DOE Hydrogen Program

High Strength Carbon Fibers for Hydrogen Storage

New materials and production processes yield low-cost high strength fibers

Background

Because of its remarkable strength-to-weight ratio and damage tolerance, high strength carbon fiber is the material of choice for the manufacture of durable, lightweight, compressed hydrogen storage vessels. Unfortunately, high strength carbon fiber is currently much too expensive for hydrogen storage applications. ORNL is developing materials and process technology to lower the cost of commercial grade carbon fiber, but its strength requirement is well below the target for compressed hydrogen storage vessels. Hence there is a need for an approach that leads to a low-cost, high strength carbon fiber. This project leverages ongoing work of the DOE EERE FreedomCAR Program to develop a low-cost, high strength carbon fiber, with the aim to achieve properties equivalent to Toray's T700/24k fiber (24k tow, 700 ksi ultimate tensile strength, 33 Msi tensile modulus), and reduce production costs by at least 25%.

Technology

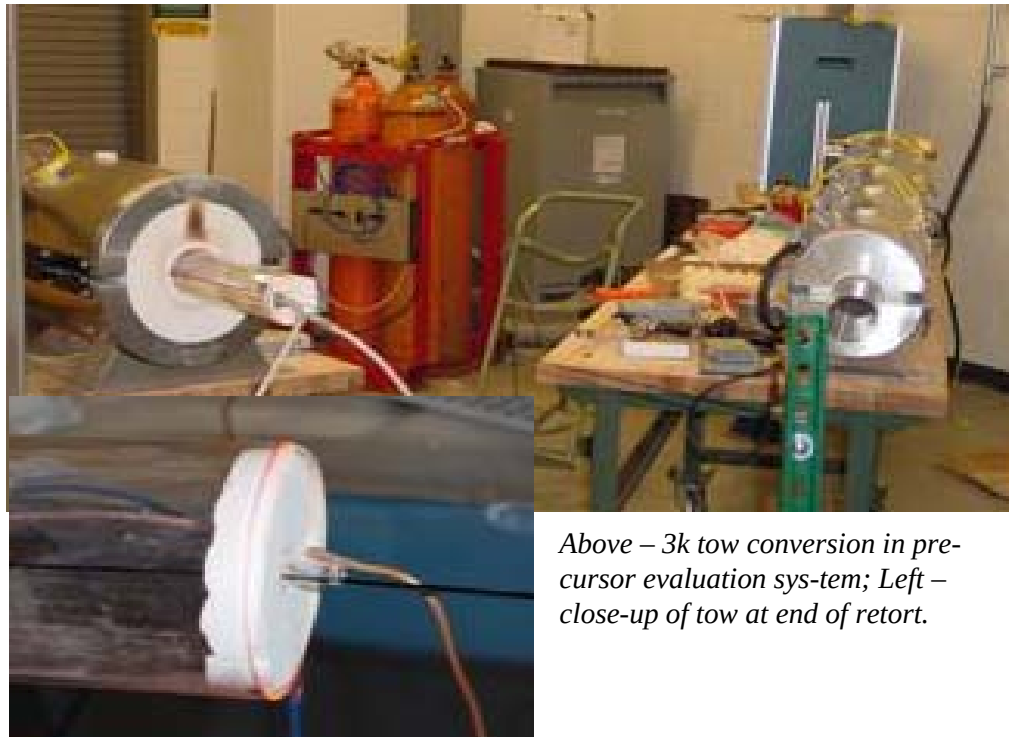
Carbon fiber production costs are roughly split between the precursor fibers and their conversion into finished product. The project addresses the development of both new materials and new processes for manufacturing carbon fibers.

Conventional precursor is wet-spun polyacrylonitrile, (PAN). Melt spinning PAN fibers offers potential cost savings because it has fewer steps and eliminates the cost of solvent and solvent operations, however is technically far more challenging than wet spinning PAN. ORNL is investigating new chemistries and processes that can potentially produce inexpensive, high strength fibers from polyolefin precursors. Other precursor options under investigation include textile grade PAN and precursors that incorporate nanomaterials.

ORNL's conventional pilot line for precursor validation and benchmarking advanced conversion processes

ORNL is also developing efficient carbon fiber conversion processes that would increase production rates with significantly reduced capital investment and energy demand per unit output. Conversion of precursor fibers into carbon fibers is normally accomplished by thermal treatment involving several time-consuming and energy-intensive steps. ORNL and several partners are investigating thermochemical, ultraviolet, and radiation-based processing methods to stabilize, or cross-link, the precursor fibers; atmospheric pressure plasma processing for oxidation; microwave-assisted plasma processing for carbonization and graphitization; and plasma-based surface treatment to enhance fiber-resin bonding. These advanced processing methods can potentially deliver higher line speeds with less energy losses.

ORNL is establishing a modular carbon fiber research pilot line to evaluate these revolutionary new processes on a comparable basis against conventional industrial processes. A conventional pilot line, shown below, is used for benchmarking advanced technologies. Eventually an advanced technology pilot line will be assembled to demonstrate that the advanced process modules work together as a functional system, and for performing system optimization.



Above – 3k tow conversion in pre-cursor evaluation sys-tem; Left – close-up of tow at end of retort.

Benefits

- Reduced raw materials cost
- Reduced unit capital investment
- Reduced unit energy cost
- Reduced labor cost

Points of Contact

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