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Designing Nanostructures at the Interface between Biomedical and Physical Systems

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Grow a Biological In Vitro Power Source on a Chip

Focus Group Description

Background

There is much interest in finding alternative and renewable energy processes; significant gains have been made in approaches such as photovoltaic, wind and solar/thermal but the costs of these units can still be considerable, and some require rather sophisticated manufacturing infrastructure. A biologically driven energy source is an appealing alternative, especially one that could convert waste into energy.

The Problem

Consider the design of a power source that is biological in nature and provides an energy output that can be utilized reasonably in an industrial setting (i.e. electricity, hydrogen,?). This system does not have to be suitable for in vivo use, nor does it have to rival the absolute efficiency of conventional systems, but should have the potential of improving the current costs to produce clean energy. For comparison, a current, commercially available, solar panel of $1.27m^2$ can generate 167 watts with irradiation of $1kW/m^2$ (~13% efficiency) and costs about $600 to purchase.

As one example of biological power sources, photosynthesis is utilized by plants to convert water and carbon dioxide into ATP and carbohydrates. This cycle can be interrupted to produce hydrogen. Other microorganisms (bacteria, algae) can also be used to produce hydrogen, in a similar cycle. Unfortunately, most of these are self-limiting reactions, where the organisms are inhibited by the reaction byproducts. It may be possible to modify the enzymes, or the sensitivity of the organisms to the reaction byproducts, to improve the efficiency of these processes, but other technical approaches (i.e. the use of membrane reactors, scavengers, etc) have also been attempted at the macro scale. Micro and nano scale systems offer many advantages for the design of continuously operating systems for biological energy conversion.

Initial References

- Hamilton O. Smith, Robert Friedman, and J. Craig Venter. *Biological Solutions to Renewable Energy*.
- Vermeglio, Andre; Cournac, Laurent; Peltier, Gilles; Fontecilla-Camps, Juan-Carlos. *Production of hydrogen from water and light by using microorganisms.* Direction Sciences Vivant, CEA, Cadarache, Fr. Clefs CEA (2001), Volume Date 2000-2001, **44** p. 20-24. (available online in English at http://www.cea.fr/gb/publications/Clefs44/an-clefs44/clefs4420a.html