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Microbial Electro-Photosynthesis for improving energy conversion efficiency in photosynthetic microorganisms

While photosynthetic microorganisms offer a promising route to generate sustainable transportation fuels and products using solar energy, boosting their photosynthetic efficiency above normal levels (<5%) will help ensure its economic viability. A major source of inefficiency is that photosynthetically active radiation (PAR, 400-700 nm) constitutes less than half of the solar energy reaching the earth's surface. Photolvoltaic (PV) devices capture twice as many photons as photosynthetic pigments and have efficiencies >20% for converting photon energy to electricity. However, current artificial systems have yet to realize the capacity of photosynthesis to produce complex molecules, high value products and high energy-density transportation fuels.

Researchers at Arizona State University (ASU) and the Biodesign Institute at ASU have modified a strain of cyanobacteria to utilize photovoltaic (PV) electricity to stimulate growth in a technology called Microbial Electro-Photosynthesis (MEPS). Specially designed chemical redox mediators shuttle electrons from a cathode directly into the photosynthetic electron transport chain. Light energy from photosynthesis is used to drive carbon fixation, yielding biomass and complex, high energy transportation fuel feedstock, which are not efficiently generated by microorganisms using electricity alone.

Potential Applications

- MEPS technology enables numerous products of commercial interest, which are naturally occurring or engineered within photosynthetic organisms, including:
  - High-density transportation fuels
  - Human and animal supplements
  - Cosmetics
  - Agrochemicals
  - Therapeutics
  - Plastics
  - Specialty Chemicals

Benefits and Advantages

- PV captures about twice the number of photons compared to capture by photosynthetic microbes alone
- The integrated MEPS bio + PV system could increase solar-to-fuel and solar-to-product conversion efficiency to >25%
- Improves productivity of oxygen sensitive metabolic processes
- Improves light utilization to allow cultures to reach higher densities

- Reduces downstream dewatering and harvesting costs
- Strain facilitates genetic engineering of new metabolic pathways to produce novel products and optimize expression yields
- Utilizes electricity from any source, including wind, hydro, and geothermal
- Can be easily integrated into standard photobioreactor designs

For more information about the inventor(s) and their research, please see Dr. Fromme's laboratory webpageDr. Rittmann's laboratory webpageDr. Thomas Moore's laboratory webpageDr. Ana Moore's laboratory webpageDr. Vermaas' laboratory webpage