U.S.-China Electric Vehicle and Battery Technology Workshop

Roundtable 1: Battery Technology Roadmapping

Discussions, August 30 - 31, 2010

By 2020, Electric Drive Vehicle (HEV, PHEV and BEVs) will be what percent of new light-duty vehicle SALES?

- China
- 4 vote < 5% ;
- 8 vote 5~10%;
- 4 vote 10~20%;
- 0 vote >20%

- USA
- 2 vote < 5% ;
- 14 vote 5~10%;
- 10 vote 10~20%;
- 1 vote >20%

Day 1: Discuss characterization techniques, modeling, and materials

- Frank McLarnon of LBNL introduced the diagnostics techniques carried out as part of DOE's BART and BATT programs to understand failure mechanisms in lithium batteries

- Xiao-Qing Yang of BNL - synchrotron-based in situ X-ray techniques

- Jon Christophersen, INL – modeling capability to predict battery lifetimes

- Shi-Gang Sun, Xiameng University - experimental studies of interfacial processes

- Xueping Gao, Nankai University - Sulfur composites as cathode for lithium-ion battery

Decided on the questions to discuss on Day 2:

- Li-ion battery chemistries, and next-generation chemistries to collaborate on
- Diagnostic tools
- Battery recycling
- Student and researcher exchange between U.S. and China

Discussion 1: Materials

The group agreed to focus the collaborations on pre-competitive research focused on four different battery technologies:

- Lithium-metal batteries, including lithium-sulfur (LiS)
  - Fundamental studies of sulfur electrode
  - Understanding electrolytes and additives as part of the whole system

- Metal-air batteries, including Li-air and zinc-air
  - Investigate the cathode electrode clogging by Li_2O
  - Understand how catalysts work and its role on reducing polarization and improving cycle life
- Multivalent battery systems
  - Fundamental study of the reason behind poor conductivity of these materials
- Next-generation lithium-ion batteries (High voltage , composite electrodes)
  - Understanding fading mechanisms and improving safety
  - Understanding why composite electrodes have poor rate capability

Action item: Need to discuss how to plan the collaboration after this meeting. The U.S. DOE's International Policy Office will develop the actual structure and secure the necessary agreements to establish the formal program.

Discussion 2: Sharing research

Several participants presented talks on their research:

•Dr. Khalil Amine , advanced chemistries for PHEV/EV applications

•Prof. Deyang Qu, University of Massachusetts at Boston - Lithium-air batteries

•Prof. Yuping Wu, Fudan University - Safety and gel membranes

•Prof. Zhou, Peking University - Lithium-ion battery cathode materials and technology

•Prof. Li Yang, Shanghai Jiao Tong University - Novel materials, including new ionic liquid electrolytes and lithium-titanium-oxide (LTO) anodes

•Prof. Wang Zhaoxiang, Institute of Physics - Battery materials

Discussion 3: Diagnostic tools, battery recycling, and scholar exchange

Discussion focused on the diagnostic tools that could be applied to characterize next-generation batteries and precompetitive materials . The following was suggested for collaboration on diagnostic tools:

- Lithium-sulfur systems
  - Spectroscopy to understand dynamic sulfide species distribution and precipitation on the sulfur electrode in various electrolytes
  - Microscopic study of sulfur retention in porous current-collector nanostructures

- Lithium-air systems
  - Spectroscopy of dynamic lithium oxide and peroxide species distribution and precipitation in various electrolytes
  - Fundamental surface studies of bifunctional air electrocatalysts

- Lithium-metal systems
  - TEM to study lithium metal/substrate nanostructures
  - Molecular-scale modeling of lithium species movement during charging/discharging

(Diagnostic tools, continued)

- Multi-electron and high-voltage lithium-ion systems
  - Diagnostic approaches described by X.Q. Yang and F. McLarnon on Day 1 of the workshop
  - Develop advanced mathematical models to help understand conductivity limitation in these systems.

China also expressed interest in collaborating in:

- Battery life predictions using advanced modeling tools
- Capturing real-world data from batteries installed in vehicles
- Theoretical calculations, combined with experimental data, to determine causes of failure and capacity fade
- Sharing facilities such as the Advanced Photon Source at Argonne National Laboratory and the Light Source at Brookhaven National Laboratory

Action item: Both the U.S. and Chinese groups need to take an inventory/survey of the experimental and diagnostics equipment and capabilities to serve as a baseline to help identify where the groups can collaborate.

Discussion 3: Diagnostic tools, battery recycling, and scholar exchange

Battery recycling discussion:

Linda Gaines of Argonne National Laboratory presented life cycle analysis of Li-ion batteries.

- Not all recycling processes are created equal. Can treat a material pretty much like an ore, put it into a smelter, and remanufacture in an energy-intensive process.Toxco has a process which recovers lithium as a carbonate and mixed metal oxides
- Umicore gets the cobalt and other metals back as elements. However, if you recover cathode materials intact, the cathode design may be obsolete by then.

Outcome of battery recycling discussion:

Both the U.S. and Chinese groups agree in their interest in collaborating on battery recycling

Discussion 3: Diagnostic tools, battery recycling, and scholar exchange

Outcome of student and scholar exchange discussion:

•Dr. Wu suggested that U.S.-China personnel exchanges can likely take one of 3 forms:

•PI level (1week – 1 month)
•Post-doctoral researcher (either in U.S. or China)
•Graduate student (could be for short- or long-term; could potentially receive a joint degree from both U.S. and Chinese universities)
•Joint publications

•Dave Howell: The graduate student joint degree option will have to be discussed with U.S. universities to get them on board and to determine the specifics about how such a program could work.