Enzyme-Based Biofuel Cells

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Enzymatic biofuel cells (EBFCs) are devices for converting the biochemical energy in sugars and alcohols to electricity under ambient temperature and atmospheric pressure using enzymes as electrocatalysts. EBFCs have received considerable attention as potentially ubiquitous devices to meet energy demands because of their efficient and eco-friendly properties. The cell is composed of a fuel-oxidizing enzyme-modified anode and an O_2-reducing enzyme-modified cathode. The simple structure would allow for the straightforward miniaturization of the EBFC.

EBFC technology is still an early stage of development, with many yet-to-be-resolved fundamental scientific and engineering problems. Among them, two critical problems are short life time and poor power density; enzymes on the electrode surface is not stable, there is a big barrier for electron transfer between enzyme active site and electrode surface, and amount of electro-active enzyme are limited. To achieve the practical application of EBFCs, a promising approach is to use porous carbon materials as enzyme supports; carbon nanotubes, carbon blacks, and interconnected mesoporous carbon materials have been developed. The large surface area of porous carbon materials can increase the enzyme loading. Moreover, the enzyme structure in the mesopores can be stabilized by the surrounding carbon wall. The macropores structure are also important to enable fast penetration of enzymes into the porous carbon layer in fabricating the enzyme electrode, as well as efficient fuel mass transfer during the bioelectrocatalytic reaction. A combination of more efficient electron transfer technology by modification of microscopic interface between enzyme and electrode with hierarchical structured carbon material would be helpful in achieving a much higher and stable current output with lower amount of enzyme, contributing to a practical advance in the fuel cell technology.