J Nanomaterials & Molecular Nanotechnology, Volume 8
DOI: 10.4172/2324-8777-C1-057

Highly thermal stable conducting pyroprotien fibers

Hyoung-Joon Jin
Inha University, South Korea

Silk is natural structured material composed of mainly two kinds of amino acids, glycine and alanine up to 80%, resulting in the highly conserved repeat units such as poly-(Gly-Ala) and poly-Ala domains. These repetitive peptide domains promote the polypeptides to construct the β-sheet conformations by numerous inter-/intra-hydrogen bonds, the most stable secondary structure in proteins. And the parallel alignment of these strong β-sheet crystals along the fibre axis results in mechanical robustness and chemical stability of silk. Moreover, the β-sheet crystals are not burned out even after pyrolysis and restructured to form unsaturated or aromatic structures by heating above 350 °C. And by further heating by 2,800 °C, they developed into pseudo-graphitic structures. However, although the exceptional theoretical modulus and strength of graphite up to ~1 TPa and ~120 GPa, respectively, the silk-derived fibres with disordered graphitic structures possess poor mechanical properties even hard to measure. Here, I demonstrated that a long-range ordered graphitic structure along the fibre axis can be realized from the inherent microstructure of silk through simple heating with axial stretching. The hexagonal carbon layers, pyroproteins, induced from the β-sheet protein molecules maintain the parallel alignment along the fibre axis and were developed into highly ordered sp^2 carbon structure by further heating up to 2,800 °C, resulting in the remarkable tensile strength and Young's modulus up to ~2.5 GPa and ~450 GPa, respectively. Considering that in the early development stage, the carbon fibres produced from the conventional precursor, polyacrylonitrile, revealed only ~ 1GPa and ~100 GPa of tensile strength and Young's modulus, respectively, these pyroprotein-based fibres prepared with a facile process show a great potential to surpass the strongest fibres available today and the lightweight and physicochemical-/thermo-stable characteristics compared with traditional inorganic materials provide them with extensive applications in aero-space, automobile, and civil engineering. In addition, the bio-derived fibres consisting of the large conjugated aromatic domains reveal the high electrical conductivity up to 4.37×10^3 S/cm, expanding their application fields to the high-technology industries such as energy storage/conversion system, e-textile, robotics, bio-electronics, and bio-medicals.

hjjin@inha.ac.kr