Abstract
Precursors of carbon fibers include rayon, pitch and polyacrylonitrile fibers that can be heat-treated for high-strength or high-modulus carbon fibers. Among them, polyacrylonitrile has been used most frequently due to its low viscosity for easy processing and good performance for high-end applications. To further explore polyacrylonitrile-based fibers for better precursors, in this study, carbon nanofillers were introduced in the polymer matrix to examine their reinforcement effects and influences on carbon fiber performance. Two-dimensional graphene nanoplatelets were mainly used for the polymer reinforcement and one-dimensional carbon nanotubes were also incorporated in Polyacrylonitrile as a comparison. Dry-jet wet spinning was used to fabricate the composite fibers. Hot-stage drawing, and heat-treatment were used to evolve the physical microstructures and molecular morphologies of precursor and carbon fibers. As compared to traditionally used random dispersions, selective placement of nanofillers was effective in improving composite fiber properties and enhancing mechanical and functional behaviors of carbon fibers. The selective position of reinforcement fillers with polymer layers was enabled by the in-house developed spinneret used for fiber spinning. The preferential alignment of graphitic planes contributed to the enhanced mechanical and functional behaviors than those of dispersed nanoparticles in polyacrylonitrile composites. The high in-plane modulus, the introduction to template crystallization, and the induction to polyacrylonitrile molecular carbonization/graphitization were the motivation of selectively placing graphene nanoplatelets between polyacrylonitrile layers. Mechanical tests with the tension mode, scanning electron microscopy, thermal and electrical properties were characterized. Applications such as volatile organic compound sensing and pressure sensing were demonstrated.