Development and Commercialization of Alternative Carbon Fiber Precursors and Conversion Technologies

Oak Ridge National Laboratory microwave assisted plasma.

Photo courtesy of Oak Ridge National Laboratory.

Reducing the Cost of Carbon Fiber Raw Materials and Processing Technologies

Introduction

Carbon fiber is an exceptionally high-strength, lightweight material with numerous applications in energy efficiency and the generation of renewable energy. However, the current cost of carbon fibers limits their use to specialty applications and markets willing to pay a premium for the performance they offer.

Carbon fiber filaments are typically made from a precursor polymer that commonly uses polyacrylonitrile (PAN) as the raw material. In the carbon-fiber-making process, the precursors are spun into long fiber strands, subjected to chemical stabilizing reactions, and carbonized. During carbonization, the fibers are heated to very high temperatures to help release non-carbon atoms. The work is performed in an oxygen-constrained environment to prevent the fibers from burning. The result is a fiber composed of long chains of carbon atoms, which then receive surface treatments and coatings.

Researchers from Oak Ridge National Laboratory (ORNL) and Dow Chemical Company (with support from the Michigan Economic Development Corporation) are working to improve the cost effectiveness of carbon fiber manufacturing. They are developing, scaling, and planning to implement alternative technology to produce the polymer fiber precursors as well as scaled, energy-efficient technologies for the conversion process. If successful, these technologies will help enable the manufacture of carbon fibers that are technically and economically viable in industrial markets.

More specifically, the researchers are seeking to develop alternative precursor chemical formulations using less expensive spinning technologies to produce carbon-fiber precursors and to accelerate the development of energy-efficient, advanced technologies to convert these raw materials into carbon fibers. Researchers will evaluate existing, low-cost polyolefins as precursor fibers and formulate new variations of the material. These advanced conversion processes under investigation are based on Microwave-Assisted Plasma (MAP) and related technologies for carbonization.

Benefits for Our Industry and Our Nation

The development and commercialization of alternative precursors and the scale-up of advanced conversion technologies have the potential to reduce residence time and energy use, lowering the production cost of carbon fibers. Lower-cost carbon fiber products can result in large downstream savings. They could, for example, reduce vehicle weight in the transportation sector and enable the use of significantly longer blades on wind turbines.

Applications in Our Nation's Industry

Lower-cost carbon fibers will be useful in a range of industrial areas critical to efficient energy production and utilization. Examples include applications in which aircraft-grade carbon fiber is not required, such as transportation, and wind energy.

Project Description

The objective of this project is to develop, demonstrate, and commercialize alternative technology to produce polymer fiber precursors and scaled, energy-efficient, advanced conversion technology to help enable technically and economically viable manufacturing of carbon fibers for industrial markets.

Barriers

- Identifying new precursors to reduce cost of carbon fiber manufacturing
- Scaling-up precursors and conversion technologies appropriate for industrial production
- Optimizing precursor formulation and conversion parameters.

Pathways

The project team plans to identify and demonstrate one or more formulations for an alternative carbon fiber precursor as well as the spinning and conversion protocols necessary to manufacture a carbon fiber that meets all mechanical property and economic requirements for full-scale production. Concurrent efforts focus on developing and scaling the equipment and gaining the process knowledge needed to produce specifications for an advanced carbonization process for demonstration at ORNL's Carbon Fiber Demonstration Facility.

The advanced conversion processes most appropriate for these materials will be based on MAP and related technologies for carbonization. The team will evaluate the overall energy usage of the hardware and materials systems to determine the energy efficiency of the technology for polyolefin-based carbon fiber. That level of efficiency will then be compared to that of conventional carbon fiber production from PAN-based fibers.

Milestones

This project started in 2010.

- Characterize the carbon fiber and show that the mechanical properties are satisfactory for future product development in composite industries
- Evaluate materials, sealing, and atmospheric pressure solutions for the conversion process
- Determine preferred microwave/plasma parameters and profiles necessary to minimize residence time
- Scale production to more than five large (24,000 filaments or more) fiber tows
- Develop a design suitable for implementation at the demonstration facility.

Commercialization

Dow Chemical Company is the primary industrial partner on this project. The company has a Cooperative Research and Development Agreement (CRADA) with ORNL to explore this avenue of development. Dow's participation in this initiative is partially funded through the Centers of Energy Excellence, a program under the Michigan Economic Development Corporation (MEDC) focusing on technology development and job creation in the state of Michigan.

In a parallel initiative, ORNL is building a new Carbon Fiber Technology Facility (CFTF) with $35 million in funding from the American Recovery and Reinvestment Act. This pilot facility will focus on the scale-up of emerging technologies to enable larger-scale material and process evaluations. Once this carbon fiber project has been completed, researchers plan to begin the scale-up phase of these technologies using the new CFTF capabilities. The final goal is to take the technologies into full-scale production at the facilities of one or more of the industrial partners.

Project Partners

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