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Electricity Generation Using Shewanella and Geobacter in Microbial Fuel Cells

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Abstract Microbial Fuel Cells (MFCs) represent an innovative bioelectrochemical technology that harnesses the metabolic activities of electroactive bacteria, particularly *Shewanella oneidensis* and *Geobacter sulfurreducens*, to generate electricity. These bacteria transfer electrons to an anode while breaking down organic matter, enabling sustainable energy production. This paper explores the principles behind MFCs, the electron transfer mechanisms of *Shewanella* and *Geobacter*, and their practical applications. Experimental results demonstrate their potential for renewable energy generation in wastewater treatment, agricultural applications, and remote sensing. The study also discusses the challenges of scaling up MFCs, their environmental impact, and future prospects.
Keywords: Microbial Fuel Cell; *Shewanella*; *Geobacter*; Bioelectricity; Sustainable Energy

1. Introduction

The demand for sustainable energy sources has led to the exploration of bioelectrochemical systems such as MFCs. *Geobacter* and *Shewanella* are among the most studied electroactive bacteria due to their ability to transfer electrons directly or indirectly to electrodes. While *Geobacter* excels in anaerobic conditions with nanowire-based electron transport, *Shewanella* adapts to fluctuating environments by utilizing soluble electron shuttles. This paper investigates their roles in electricity production and evaluates their feasibility in large-scale applications.

2. Electron Transfer Mechanisms

2.1. Direct Electron Transfer (Geobacter)

Geobacter sulfurreducens uses conductive pili, also known as nanowires, to facilitate direct electron transfer (DET) to the anode. This process allows efficient and continuous electron flow in strictly anaerobic environments, making it ideal for stable power generation.

2.2. Indirect Electron Transfer (Shewanella)

Shewanella oneidensis employs a combination of DET and indirect electron transfer (IET). It secretes flavins and other mediators to shuttle electrons to the electrode, enabling it to function in environments with fluctuating oxygen levels.

3. **Methodology**

MFC prototypes were designed using soil-based and wastewater-based systems. The anode chamber was maintained in anaerobic conditions to promote *Geobacter* growth, while *Shewanella* was introduced into oxygen-variable conditions. Carbon felt electrodes were used to enhance bacterial adhesion and electron transfer efficiency. Voltage outputs were measured using a digital multimeter, and microbial activity was analyzed using cyclic voltammetry.

4. Results and Discussion

- *Geobacter*-dominated MFCs generated stable power outputs of 0.5–1V per cell.
- *Shewanella* showed flexibility in various environments but exhibited lower electron transfer rates due to dependence on electron shuttles.

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- Combining both bacteria improved overall performance, with increased adaptability and sustained power production.
- Applications in wastewater treatment demonstrated dual benefits of pollution mitigation and bioelectricity generation.

5. Applications and Future Prospects

MFCs utilizing *Shewanella* and *Geobacter* hold promise for:

- **Agriculture:** Powering soil sensors and irrigation controllers.
- **Wastewater Treatment:** Energy recovery from organic waste.
- **Remote Sensing:** Providing off-grid power for environmental monitoring. Challenges such as low power density and scalability require further research, but advancements in electrode materials and system optimization may improve commercial viability.

6. **Conclusion**

Microbial Fuel Cells using *Geobacter* and *Shewanella* offer a renewable and sustainable energy solution. Their unique electron transfer mechanisms enable efficient bioelectricity generation, but challenges in scalability and cost-effectiveness must be addressed. Future research should focus on optimizing bacterial synergy and improving electrode materials to enhance energy output.

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