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Degradation of algal organic matter using microbial fuel cells and its association with trihalomethane precursor removal

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ABSTRACT

In order to provide an alternative for removal of algal organic matter (AOM) produced during algal blooms in aquatic environment, microbial fuel cell (MFC) was used to study AOM degradation and its association with THM precursor removal. The chemical oxygen demand (COD) removals in MFCs were 81 ± 6% and 73 ± 3% for AOM from *Microcystis aeruginosa* (AOM_M) and *Chlorella vulgaris* (AOM_C), respectively. THM precursor was also effectively degraded (AOM_M 85 ± 2%, AOM_C 72 ± 4%). The major AOM components (proteins, lipids, and carbohydrates) were obviously removed in MFCs. The contribution of each component to the THM formation potential (THMFP) was obtained based on calculation. The THMFP produced from soluble microbial products was very low. If the energy input during operation process was not considered, MFCs treatment could recover electrical energy of 0.29 ± 0.02 kWh/kg COD (AOM_M) and 0.35 ± 0.06 kWh/kg COD (AOM_C).

1. Introduction

In China, approximately 43.3% lakes and reservoirs have reached the mesotrophic/eutrophic state. Most of eutrophic freshwater lakes (e.g., Dianchi Lake, Taihu Lake and Chaohu Lake) are still used as the water supply for the surrounding urban and rural areas, because of a serious shortage of water (Liu and Qiu, 2007). During algal bloom seasons, algal concentration increases hundreds of times and the highest algal cell density can reach 10^9 cells per liter. Large quantities of algal organic matter (AOM), including algal intracellular and extracellular organic matter, is released into the aquatic environment resulting in water quality deterioration and an increase of disinfection by-products (DBPs) precursor (Nguyen et al., 2005). This is directly related to the safety of drinking water. The odorous tap water accident occurred in Wuxi City in 2007 was attributed to a bloom of *Microcystis aeruginosa* in Taihu Lake (Zhang et al., 2011). It's necessary to develop pretreatment technologies to reduce AOM quantity before conventional processes when AOM was in a high concentration.

Microbial fuel cells (MFCs) have been recently developed as a bioelectrochemical technology for generating electricity while simultaneously treating waste organic matter. In MFCs, electrochemically active bacteria oxidize organic matter to transfer electrons to an anode, while releasing protons into the solution. These electrons flow through a circuit to a cathode, where they combine with protons and oxygen or other chemicals, such as ferricyanide (Logan et al., 2006). The greatest benefit of using MFCs is the electrical energy recovery, which can partly offset the operation and energy costs of the treatment processes. An additional benefit is that the microorganism in MFCs can utilize various types of substrates, including carbohydrates, proteins, lipids, alcohols, organic acids, hydrocarbons and a variety of complex wastewaters (Pant et al., 2010). Bioelectrochemical degradation of organic materials using MFCs demonstrates different metabolic processes with conventional aerobic or anaerobic treatment (Pham et al., 2006). Electrochemically active bacteria can not only completely oxidize fermentable compounds, such as sugar or amino acids, to CO_2 with the electricity generation, but can also further metabolize the fermentative products (e.g. organic acids) that cannot be used by fermentative bacteria to CO_2 with the current production (Lovley, 2006). Because substrates are more completely degraded and most substrates are converted to current rather than biomass (Logan, 2009), MFCs also have the advantage of producing fewer soluble microbial products compared to conventional aerobic treatment (Rabaey et al., 2003).

In previous study, Velasquez-Orta et al. (2009) have tested the algae as a possible plentiful and sustainable biomass (Hulatt and Thomas, 2010) for electricity production in MFCs in laboratory scale. It is conceivable that MFCs can be applied as a cost-effective and energy-efficient biological pretreatment, in combination with conventional water treatment procedures, for AOM degradation. Previous studies have focused primarily on bioelectricity production

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