Aligned CNT fibres and multifilament fabrics: mechanical analysis and integration into structural composites

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High specific tensile properties of carbon nanotube (CNT) fibres produced by the Floating Catalyst CVD synthesis make them attractive reinforcing elements for structural composites [1]. However, the possibility to produce macroscopic unidirectional CNT fabrics with mechanical performance being at the same level as that of individual CNT fibres is one of the major challenges [2].
In this work, we demonstrate the merit and feasibility of synchrotron wide- and small-angle X-Ray scattering (WAXS ad SAXS) in obtaining accurate structural descriptors [3] for hierarchical CNT ensembles, which longitudinal mechanical properties are strongly dominated by the coexisting porosity, imperfect packing, and misalignment of constituent CNTs. By treating CNT fibres as a network of fibrillary crystallites and defining the corresponding CNT bundle orientation distribution function through static and in-situ WAXS/SAXS measurements, we introduce the micromechanical model [4] that accurately describes the tensile properties of highly-aligned CNT fibres in the elastic and plastic regimes.
Next, we present the advantages of the direct gas-phase synthesis in merging multiple CNT aerogel filaments into a fully integrated continuous network and the approaches of post-synthesis stretching that render the multifilament CNT fabrics with enhanced alignment. We then extend WAXS/SAXS analysis to CNT fabrics to identify the structural evolution in stretching and related tensile performance. Such fabrics with controlled alignment could be finally integrated as electrodes into the structural composites with energy-storing capabilities [5], and the perspectives of using them in composite manufacturing will be briefly presented.

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