Optimizing Microbial Fuel Cell Electrical Performance through a Single-Chamber Design and Novel, Natural, Cost-Effective Anodes

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With the global energy crisis and pollution issues, like the BP Oil Spill and Flint Water Crisis, there is a major need for clean, accessible energy and sustainable remediation methods. Microbial fuel cells (MFCs) use bacteria in organic matter (e.g. wastewater and soil) to produce energy and simultaneously remove pollutants (e.g. heavy metal and hydrocarbons) from these sources. This study aimed to optimize MFC electrical performance by engineering efficient, affordable MFC systems that can be commercialized. MFC system structure and various anodes were developed and tested. Single-chamber MFCs with air cathodes were constructed as a compact design with passive oxygen transfer. Carbonized loofah sponges (LS) were tested as natural, low-cost, porous alternatives to commercial anode materials. Graphene-based anodic surface coatings were studied. Electrical performance and anode morphology was evaluated. Results showed LS-based anodes significantly ($p=0.000001506$) increased MFC power density. The LS with a nitrogen-functionalized graphene coating (LS-NG) had the highest electrical performance with a power density 162 times greater than the control. LS-NG's high anodic performance can be attributed to a synergetic enhancement of surface area, electrical conductivity and bacterial affinity from the LS and NG. The single-chamber system was low-maintenance and reduced the electron transport path. This proposed MFC anode and system dramatically reduced costs for commercialization, being 28 times more cost-effective than standard MFCs. This novel, high-performing, cheap MFC design can be implemented in wastewater treatment plants or previously unusable polluted areas to provide profitable cleanup and sustainable energy to industrial facilities and notably developing countries.