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Multifunctional Carbon Fibers with Aligned Graphitic Layers

-Carbon fibers can be made from carbonized precursors, e.g., cellulose, lignin, pitch, polyacrylonitrile (PAN), or Kevlar. Compared to pitch, PAN has advantages of controlled molecular weights from chemical synthesis, easy processability, reduced viscosity, and controlled crystallinity and molecular alignment that can benefit the efficiency of carbon fiber conversion.

There are three stages in the transformation of precursor PAN to carbon fibers: oxidative stabilization, carbonization, and graphitization. Throughout these stages, the carbon fibers will form continuous graphitic layers. The alignment of noncontinuous, powder-like graphene layers has been challenging due to the low bending modulus (i.e., low degree of stiffness) of a few or even single-layered graphene. Thus, the integrity of graphene will significantly get lost as a function of decreased graphene layers. As a result, the graphene layers may crumble or fold, serving as structural defects, causing cracks and contributing to negative property effects (e.g., mechanical properties, electrical properties, etc.). Hence, a method of producing multi-layer and multi-functional carbon fibers with precise engineering for graphene morphology control is needed.

Researchers at Arizona State University have developed a method of producing carbon fibers from polyacrylonitrile (PAN) precursor fibers with the inclusion of aligned graphitic layers. This method produces a carbon fiber that utilizes the interfacial interactions between each layer for graphene alignment between graphitic layers. The resulting carbon fibers have hybrid structures between PAN and pitch-based fibers. Also, the aligned graphitic layers significantly improve modulus (i.e., improve degree of stiffness) and increases electrical conductivity of resulting carbon fiber.

Potential Applications

- In the manufacture of carbon fibers used in a variety of products:
  - sporting goods equipment
  - aerospace equipment
  - road and marine transport parts
  - medical devices
  - machine parts
  - chemical processing equipment
  - sensors
  - supercapacitors
  - actuators
  - electrodes
  - filtration devices

Benefits and Advantages

- Scalable fabrication method of a new carbon fiber structure
- The new carbon fiber structure has:
  - Aligned graphene nanoplatelets
  - Improved modulus (i.e., improved degree of stiffness)
  - Increased electrical conductivity

Related publication: Reinforcing carbonized polyacrylonitrile fibers with nanoscale graphitic interface-layers