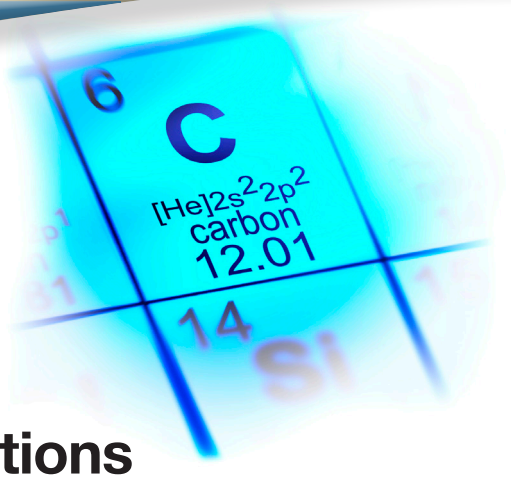
FTA RESEARCH
FEDERAL TRANSIT ADMINISTRATION

REPORT SUMMARY

U.S. Department of Transportation
Federal Transit Administration



Low-Cost Carbon Fiber Technology Development for Carbon Fiber Composite Applications

Background

Lightweight carbon fiber-based composite materials are used in diverse applications such as aerospace and aircraft structures, ships, wind energy systems, bridges and other infrastructure, etc., due to their high strength-to-weight ratio and highly-desired physical and chemical properties. However, broader use of these composites in automotive applications is currently limited because of the high cost of carbon fiber and the manufacturing processes used to make carbon fiber composite components. The principal investigator of this research was involved with ConocoPhillips in developing a low-cost carbon fiber production process. In 2004, the University of Tennessee Space Institute (UTSI) received the ConocoPhillips pitch-based carbon fiber technology Research and Development lab and technology know-how to continue the development of low-cost carbon fiber production and application technologies.

Objectives

The purpose of this research was to further develop the technology for low-cost carbon fiber production for a variety of commercial applications and to make recommendations based upon the findings of this research. Major research objectives were to:

- Demonstrate production and characterization of low-cost carbon fibers, including installing and testing all fiber spin lab equipment; procuring furnaces for heat treatments (dry, stabilization, and carbonization); characterizing carbon yield, fiber diameter, uniformity, microstructure, and surface modification; and evaluating the relationship between processes and fiber micro-structure and its physical/mechanical properties.
- Demonstrate fabrications and characterize composites made from low-cost carbon fiber. The purpose of this effort was to assess the potential for a wide range of composite applications for the low-cost carbon fibers, including fabricating different fiber forms, evaluating different processes for fabrication of the carbon fiber composites, and investigating the effects of matrix, fiber forms, fiber surface treatments, hybrid fibers, and additives on the physical and mechanical properties of the prepared composites.

Findings and Conclusions

Low-cost pitch-based carbon fiber and composites were produced and studied during this project at UTSI.

- Pitch fiber with diameters below 10 microns were produced from solvated (Mesophase) pitch using a patented high-speed melt-blown fiber spinning technique. A drying process (removing solvents) as well as stabilization and carbonization were proven to be key processes in the conversion of pitch fibers to carbon fibers and its properties. High carbon fiber yield (>75% by weight), relative faster stabilization, lower required carbonization temperature, and the low cost of raw pitch material and the high-speed fiber spinning process make the resulting carbon fiber at low cost with high mechanical properties.
- The typical form of prepared carbon fiber is a nonwoven strip with a low packing density. It may be directly employed as a fabric for use in composite fabrication. It can also be readily fabricated into carbon fiber mats with polymer binders. Vacuum bagging fabrication processes can be used to increase fiber volume and reduce porosity for the carbon fiber composite. Fiber surface treatment with ozone (O_3) improves the mechanical properties of the composites. Hybrid fiber composites were also fabricated, which may have an increased price-performance ratio.

Benefits

The potentially low-cost carbon fiber composites will be in a position to provide enormous advantages to a number of technologies for current and future everyday life applications, including a number of advanced technologies that are not currently commercially feasible. Lightweight components for automobiles, buses, trains, aircraft, ships, and applications including lightweight panels and load-bearing structures could result in weight savings, leading to a major saving in the nation's and world's energy consumption.

Low-cost carbon fiber is a national goal towards accomplishing a number of manufacturing technological breakthroughs. The findings of this report point to the possibility for significantly reduced cost for carbon fiber production. The next step in carbon fiber production and advanced carbon fiber-based material applications development is the scaling up of the R&D results, including forming a consortium of interested industrial and government partners working collaboratively to accomplish the goal of low-cost carbon fiber production technology at a commercial level. The technology and applications development collaborations will benefit the Federal Transit Administration (FTA) and help manufacturing technology and create jobs.

Project Information

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This research project was conducted by Dr. Ahmad Vakili of the University of Tennessee Space Institute. For more information, contact FTA Project Manager Lisa Colbert at (202) 366-9261, Lisa.Colbert@dot.gov. All research reports can be found at **www.fta.dot.gov/research**.