Unveiling the Structural Parameters of Graphitic and Non-graphitic Carbons Derived from Biopitch Precursors

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Abstract: This study presents an experimental analysis of the development of innovative carbon materials, focusing on graphitic carbon (GC) and non-graphitic carbon (NGC) derived from sustainable biopitch precursors through various processes, including catalytic fast pyrolysis, carbonization, and graphitization. carbonization and graphitization processes. catalytic fast pyrolysis and phenol extraction produced a deoxygenated biopitch leading to a GC with superior graphitic structures. In contrast, CFP alone produced a biopitch with high oxygen content resulting in NGC consisting of varied cross-linked lamellae that inhibited crystalline growth. The research further examined the impact of varying heating temperatures on the structural parameters, morphology, crystal structure, and molecular characteristics of both GC and NGC. X-ray diffraction (XRD) analysis revealed that GC samples exhibited a lower d_{002} value and significantly larger crystallite diameter (L_a) and stacking height (L_c) compared to NGC samples. High-resolution transmission electron microscopy (HRTEM) images supported these findings, showing well-defined, long-continuous graphitic lamellae in GCs, while NGCs displayed extensively intertwined ribbons and curved lamellae, even at 2500 °C. Additionally, a custom in-house fringe-analysis algorithm developed in MATLAB was employed to extract fringe length and tortuosity statistics from HRTEM images. Raman spectroscopy confirmed that GCs possess a crystalline structure with long-range order, whereas NGCs lack such order. The outcomes of this research offer significant contributions to materials science and engineering, providing valuable insights into the development of sustainable carbon materials with optimized structural properties for a wide range of applications.