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Application of conductive polymers in biocathode of microbial fuel cells and microbial community

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ABSTRACT

Four kinds of conductive polymers, polyaniline (PANI) and its co-polymers poly (aniline-co-o-aminophenol) (PANOA), poly (aniline-co-2, 4-diaminophenol) (PANDAP) and poly (aniline-1, 8-diaminonaphthalene) (PANDAN) were applied to modify carbon felts as the aerobic abiotic cathodes and biocathodes in microbial fuel cells (MFC). Compare to unmodified, all the four polymers can significantly improve the power densities for both abiotic cathodes (increased by 300%) and biocathodes (increased by 180%). The co-polymers with different functional groups introduction had further special advantages in MFC performance: PANOA and PANDAP with –OH showed less sensitivity to DO and pH change in cathode; PANDAP and PANDAN with $-NH_3$ provided better attachment condition for biofilm which endowed them higher power output. With the help of conductive polymer coats, the cathode biofilm became thicker, and according to biodiversity analysis, the predominated phyla changed from β-*Proteobacteria* (unmodified) to α, γ-*Proteobacteria* (modified), which may be responsible for the superiority of the modified MFCs.

1. Introduction

Microbial fuel cell (MFC) was recognized as a promising method of wastewater treatment since they use microorganisms as the catalysts to convert the chemical energy directly into electricity power. However, the poor cathodic oxygen reduction rate, which is considered as the major limiting factor for power generation, hinders the practical application of MFC. In order to decrease the high cathodic overpotential, biocathode, which applies bacteria as the catalysts, was raised and had gained great interests for its low cost and sustainability (Clauwaert et al., 2007).

Cathode material is known to be an important factor for all sorts of cathode in MFC (Wei et al., 2011), including biocathode, since it plays a key role for the oxygen reduction and the biofilm formation. Therefore, to find superior cathode materials is a crucial problem, and is attracting more attentions.

Various materials for biocathode had been investigated. Clauwaert et al. (2007) treated the graphite felt cathode with manganese oxides to decrease the MFC startup period by 30% versus a non-treated one. You et al. (2009) used graphite fiber brush with high specific area as biocathode to increase the amount of biomass, which gained power density of 68.4 W/m^3. Zhang et al. (2011) applied graphite fiber brush together with graphite granules as biocathode, which could shorten the startup time and increase the power output comparing with the individual. Carbon nanotube/chitosan nanocomposite was used as biocompatible biocathode material by Liu et al. (2011) to improve power density by 130% compare to the unmodified cathode.

Conductive polymer polyaniline (PANI), was widely used in electronics, due to its high conductivity at room temperature and environmental stability. Some new co-polymer materials based on PANI such as poly (aniline-co-o-aminophenol) (PANOA), poly (aniline-co-2, 4-diaminophenol) (PANDAP) and poly (aniline-1, 8-diaminonaphthalene) (PANDAN) had been gradually synthesized, and these functional groups introduction can change the characteristics of primary PANI, which also endowed these co-polymers excellent performance in electrochemistry research (Mu, 2004; Li et al., 2011a).

Taking into account that PANI and its co-polymers have the ability of catalytic oxidation of oxygen and good biocompatibility (Khomenko et al., 2005), these materials seem to have the potential to improve the biocathode in MFCs.

Moreover, the biofilm on electrode is another crucial factor for the MFC performance. And the various electrode materials also influence the biofilm activities and the potential of attachment surface. However, electrode-oxidation bacteria which can catalyze cathodic reductions in cathode biofilm are rarely studied, and the information on the electron transfer mechanisms for biocathode is limited (Lovley, 2008).

In our previous study (Li et al., 2011b), conductive polymer modified anodes were prepared and their biodiversity were

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