

Sustainable Carbon Materials for Enhanced Composites and Energy Storage

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Abstract: Carbon materials play a crucial role in improving the properties of polymer and pitch composites, offering benefits such as enhanced conductivity, mechanical strength, abrasion resistance, UV protection, and acting as pigments. Graphitic carbons also are indispensable as anode materials for batteries and capacitors. In our research, we focus on enhancing the mechanical and electrical properties of composites while reducing process temperature requirements, upgrading precursors through reactive plasma treatment, surface modification of carbon blacks and carbon fibers, and utilizing laser-based fast annealing techniques. We have formulated several strategies for obtaining upgraded as well as alternative precursors and developing approaches for achieving high graphitic quality at lower heat treatment temperatures. A reactive plasma containing CH₄ or H₂ has been used to upgrade hydrocarbon precursors by increasing the H/C ratio which leads to graphitic quality. We have additionally pioneered a method to convert conventionally deemed non-graphitizable precursors into graphitic carbons. As a different approach, the emergence of graphitic order can be catalyzed by the addition of a templating or structure-directing agent such as graphene to pitches, polymers, and waste plastics. Our major process innovation is upcycling waste plastic into graphitic carbon, which addresses three pressing challenges – the escalating demand for graphite, the declining availability of precursors, and the ever-growing burden of plastic waste.