別紙様式８

研　究　主　論　文　抄　録

論文題目　　Electricity and hydrogen generation by two-chamber microbial fuel cell and microbial electrolysis cell

（二槽式微生物燃料電池と微生物水電解セルによる電気エネルギーおよび水素ガスの生成に関する研究）

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主論文要旨

A microbial electrochemical cell (MXC) provides social benefits by using reactions by anode-respiring bacteria to produce electrical current from the oxidation of organic compounds at an anode. MXCs include two important approaches for bioenergy generation from organic streams: microbial fuel cells (MFCs) for producing electricity and microbial electrolysis cells (MECs) for producing hydrogen. This is a quite interesting technology in wastewater treatment, because it can recover energy directly from organic compounds in wastewater.

In my dissertation, I studied the effects of type of membrane, temperature and other abiotic factors on energy generation from wastewater by using MFC system and MEC system. The main results of my study can be attributed as follows:

The one of issues on MFC reactor is the characteristics and performance of ion-exchange membrane between anode and cathode. In the first part of this study, MFC performance and bacterial community were investigated with three types of ion-exchange membranes by sequential batch experiments. Maximum voltages were obtained at the same level in all the MFC reactors by using two proton-exchange membranes (PEMs) and a conventional cation-exchange membrane (CEM). Coulombic efficiency (CE) was also comparable between them although it was slightly higher in the reactor with CEM than PEMs. A little difference was observed in bacterial community of the biomass on anodic electrode between each MFC reactor and contribution of *Lactococcus* species to

MFC performance was suggested in this part study.

In the second part of this study, MFC performance and bacterial community were weighed at different temperatures. Experiments were carried out in two-chamber reactors with three different types of ion-exchange membranes which were investigated in the first part of this study. The maximum voltage and CE were comparable between the MFCs by using different types of membranes at the temperatures of 23, 28 and 33 °C. However, the MFC performance with a CEM was a little higher than with two types of PEMs at 28 and 33 °C. The DNA-band pattern on denaturing gradient gel electrophoresis (DGGE) for the biomass attached to the anode electrode varied according to the temperature and the types of membranes, however, the definite relationship between the bacterial community and the temperature was not found.

In the third part of this study, based on the evaluation indexes of output voltage, CE, power density and total organic carbon (TOC) removal rate of MFCs, three abiotic factors (anode size, membrane and membrane size) were investigated with an orthogonal experiment (L_4 (2^3)). The results showed that the impact order of factors through analyzing the value "R" was "anode size > membrane > membrane size". The optimal set with these three factors for the performance of MFCs was: big size anode, Naf-117 and big size membrane. Meanwhile, the high TOC removal rate (more than 90%) and high acetates consumed rate (100%) showed the MFCs had strong ability of wastewater treatment.

In the fourth part of this study, I aimed to produce hydrogen gas by using two-chamber MECs, which were altered from two-chamber MFCs. Two PEMs and a conventional CEM which had been tested in the first part of my study were investigated in MECs. Hydrogen gas can be acquired with two PEMs at an applied voltage of 0.8, 1.0 and 1.4 V, meanwhile hydrogen production was also found with CEM Yumi-28 at an applied voltage of 1.0 and 1.4 V. The maximum overall hydrogen recovery efficiency and total energy recovery efficiency was 25% and 30%, respectively in this part of study. TOC removal rate has been steady about 90% with these three types of membranes at each applied voltage, and acetate was consumed completely in all experiments. The ability of wastewater treatment with MECs was confirmed by these results.

The successful application of MXCs technology with different types of membranes, temperature and other abiotic factors would provide the theoretical foundation and operating experience for industrial applications.