Flame Retardant Materials

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Technology Summary

Most flame retardant fabrics on the market today are produced from high density PAN based fibers made by an oxidation process. Because of the time and expense involved in making these fibers, there is a continuing need to find new methods and new materials with improved flame retardancy and acceptable—and adjustable—mechanical properties. ORNL researchers have discovered an oxidation method that is 3 to 4 times faster than conventional methods and a way to substitute lower cost polyolefins for PAN.

Carbon fiber reinforced composites are stronger and lighter than steel, so they can replace steel and other metals in automotive and aircraft parts, thus saving weight and fuel. Most carbon fibers are produced from textile polyacrylonitrile (PAN) precursor fibers, which are made in an expensive multistep process that uses toxic solvents. ORNL researchers have developed a process that will enable use of lower cost polyolefins to produce carbon fibers. In addition to cost advantages, polyolefins have a higher potential carbon yield than PAN; are produced by melt spinning, which doesn't use toxic solvents and is faster than the process used to make PAN; and are produced commercially in the United States (PAN fibers are not). The one stumbling block to their use is stabilization before carbonization. Current processes take up to 12 hours and are not amenable to most industrial settings. ORNL researchers have developed a new stabilization process that takes only 1 hour. This stabilization step uses standard, low cost chemicals and industrial methods and is even faster than the stabilization processes used for PAN fibers. Some of the resulting fibers exhibit flame retardant properties and could be used to produce flame retardant fabric in addition to carbon fiber reinforced composites.

ORNL researchers used their experience with plasma processing techniques to develop an advanced plasma based oxidation process in which rapid and aggressive oxidizing conditions are used to create an oxidized PAN fiber (OPF) possessing a high degree of crosslinking and corresponding density. (Typically, an increase in the density of a PAN fiber increases its flame retardant properties.) One key aspect of the process is the use of reactive oxidizing species, which ensures rapid, simultaneous oxidation of all parts of the fiber, including the core. The OPF produced by this method, while not suitable for carbon fiber production, possesses exceptional flame retardant properties along with advantageous physical and mechanical properties, such as resistance to chemical attack, that result in improved integrity during use. In addition, the process conditions can be adjusted to further fine-tune the mechanical properties of OPFs.

Advantages

- High carbon yield
- Low raw material cost (recycled materials could be used, further reducing costs)
- Short stabilization time
- Enhanced physical and mechanical properties
- Superior flame retardant properties
- Minimal use of corrosive/toxic solvents
- Flexible, industry friendly
- Cost-effective

Potential Applications

- Flame retardant materials
- Asbestos replacements
- Fiber reinforced composites
- Automotive and aircraft industries

Patent

Felix Leonard Paulauskas, Amit K. Naskar, and Truman Bonds. *Advanced Oxidation Method for Producing High-Density Oxidized Polyacrylonitrile Fibers,* U.S. Patent Application 13/163,134, filed June 17, 2011.

Other patent applications in progress.

Inventor Point of Contact

Felix L. Paulauskas and Amit K. Naskar
Materials Science and Technology Division
Oak Ridge National Laboratory

Licensing Contact

Alexander G. DeTrana
Senior Commercialization Manager
UT-Battelle, LLC
Oak Ridge National Laboratory
Office Phone: 865.576.9682
E-mail: detranaag@ornl.gov