liquor suspended solid was measured by standard method.

2.6. Measurement of half sedimentation time (HST)

The sample isolated from bioreactor put in 1000 ml of mass cylinder and then the time for precipitation of half volume of flocks was measured. This is similar to the SV₃₀ but more comfortable and useful for measurement of agglutination of suspended solid.

2.7. Measurement of SV₃₀

Sediment volume precipitated for 30 min was measured by the standard method.

2.8. Measurement of micro-particles in supernatant after sedimentation for SV₃₀

The micro-particles suspended in the supernatant over the sludge (SV₃₀) were spectrophotometrically measured at 660 nm as an optical density.

3. Results and Discussion

The continuous variations of environmental factors, such as temperature, ionic strength, salt concentration and concentration of charged ionic compounds, can act as a signal. The some signals are possible to stimulate or others are possible to inhibit the bacterial growth. Generally, the bacterial growth has to be activated under environment with growth factor and good signals, by which the bacterial mass can be increased and substrate consumption has to be increased. And the inhibitors or bad signals can influence on the bacterial growth, by which, however, the bacterial metabolism for oxidation of substrates may be activated for production of more energy. Inhibitory factors except the antibiotics

can suppress the bacterial growth but not killed. Some ionophore was reported to make bacterial cell consuming more energy for overcoming effects of the inhibitory factors. We operated the bioreactor for wastewater treatment for 25 days and added fresh substrates to the reactor two times more after starting the operation at 4th and 14th day. As shown in Fig. 1, the COD consumption was more decreased under electric field forming in the bioreactor than in control reactor. This shows that the ionic charge variation in the electric field can activate bacterial metabolism or bacterial growth. As

shown in Fig. 3, the MLSS was higher under the electric field forming in the bioreactor with the electrode. This is a clue that the bacterial growth was activated under electric field and the increased biomass makes increasing the substrate consumption efficiency of bacteria. We did not expect that the TN and TP were decreased in the bioreactor with and without electric field because this system was operated under strict aerobic condition. Under constant aerobic condition, the bacteria cannot do the anaerobic respiration with nitrate as an electron acceptor. As shown in Fig. 4 and Fig. 5,

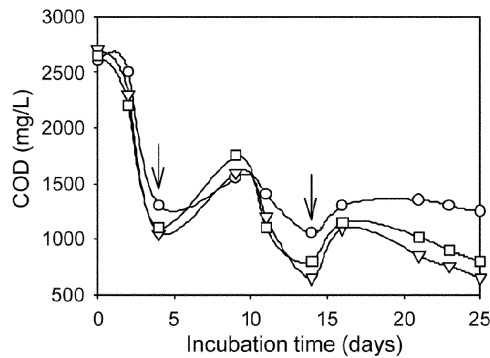


Fig. 2. COD variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

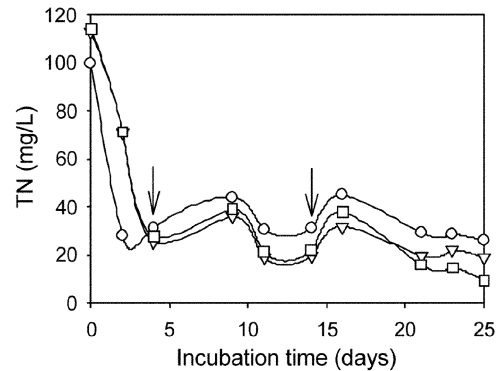


Fig. 4. Total nitrogen variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

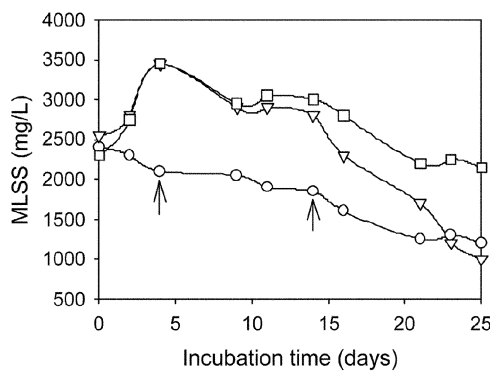


Fig. 3. MLSS variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

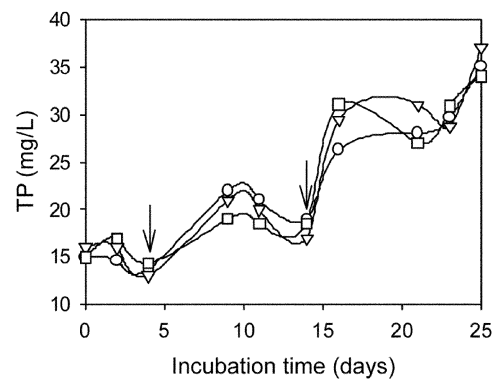


Fig. 5. Total phosphorus variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

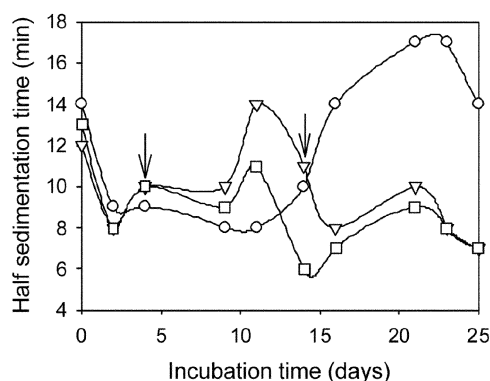


Fig. 6. HST variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

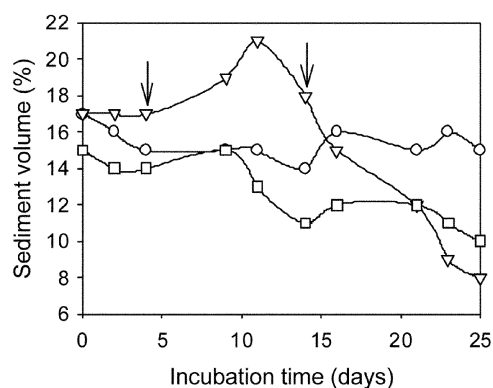


Fig. 7. Sediment volume variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes after the MLSS was precipitated. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

the TN and TP were not different between reactors with electric field and without electric field. This is a rational result, which has been expected from the time when the reactor was designed. However, the half sedimentation time and SV_{30} were influenced by the electric field forming in the bioreactor. As shown in Fig. 6 and Fig. 7, the formation of flocks and sedimentation time was activated and decreased, respectively, under electric field forming in bioreactor. The sedimentation efficiency was measured by optical density of supernatant

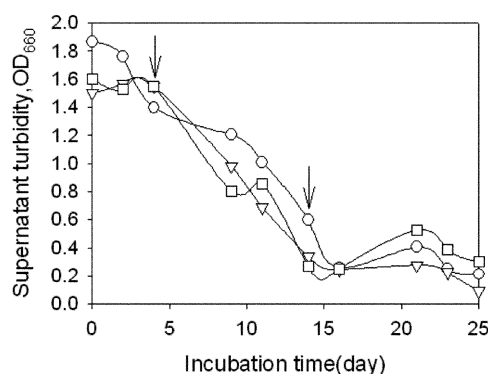


Fig. 8. Supernatant turbidity variation of wastewater being treated in the fed-batch type bioreactor without electric field (○), with 4 volt electric field (▽) and 8 volt electric field (□) between two electrodes after MLSS was precipitated. The arrow marks indicate that new substrate was added to the reactor that is a fed-batch system without removal of products.

after sludge was precipitated. As shown in Fig. 8, the optical density was continuously decreased in proportional to the reaction time. It shows that the wastewater treatment efficiency is getting better in the course of reaction for a long time. Totally, the treatment efficiency of wastewater under electric field is similar to the value we expected before operation.

4. Conclusion

The ionic charge variation forming in electric field between anode and cathode can activate the bacterial growth, substrate consumption, sludge formation and sedimentation of sludge. The ionic charge did not inhibit the bacterial growth and metabolism but was confirmed to active the bacterial wastewater treatment.

Acknowledgements

This research was supported by the Core Environmental Technology Development Project for Next Generation (project No. 2003-1001-0005-1) of Korea Institute of Environmental Science and Technology.

This research was supported by a grant No. R01-2003-000-10563-0 from the Basic Research Program of the Korea Science & Engineering Foundation.

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