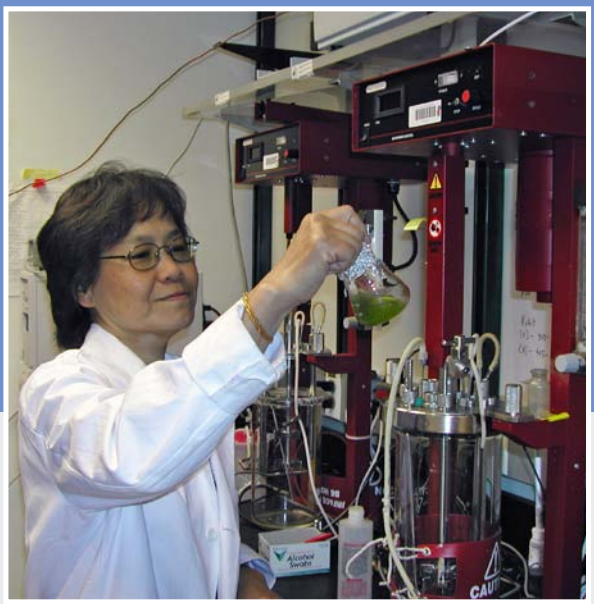
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Photobiology Research Laboratory

Understanding fundamental biological processes for the production of fuels and chemicals, and understanding electron transport for hybrid generation of solar fuels



Pin Ching Maness operates a fermenter containing microbes that convert biomass into H_2 gas. *Photo by Jianping Yu, NREL/PIX 15277*

The photobiology group's research is in four main areas:

- Comprehensive studies of fuel-producing photosynthetic, fermentative, and chemolithotrophic model microorganisms
- Characterization and engineering of redox enzymes and proteins for fuel production
- Genetic and pathway engineering of model organisms to improve production of hydrogen and hydrocarbon fuels
- Studies of nanosystems using biological and non-biological materials in hybrid generation.

NREL's photobiology research capabilities include:

- Controlled and automated photobioreactors and fermenters for growing microorganisms under a variety of environmental conditions
- High-and medium-throughput screening of H_2-producing organisms
- Homologous and heterologous expression, purification, and biochemical/biophysical characterization of redox enzymes and proteins
- Qualitative and quantitative analyses of gases, metabolites, carbohydrates, lipids, and proteins
- Genetic and pathway engineering and development of novel genetic toolboxes
- Design and spectroscopic characterization of enzyme-based biofuel cells and energy conversion nanodevices.

Laboratory Research Highlights

Research Area	Equipment
Microorganism growth	Multiple 1-L Quibit photobioreactors Fermenters with automated feeding and online GC
Microorganism screening and characterization	Fluorocam, Clark electrode with detection of O_2 and H_2 Fluorescence microscope
Protein purification	Anaerobic glove boxes FPLC Microfluidizer processor
Protein/DNA/metabolite quantification and characterization	HPLC with UV/VIS, RI, and ELSD detectors GC/TCD GC/FID GC/MS Q-PCR Multiple PCR machines
Biophysical studies of proteins/ bionanomaterials	Potentiostat/rotating disc electrode Capillary MS Spectrophotometers FTIR

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Applications

Studies of fuel-producing microbes

- Physiological and genetic studies, with or without key nutrients/O_2 that induce fuel (H_2 or lipid) production, of:
  - *Chlamydomonas reinhardtii* (green alga)
  - *Synechocystis* 6803 (cyanobacterium)
  - *Clostridium thermocellum* (fermentative bacterium)
  - *Ralstonia eutropha* (chemolithoautotroph)
- Purification and biochemical/biophysical analysis of hydrogenases
- Assay development to screen for H_2-producing microorganisms.

Characterization and engineering of fuel-producing enzymes

- Hydrogenase engineering to improve catalytic properties and O_2 tolerance.

Genetic and pathway engineering of model organisms

- Heterologous expression of bacterial hydrogenases in photosynthetic organisms
- Gene deletions and novel pathway introduction into cyanobacteria and green algae.

Dr. Alexandra Dubini isolates oxygen-sensitive proteins in a glove box under anaerobic conditions. *Photo by Jack Dempsey, NREL/PIX 14561*

Studies of bio-nanosystems

- Enzyme interaction with non-biological materials to construct highly efficient enzyme-based electrodes and nanodevices for photoconversion.

Associated publications

Wecker, M.S.A., et al. (2011). "Design of a New Biosensor for Algal H2-Sensing System of *Rhodobacter capsulatus*." I*nt. J. Hydrogen Energy* (36); pp. 11229-11237.

Yacoby, I., et al. (2011). "Photosynthetic Electron Partitioning between [FeFe] Hydrogenase and Ferredoxin: NADP+ -Oxidoreductase (FNR) Enzymes *in vitro*." *PNAS* (108:23); pp. 9396-9401.

Kosourov, S.N., et al. (2011). "Truncated Antenna Mutants of *Chlamydomonas reinhardtii* Can Produce More Hydrogen than the Parental Strain." *Int. J. Hydrogen Energy* (36); pp. 2044-2048

Brown, K.A., et al. (2011). "Characterization of Photochemical Processes for H_2 Production by CdS Nanorod-[FeFe] Hydrogenase Complexes." *J. Am. Chem. Soc.* (134); pp. 5627-5636.

Tekucheva, D.N., et al. (2011). "Immobilization of Purple Bacteria for Light-Driven H2 Production from Starch and Potato Fermentation Effluents." *Int. J. Hydrogen Energy;* DOI: 10.1002/btpr.668.

Svedružić, D., et al. (2011). "High-Performance Hydrogen Production and Oxidation Electrodes with Hydrogenase Supported on Metallic Single-Wall Carbon Nanotube Networks." *J. Am. Chem Soc.* (133:12); pp. 4299-4306.

Carrieri, D., et al. (2011). "The Role of the Bidirectional Hydrogenase in Cyanobacteria." *Bioresour. Technol.* (102); pp. 8368-8377.

Weyman, P.D., et al. (2011). "Heterologous Expression of *Alteromonas macleondii* and *Thiocapsa roseopericina* [NiFe] Hydrogenases in *Synechococcus elongatus*." *PloS ONE* (6:5); e20126.

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NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-5100-54668 • June 2012