Natural, Cost-Effective Anodes for Optimized Sediment Microbial Fuel Cells: Engineering a Novel Approach to Harvesting Energy and Cleaning Up Oil-Polluted Regions

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Over 5 million tons of oil is spilled annually in the world while 1.3 billion people lack access to energy. We hypothesized microbial fuel cells (MFCs) can clean up oil-polluted regions and generate electricity. Yet, current MFCs produce low electrical outputs and use costly materials. The purpose of this study was to engineer efficient, affordable MFC anodes that optimize electrical output and oil remediation using structural and surface coating configurations. For structure, carbonized Luffa aegyptiaca, or loofah sponges (LS), were tested as cheaper 3-dimensional (3D) alternatives to commercial materials (carbon fiber and RVC). For surface coating, hybrids were synthesized to increase electrical properties. Coatings were uncoated, TiO2, graphene, and graphene/TiO2 composite. Nine different anodes were made from these structure/coating combinations. MFCs were individually placed into marine-sediment system and oil-containing system. A multimeter measured electrical outputs while UV-VIS spectroscopy measured oil degradation. All data was analyzed with ANOVA post-hoc Scheffe for statistical significance. Data showed anodes increased oil degradation. LS groups had significantly higher power densities than standard 2D and 3D anodes. LS-graphene/TiO2 composite had the highest power density (2087.1 mW/m^2) and oil remediated (93%). Results reveal structure and surface coating synergistically improve surface area, biocompatibility, and electrical conductivity for optimized MFC performance. LS are over 90% cheaper than RVC and come from accessible, sustainable sources. LS-composites are novel, efficient, commercially-viable anodes. This MFC design can be used for remediating oil pollution and providing clean energy for industries, remote sensors, and 3rd world countries.