PROGRESS ON HIGH-PERFORMANCE CONTINUOUS NANOFIBERS AND STRUCTURAL NANOCOMPOSITES

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Development of advanced fibers and composites in the second half of the 20th Century has revolutionized the field of structural materials. However, new fiber development has been mostly evolutionary in the last two decades. It is well-known that fiber properties can increase dramatically with their diameter decrease. However, conventional mechanical spinning techniques cannot produce fibers with diameters smaller than about two micrometers. Most reinforcing fibers are many times that diameter due to trade-offs between cost and reliability. Recently, there was a rapidly growing interest in using nanotechnology to further improve fiber properties. Carbon nanotubes have been used as nanoreinforcement in polymer and carbon fibers and pure CNT fibers have been produced by several techniques. However, the formidable issues with CNT alignment, high volume fraction, interfacial stress transfer, and the potential health issues are yet to be resolved and no CNT superfiber has yet been demonstrated. This presentation will review the state-of-the-art and recent breakthroughs in the author's group on an alternative nanotechnology, i.e. continuous nanofibers produced by electrospinning. Recent progress on nanomanufacturing of individual nanofilaments and nanofiber assemblies will be discussed. Prospects of modeling-based precision nanomanufacturing of complex hierarchical 2D and 3D nanofilamentary architectures will be analyzed. Results of nanomechanics testing of individual nanofibers and pioneering discovered nanoscale size effects will be presented and discussed. Unique new simultaneously superstrong / tough continuous nanofilaments for structural applications will be reported for the first time. Mechanics of nanofiber assemblies and networks will be analyzed based on experiments and simulations. Possibility of further significant improvement of fiber strength and toughness by controlled lateral interaction of nanofilaments will be demonstrated. Recent breakthroughs on nanofiber-reinforced supernanocomposites (defined as nanocomposites exceeding the properties of conventional advanced composites [3]) will be presented and discussed. Recommendations on the cost-effective designs of structural nanocomposites for near-to-medium term applications will be formulated. Brief overview of other nanofiber uses will also given, including applications in biomedicine and sensors/actuators.

References

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