A facile method for preparing carbon nanosheets based on silk protein

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Carbon nanosheets (CNS) have attracted significant attention from both academic and industrial researcher due to the potential for creating CNS-based advanced materials and composites with tunable chemical functionality, as well as electrical, mechanical, and optical properties. One of the facile pathways to generate the two-dimensional carbon nanosheets is pyrolysis of a molecularly thin film made of polymeric carbon precursor. In this work, we successfully fabricated carbon nanosheets using a biopolymeric carbon precursor, silk protein, with simple spin-casting and carbonization process. Through a spin cast method, silk protein thin films with thickness ranging from 10 to 100 nm were prepared using different protein concentrations and spin speeds. With increasing heat treatment temperature up to 1200 °C in nitrogen, the formation of nanometric thin carbon nanosheets was controlled. The evolution of the carbon structure as a function of carbonization process parameters was investigated using surface profilometry, atomic force microscopy, X-ray photoelectron spectroscopy, Raman spectroscopy, and field-emission transmission electron microscopy analysis. Through the development of graphitic carbon structure, silk protein-based carbon nanosheets showing good transparency and electrical conductivity (transmittance and the sheet resistivity up to 91.6% at 600 nm and 1.1×10^2 kΩ/sq, respectively) were obtained, which is comparable to those of other carbon nanosheets or graphene-derived carbon thin films. Our approach has advantages such as the use of natural polymeric material, solution processability, and tunability of film properties. Hence, this work paves the way for promising scalable and eco-friendly manufacturing of advanced carbon nanomaterials based on the carbonization of biomolecular structures.