A New Concept of Carbon Nanotube based Textiles for Civil Protection Services

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Up to now a lot of research has been done in the field of protective textile. Body armour materials have traditionally been designed to protect the wearer against any kind of weapon threats. Which are the basic concepts of body armour? First, it should stop weapons' bullets before they completely penetrate the armour and reaches the wearer's body and second, it should spread the bullet's energy over a larger portion of the body armour, so that the final impact causes less damage.

Several new fibers and construction methods for bullet-proof fabrics have been developed besides woven Kevlar®, such as DSM's Dyneema®, Honeywell's Gold Flex® and Spectra®, Teijin Twaron's Twaron® and Toyobo's Zylon®. These high performance fibers are characterized by low density, high strength and high energy absorption. However, to meet the protection requirements for typical ballistic threats, several layers of fabric are required. It is also frequently to improve the body armour with stab resistant, materials including for example metal ring mesh, layers of titanium foil, rigid metal, ceramic or composite plates are utilized. The resulting bulk and stiffness of the armour limits the wearer's mobility and agility. There is an obvious need to develop flexible and lightweight protective body armour.

This gap can be filled by carbon based materials. Since Iijima's report on carbon nanotubes (CNT) in 1991 [1], scientists have been attracted by CNT's unique atomic structure and properties. Because of the combination of low density, nanometer scale diameters, high aspect ratio, and more importantly, unique physical properties such as extremely high mechanical strength and modulus, CNTs are ideal as potential reinforcing filler without adding extra weight and contributing with excellent performance. In this context, a Canadian company recently announced a line of custom-fitted suits by several "sheets" of carbon nanotube fabric in its lining that will provide to the wearer a certain level of protection from bullets and knives. [2]

The inclusion of CNTs in a polymeric matrix holds the potential to improve the host material's mechanical, electrical or thermal properties by orders of magnitude well above the performance of traditional fillers. The challenges for developing high performance polymer/CNTs composites include the dispersion of CNTs in the polymeric matrix and interfacial interactions to ensure efficient load transfer from the polymeric matrix to the CNTs. Carbon nanotubes are usually present in bundles and exhibit a highly aggregated state in the polymeric matrix because of the strong inter tube Van der Walls force between the tubes, which holds the bundles together. The challenge of achieving efficient CNT dispersion and orientation within the polymer composite poses a substantial obstacle to the development of relevant beyond the state of the art fabrics. In other words, the mechanical properties of CNT composites fibers are highly dependent on CNT loading, dispersion and orientation, as well as pertinent to the polymer matrix characteristic properties.

In order to obtain desirable polymer/CNTs composites, homogeneous dispersion of CNTs in polymeric matrixes is the prime task. It is in that sense that a new Raman spectroscopic methodology has been very recently proposed by our group in order to monitor the weight fraction of MWCNTs in polymeric composites. [3] The orientation of the CNTs in the polymeric fibers, the concomitant polymer induced crystallization and the resulting mechanical strength have been evaluated. The orientation of

CNTs in synthetic fibers has been investigated with polarized Raman spectra and IR dichroic ratio, while tensile tests have been performed to evaluate the mechanical properties.

References

[1] Iijima S., Nature, 354 (1991) 56-58.
[2] http://garrisonbespoke.com/custom-suits/bulletproof-suit/ (accessed June 16, 2014)
[3] Bounos G., Andrikopoulos K.S., Karachalios T.K. and Voyiatzis G.A., Carbon, 76 (2014) 301-309.

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