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MICROBIAL DIVERSITY AND POPULATION DYNAMICS OF ACTIVATED SLUDGE MICROBIAL COMMUNITIES PARTICIPATING ELECTRICITY GENERATION IN MICROBIAL FUEL CELLS

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Activated sludge microorganisms are known to generate electricity in MFCs (microbial fuel cells) by transferring electrons from an electron donor to an electron acceptor. Although microbial ecology factors such as diversity and community structure may influence the stability and efficiency of electricity generation in MFCs, little is known about microbial ecological information when activated sludge is seeded for MFCs. In this study, we performed microbial community analysis to examine microbial diversity and community structure in MFCs seeded with activated sludge from a municipal wastewater treatment plant in Korea. Because anode-attached biofilm populations are particularly important in electricity transfer, the microbial ecology characteristics of anode-attached biofilm microbes were explored and compared with those of suspended-growth microbes in an anode chamber. In laboratory, MFCs was operated in a fed-batch mode.

An anode and a cathode were separated in each transparent polyacrylic plastic bottle. To transfer protons, a proton exchange membrane was installed between the anode and cathode bottles. As an electron donor glucose (1000 mg COD/L) was dosed to the anode bottle. To enhance the transfer of electrons from the cathode to water, glucose (500 mg COD/L) and oxygen (via air) were provided to the cathode bottle. After biofilm formation became stabilized, the fuel cell system generated 21.34 mW/m2 of power density, which is typical in MFCs seeded with activated sludge. For microbial diversity measurement, T-RFLP (terminal-restriction fragment length polymorphism) analysis was conducted with 16S rDNA primers (27F-FAM and 1492R) and two restriction enzymes (HhaI and MspI). The degree of bacterial diversity was estimated using Shannon-index, Richness, and Evenness indices.

For determining microbial community structure, bacterial 16S rDNA were amplified (with 27F and 1492R primers), cloned (TA-TOPO cloning kit), and sequenced. For phylogenetic analysis, web-based softwares such as CLUSTALW (EBI) and CLASSIFIER (RDPII) were used. T-RFLP analysis showed that the degree of diversity in anode-attached biofilm is higher than those for the suspended-growth microbes in the both anode and cathode bottles. Although the diversity of anode-attached biofilm did not significantly change compared to that of the original activated sludge, the community structure of biofilm was shifted from the original activated sludge. In the anode biofilm community, Clostridia, Bacteroidetes, OP10, OP11, and Spirochaetes were populations that preferentially grew during the electricity generation. In suspended-growth communities, unclassified bacteria were dominant increased for the both anode and cathode samples, compared to the biofilm community as well as the original activated sludge. Because anode biofilm populations actively participate in electron transfer on an anode, the high degree of diversity in the biofilm may have positive effects in the performance stability of MFCs. In addition, the community structure results suggest that stimulating the biofilm specific populations in an anode may be helpful in enhancing the efficiency of electricity generation.

Keywords: MFC, microbial diversity, microbial community structure