Prospective ways for production of long aligned carbon nanofiber strands

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Carbon fiber science and technology is one of the most vividly developing branches of materials science. Great promises are related with carbon fibers based on long aligned strands of carbon nanofibers as described in our earlier work [1] in detail. The high-strength and high-modulus carbon nanofibers can become a cheaper alternative to carbon fibers based on traditional technology of carbonization/graphitization of fibrous precursors (PAN, viscose, pitch, lignin, etc.). Indeed, the tensile strength of an individual nanofiber may exceed 30 GPa while the best fibrous precursor-based fibers never show tensile strength higher that 7 GPa. Moreover, the carbon fiber production based on catalytic growth of nanofibers would include simpler technological chain and no annealing at the temperatures of around 2000°C, which imply very complex and expensive equipment and extraordinary energy expense.

Here we consider prospective ways for production of long aligned carbon nanofiber strands. Several research groups throughout the world have started research and development in this area since recently. Approaches of making carbon nanofibers via long single wall carbon nanotubes "smoke" or via multiwall carbon nanotube/nanofiber strands or via multiwall carbon nanotube forests are analyzed. The problems of providing proper quality of the future technological fibers such as length, morphology, crystallinity of individual fibrilles are presented. The transition from as-grown material to spun fibers by spinning threads is shown to be as important as the growth itself.

The results of laboratory-scale synthesis of long strands of carbon nanofibers are presented. It is shown, in compliance with our earlier work [1], that catalytic synthesis at very moderate temperatures of 1050°C during 3 hr may give centimeter-length strands of carbon nanofibers suitable for spinning into threads. Characterization by optical microscopy, TEM, SEM, TGA and XRD showed that the product of catalytic growth is dominated by long strands consisting by individual long carbon nanofibers with tubular structure. Length of individual carbon nanofiber varies in the range 7-10 cm, while diameter can be from 10 to 100 nm. No non-CNT carbon was observed.

The results show the possibility of production of very long of strands of carbon nanofibers suitable as precursor for manufactoring super-strength carbon threads and fibers.

[1] V.Z.Mordkovich, Ultra-high strength carbon nano-fibres. *Khim. Prom. Segodnya* **2**, 12 (2003).