Characterizing the snorkeling respiration and growth of *Shewanella decolorationis* S12

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**A B S T R A C T**

Microbial electrochemical snorkel (MES) reactor is a simplified bioreactor based on microbial fuel cells (MFCs) and has been suggested to be a promising approach to solve many environmental problems. However, the microbial processes in MES reactors have not yet been characterized. This study shows that *Shewanella decolorationis* S12 can use the conductive snorkel as direct electron acceptor for respiration and growth. Similar with current-generating biofilms, cellular viability in MES biofilms decreased with the distance from snorkel. MES reactors showed more rapid cell growth and substrate consumption than MFCs. Although the biomass density of MES biofilm was higher than that of anode biofilms, the current-generating capacity and electrochemical activity of MES biofilm were lower, which could be attributed to the lower cytochrome c expression in MES biofilm caused by the higher redox potential of MES. These microbiological and electrochemical properties are essential for the further development of MES reactors.

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**HIGHLIGHTS**

- Shewanella growth and lactate removal in MES reactor are rapid than that in MFC.
- MES biofilms have lower current-generating and electrochemical activities.
- The high potential of MES suppresses cytochrome c expression.

**1. Introduction**

Microbial anaerobic respirations are ubiquitous in subsurface environments (e.g., sediments and soils) and play crucial roles in various geochemical cycles and bioremediations. Many extracellular electron transfer strategies, such as outer-membrane cytochrome c (OMCs), endogenously secreted electron mediators and conductive pilus, have been evolved by some microorganisms to use electron acceptors that are insoluble or inaccessible (Gorby et al., 2006; Lovley, 2011; Marsili et al., 2008). Moreover, microorganisms can employ redox chemicals or (semi)conductive minerals to deliver electrons to electron acceptors or microbial partners in natural environment (Kato et al., 2012).

Electrode reduction in microbial fuel cells (MFCs) has been considered as a new form of microbial extracellular respiration in which the conductive electrodes and external circuits form an artificial electron transfer pathway linking the anodic microbial oxidation and the cathodic electron acceptor reduction. Generally, MFC anode and cathode are spatially separated by a membrane and physically connected via an external circuit which is essential for current generation and collection. However, the separator and distance between anode and cathode usually result in significant internal resistances which would prevent the electron transfer in MFCs, especially for scaled-up MFCs (Liu et al., 2005). Moreover, the external resistance usually prevents the organic removal efficiency (Erable et al., 2011). Microbial electrochemical snorkel (MES) reactor (Erable et al., 2011), a novel design developed from MFCs, employs a single piece of conductive material to deliver microbial respiratory electrons to the final electron acceptors, ruling out the resistance resulted by the electrode separation in MFCs. Although MES cannot recover electricity from organics, it has been used as a simple, inexpensive and durable approach to stimulate organic pollutant degradation, attenuate the mobility of toxic metals and prevent methane emission in anaerobic environments (Erable et al., 2011; Lovley, 2011; Nevin et al., 2012).