NREL Highlights

SCIENCE

New Biohybrid Structure Produces High-Performance Hydrogen Electrodes

Union of carbon nanotube networks and the hydrogenase from *Clostridium acetobutylicum* amps up the process of electrode electrocatalysis.

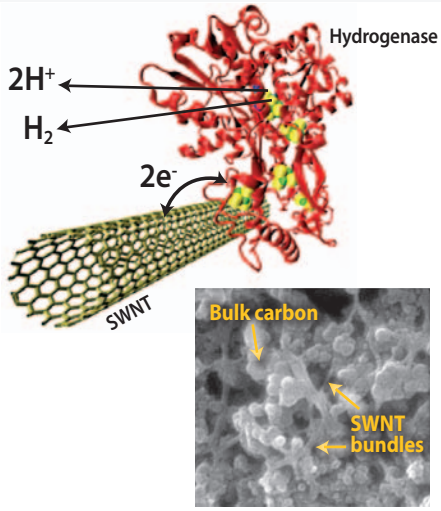
Recently published research from the National Renewable Energy Laboratory (NREL) reports that biohybrid hydrogen electrodes comprising metallic single-walled carbon nanotube (SWNT) networks and the hydrogenase from *Clostridium acetobutylicum* achieved a new activity record for hydrogenase-based electrode electrocatalysis. These results demonstrate that hydrogenase/SWNT electrodes have the potential to provide a cheaper but equally efficient alternative to the precious metal catalysts, such as platinum, for application in photoelectrochemical or fuel cells.

The high-performance hydrogen electrodes are based on the [FeFe]-hydrogenase from *C. acetobutylicum* immobilized onto SWNT networks. The researchers prepared the electrodes with varying ratios of metallic (m-) and semiconducting (s-) SWNTs to explore the role of SWNT electronic structure in the biohybrid electrodes. Although most hydrogenase/SWNT electrodes showed improved performance in comparison to the hydrogenase immobilized directly to bulk carbon, high current densities up to 12 mA cm^{-2} (at –1 V vs. SHE) were achieved with hydrogenase immobilized on SWNT networks with high m-SWNT content. Using electrochemical methods, NREL researchers showed that m-SWNTs contribute to increased electrode electroactive surface available for hydrogenase binding and improve electronic coupling between the electrode and the hydrogenase redox sites.

This work was supported through the Laboratory Directed Research and Development program at NREL.

Technical Contact: Drazenka Svedruzic, *drazenka.svedruzic@nrel.gov*

Reference: D. Svedruzic, J.L. Blackburn, R.C. Tenent, J.D. Rocha, T.B. Vinzant, M.J. Heben, and P.W. King, "High Performance Hydrogen Production and Oxidation Electrodes with Hydrogenase Supported on Metallic Single Wall Nanotube Networks," *JACS* (2011,133(12): 4299–4306).



Hydrogenase/SWNT electron-transfer complex

Key Research Results

Achievement

Using electrochemical methods, NREL scientists discovered that metallic single-walled carbon nanotubes (SWNTs) contribute to increased electrode electroactive surface available for hydrogenase binding and improve electronic coupling between the electrode and the hydrogenase redox sites.

Key Result

The scientists identified the role of the electronic structure of SWNTs in biohybrid hydrogenase/SWNT hydrogen electrodes.

Potential Impact

These hydrogenase/SWNT electrodes may provide a cheaper but equally efficient alternative to the precious metal catalysts such as platinum that are now used in photoelectrochemical or fuel cells. Such an application could contribute to the large-scale deployment of fuel cells and other high-value technologies.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

1617 Cole Boulevard | Golden, Colorado 80401-3305 | 303-275-3000 | www.nrel.gov

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-2700-51425 • May 2011