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Design and characterization of a microbial fuel cell for the conversion of a lignocellulosic crop residue to electricity

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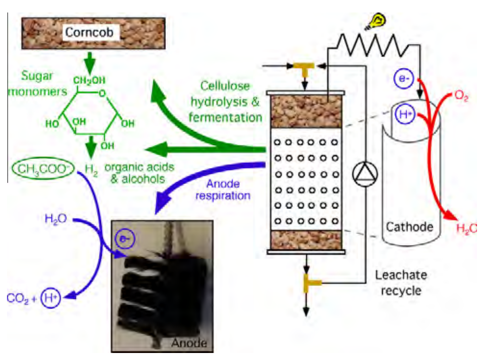
HIGHLIGHTS

- ▶ A novel, solid-substrate microbial fuel cell was developed.
- ▶ Cellulose hydrolysis, fermentation, and anode respiration occurred in one chamber.
- ▶ Electricity was produced directly from corncob pellets and sustained for >60 d.
- ▶ Power production was enhanced by periodic exposure to oxygen.
- ▶ Adding *Geobacter metallireducens* increased power in absence of methanogenesis.

GRAPHICAL ABSTRACT



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ABSTRACT

Agricultural crop residues contain high amounts of biochemical energy as cellulose and lignin. A portion of this biomass could be sustainably harvested for conversion to bioenergy to help offset fossil fuel consumption. In this study, the potential for converting lignocellulosic biomass directly to electricity in a microbial fuel cell (MFC) was explored. Design elements of tubular air cathode MFCs and leach-bed bioreactors were integrated to develop a new solid-substrate MFC in which cellulose hydrolysis, fermentation, and anode respiration occurred in a single chamber. Electricity was produced continuously from untreated corncob pellets for >60 d. Addition of rumen fluid increased power production, presumably by providing growth factors to anode-respiring bacteria. Periodic exposure to oxygen also increased power production, presumably by limiting the diversion of electrons to methanogenesis. In the absence of methanogenesis, bioaugmentation with *Geobacter metallireducens* further improved MFC performance. Under these conditions, the maximum power density was 230 mW/m^3.

1. Introduction

Improving the sustainability of worldwide agricultural operations will require a reduction in the industry's net energy consumption—currently estimated at one quadrillion Btu in the US alone (Schnepf, 2004). Recovery of biochemical energy available in plant biomass is one strategy that could be used to offset the country's current petroleum consumption. Corn is the most widely planted crop in the US. While some plant residues should be left on agricultural fields to maintain soil organic carbon and prevent erosion, it is estimated that more than 75 million dry tons of corn stover could be harvested sustainably each year (Kadam and McMillan, 2003). Current methods for extracting energy from cellulosic biomass rely heavily on thermochemical pre-treatment methods to produce monomers amenable to biodegradation (e.g., via anaerobic digestion); however, such methods have a number of environmental limitations and process inefficiencies. Thus, there

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