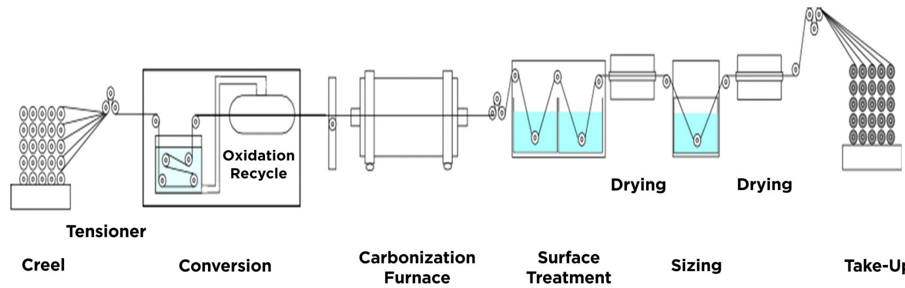
Scale Up of Novel, Low-Cost Carbon Fibers Leading to High-Volume Commercial Launch

Demonstrating a Revolutionary Process for Manufacturing Carbon Fiber Based on a Novel Polymer Fiber Precursor



The Process for Converting Polyolefin to Carbon Fiber. *Schematic courtesy of Dow Chemical*

In order to advance the clean energy economy, the United States must find new ways to conserve energy. One approach is to develop low-cost, alternative composites and structural materials for end-use products, that are lightweight yet still provide the required strength, stiffness, and corrosion resistance. Currently, continuous filament glass fiber is the most common and least expensive fiber used in strengthening polymers to form composite materials. However, carbon fiber (CF)-based composites provide higher modulus and strength as well as decreased density and weight.

High quality carbon fibers are essential to addressing the needs of the automotive industry as well as emerging industries, such as wind turbine manufacturing. Customers in these industrial markets use CFs for necessary performance benefits but have not explored the full range of possibilities due to high manufacturing costs.

Currently, conventional CF precursors are specialty grade, polyacrylonitrile (PAN)-based. The multi-operation process to manufacture PAN-CFs involves handling and recovering hazardous solvents and requires two kilograms of high-cost PAN resin to produce one kilogram of CF. This project will demonstrate a revolutionary technology for producing low-cost CFs based on a novel polyolefin (PO) precursor and proprietary process technology at laboratory and pilot-scales. These new PO precursors produce a higher yield of CF (65%–80%), when compared to PAN precursor fibers (50% yield), and at a lower cost.

Benefits for Our Industry and Our Nation

PO-based CF production offers significant energy and environmental benefits, including:

- Lowering the cost of CF production by 20%;
- Doubling the energy productivity of CF manufacturing;
- Reducing CO_2 emissions per unit of CF output by more than 50%; and
- Creating domestic manufacturing jobs.

Applications in Our Nation's Industry

This project focuses on technology deployment in two potentially significant markets with major impact on U.S. energy security: automobiles and wind energy. PO-based CF may help enable widespread CF composites adoption in the mainstream U.S. automotive market and can help meet the new Corporate Average Fuel Economy (CAFE) standards. In addition, heavy trucks are also a potential market for PO-based CFs. Low-cost CF is also an enabling material for modern, grid-scale wind turbines due to its light weight and attractive tensile properties. While the wind energy market currently uses PAN-based CFs, the lack of a stable CF supply and high pricing inhibits their use.

Project Description

The primary objective is to scale up the technology to market development scale (1,000-fold above the anticipated pilot scale throughput). The goal of this scale-up is to produce low cost CF from novel PO polymer precursors in higher yield and at lower cost than the incumbent CF made from specialty-grade PAN fiber. This project will demonstrate innovative breakthroughs that deliver both rate and quality in the manufacturing of PO-based CF.

Barriers

- PO-based CFs have not been validated beyond laboratory scale and PO precursors have not been used for the commercial production of CF.
- Scaling of the technology poses a significant challenge that will require disciplined innovation.
- High-volume production of advanced CF-composite vehicle components will require new fabrication and joining technologies and parts production capacity.

Pathways

Researchers will conduct CF processing studies and fabricate and characterize CF resin composites to demonstrate that the new, low-cost CF is promising for use as composite parts in motor vehicles. Scale-up will be performed using the following three-step process:

1. Synthesis of a PO copolymer precursor fiber with a specially designed molecular structure;
2. Chemical conversion of the polymer to a proprietary stabilized precursor fiber in high yield; and
3. Carbonization to form the CF.

If necessary, CF post-treatment technologies will be researched and developed to ensure that the CF functions effectively in composites.

Milestones

This project began in 2012.

- Demonstrate production of carbon fiber (50 grams) from polyolefin precursor material at pilot scale production rate of grams/hr (2013).
- Complete construction of market scale sulfonation – desulfonation plant rated at 4 kg/hr (2014).
- Demonstrate pre-market scale operation at the Oak Ridge Carbon Fiber Technology Facility by producing 800 kg of CF at 4 kg/hr that meet the DOE Vehicle Technology Office quality requirements of 172 GPa modulus (25 Msi) and 1.72 GPa (250 ksi) strength at greater than or equal to 1% strain (2015).

Commercialization

This scale-up project will provide data to obtain the confidence needed for high-volume, commercial-scale deployment, and successful demonstration will allow a positive decision to commercialize the technology. Fiber spinning equipment with adequate capacity to produce the quantities of PO fiber required for the project has already been obtained and the expertise and facilities for CF processing, testing, characterization, and fabrication of CF-resin composites for automotive applications are readily available. Dow and Ford represent a critical link to the automotive materials value chain, which may enable rapid commercial deployment of the technology.

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