Mobilizing Science in the Quest for Solar Fuels

Joint Center for Artificial Photosynthesis Leads New Collaboration Effort on Solar Energy

In mid-September, some 40 Center Directors and Associates from 19 of the DOE Energy Frontier Research Centers (EFRCs) converged on Lawrence Berkeley National Laboratory for the first-ever Artificial Photosynthesis (AP) Meeting, sponsored by the DOE Joint Center for Artificial Photosynthesis (JCAP). JCAP, led by the California Institute of Technology in close partnership with Berkeley Lab and SLAC, is one of three large Energy Innovation Hubs established by DOE in 2010. (Both JCAP and the 46 EFRCs--the latter established in 2009--are supported by the DOE Office of Science.)

The EFRC researchers were welcomed at the newly refurbished "JCAP-North" headquarters (a similar "JCAP-South" facility is being refurbished down at Caltech). They toured the bright, newly equipped laboratories, met and talked with their fellow researchers, and settled in for two days of serious scientific discussions.

The Energy Innovation Hubs are large, multidisciplinary research centers aimed at tackling major energy research challenges (the other two Hubs focus on modeling and simulation for nuclear reactors and building efficiency, respectively).

As their name implies, the Hubs are also designed to be centers of coordination and collaboration for the larger community of researchers working in their area. JCAP's purpose in organizing the AP Meeting was to bring together EFRC solar energy researchers from across the nation in an effort to identify research gaps and build new collaborations. All this follows in part from a larger effort by the Department of Energy and its Office of Science to accelerate energy research by encouraging the establishment of new collaborations and synergies among researchers.

The challenge being tackled by JCAP is a big one: to "develop and demonstrate a manufacturable solar-fuels generator, made of Earth-abundant elements, that will take sunlight, water and carbon dioxide as inputs, and robustly produce fuel from the sun 10 times more efficiently than typical current crops."

The plan to attack an unprecedented continuum of scale – from nanoscale, to macroscale, to systems and device scale – requires JCAP to work with both bottom-up and top-down research strategies. To do this successfully, on an accelerated time fame, strong collaborative relationships between the Hub and the EFRCs are essential. The meeting was designed to initiate a series of substantive interactions between JCAP and members of the EFRC community, so that the Hub can provide a focal point for solar fuels efforts and can leverage the investment and pioneering multidisciplinary research being performed nationwide in the EFRCs.

During the intense twoday meeting, JCAP presented eight key research projects, each of which addresses continuing impediments to the development of the solar to fuels industry:

- Light Capture and Conversion Materials
- High Throughput Experimentation
- Membranes and Mesoscale Assembly
- Catalyst and Photochemical Benchmarking
- Molecular and Nanoscale Interfaces
- Scale-Up and Prototyping
- Heterogeneous Catalysts
- Molecular Catalysts

Specific examples of collaborative efforts established at the meeting included:

- Center of Inverse Design (CID, National Renewable Energy Laboratory, Director: Bill Tumas) will collaborate with JCAP PIs to update and utilize NREL's existing simulation database on ternary oxide semiconductors for structure/function predictions.

- Center for Molecular Electrocatalysis (CME, Pacific Northwest National Laboratory, Director: R. Morris Bullock) will work with JCAP to place CME's world-leading H_2-evolving catalyst on photoelectrode supports for testing in JCAP solar fuels prototypes.

- Center for Bio-Inspired Solar Fuel Production (BISfuel, Arizona State University, Director: Devens Gust) will send 50 samples of molecular linkers from their current library to JCAP for use as tethers between catalysts and oxide supports. Charge transfer efficiency will be measured by JCAP.

- Center for Energy Nanoscience (CEN, University of Southern California, Director: P. Daniel Dapkus) has offered JCAP the use of their Metal-Organic Chemical Vapor Deposition (MOCVD) instrumentation for the growth of semiconducting materials.

- Energy Materials Center at Cornell (emc^2, Cornell University, Director: Héctor D. Abruña) will share samples of their fuel cell catalyst (fuel decomposition) with JCAP to be used in the reverse reaction (fuel formation). JCAP has already hired an Emc^2 graduate to lead their high throughput efforts.

The targeted research projects were used as the focus of breakout groups in which the JCAP and EFRC investigators further refined specific targets, procedures, and protocols of mutual interest.

"Overall, the discussion was very lively, and the breakout sessions extended well into the night," noted Peidong Yang, JCAP Department Head for Science of Large Scale Systems. "I

sensed the great enthusiasm. All attendees were very excited and eager to contribute their expertise in order to address the scientific and technical challenges for AP research."

"This meeting was very useful and critically needed as a mechanism to begin the process of coordinating and leveraging the R&D (research and development) activities of the large JCAP Solar Fuels Hub with the many EFRCs that are also conducting related, but uniquely different, aspects of solar fuels research and production," said Art Nozik, Senior Research Fellow and Team Lead at the National Renewable Energy Laboratory and Associate Director for the Center for Advanced Solar Photophysics (CASP), an EFRC centered at Los Alamos National Laboratory. "We identified specific issues that will be aired and resolved as a result of the meeting--specifically the role and need for unique membranes in the JCAP designs, and the role of nanostructures in optimum device architectures."

"The lofty goals for the meeting were not only met but were exceeded," said JCAP Director Nathan Lewis. " We established and commissioned a Hub/EFRC advisory board, laid the groundwork for a whole spectrum of substantive, win-win collaborative interactions for both the Hub and the EFRCs, and are set to exploit, in unprecedented ways, these new modalities of performing energy research within the DOE's Office of Science to dramatically accelerate and leverage the nation's support of R&D in support of developing the needed new science and technology to allow the production of fuels directly from sunlight."