MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialised Technologies, Including Nanotechnology (8)

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CARBON NANOTUBE-REINFORCED STRUCTURAL COMPOSITES FOR SPACECRAFT APPLICATIONS ENABLED BY THE POPTUBE APPROACH

Abstract

An ideal candidate to accomplish the reinforcement of the matrix and interphase zone of FRPs is carbon nanotubes (CNTs), because of their superior mechanical properties and excellent thermal and electrical properties. Direct dispersion of CNTs into the matrix of composites has been shown to be very difficult. A more effective way to reinforce FRPs using CNTs is to grow CNTs directly on the reinforcing fibers/fabrics. A novel method, referred to as the PopTube Approach, has recently been developed at The University of Alabama and Auburn University. This method uses microwave irradiation to grow CNTs in 15-30 seconds at room temperature in air, without the need for inert gas protection or additional feed stock gases. Compared to other existing manufacturing methods of CNTs, the PopTube Approach enjoys many advantages: little damage/chemical alteration is induced in the fibers; high-yield, large-scale manufacturing requires only simple equipment; and energy efficiency and cost effectiveness is greatly enhanced. This novel method paves the way for the next generation of structural spacecraft materials by providing a practical means of producing large-scale CNT-reinforced structural composites. In this study, laminate composites were manufactured using carbon fiber fabrics treated with the PopTube Approach. Several tests were considered as a means of characterizing this novel method. In each test, a PopTube Approach-treated group (with CNTs) was considered, in addition to a control group (without CNTs). One test in particular, the double cantilever beam (DCB) test, shows especially promising results. DCB testing, which was carried out according to ASTM D 5528, shows that this novel method can improve the Mode I fracture toughness of laminate composites by approximately 44%. This enhancement - coupled with the method's simple, scalable, inexpensive, and efficient nature - solidifies the PopTube Approach's viability in producing CNT-reinforced hybrid composite materials for spacecraft applications.