Cryogenic Treatment of Glass Fabric Epoxy Composites by Incorporating Cnt-Al_2o_3 - A Review

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Abstract

The multi-scale hybridization of carbon nanotubes (CNTs) with micro-particles in polymers offers new opportunity to develop high performance multifunctional composites. In this review, hybrid fillers comprised of CNTs directly grown on alumina micro-spheres by chemical vapor deposition were incorporated into epoxy matrix that was then reinforced with woven glass fibers. After that the composites are subjected to cryogenic treatment to increase its mechanical properties. This review reveals the potential of forming fiber-reinforced composite by using multi-scale carbon hybrids with the help of cryogenic treatment.

Keywords - *glass fabric, CNTs, cryogenic*

I. INTRODUCTION

Glass fiber-reinforced laminated composites are now widely used as structural materials due to their high specific modulus and strength, providing considerable weight reduction relative to metallic materials. The fibers play an important role on the load carrying capacity. However, their out-of plane properties are strongly dependent on the polymer matrix properties and the fiber/matrix interfacial adhesion. In general, the weak out-of-plane properties of fibrous composites are mainly attributed to the matrix dominated cracks at low strain and inefficient stress transformation. There have been several attempts toward enhancing mechanical properties of the fiber/polymer composites by using modified matrix.

On the other hand, recent advances and breakthroughs in nanoscale science and engineering have provided new opportunities to develop the composite materials with improved performances. In particular, carbon nanotubes (CNTs) with excellent mechanical properties are considered as attractive candidates for the reinforcement materials. Much attention has been paid to the hierarchical composites comprised of the CNTs modified matrix reinforced with the conventional micro-scale fibers. These hierarchical composites are synchronously reinforced by both nano and micro-scale fillers. The CNTs presence was demonstrated to potentially improve both the in-plane matrix dominated and out-of-plane properties of the composites.

However, the incorporation of CNTs into fibrous composites remains a challenging task. One hindrance to prevent the utilization of CNTs from being used for matrix modification is the difficulty in achieving their good dispersion in the matrix, because CNTs tend to agglomerate and entangle due to van der Waals attractions. Moreover, a strong interfacial interaction is required to obtain efficient load transfer from matrix to CNTs. Hence, the poor dispersion and weak interfacial bonding can limit the reinforcing effectiveness of CNTs or even deteriorate the composite properties. Another obstacle is the processing difficulty induced by the increased viscosity of polymer matrix due to CNTs introduction. Considering these issues, a number of approaches, such as stirring, high shear mixing, ultrasonication, chemical functionalization have been proposed. Good dispersion of CNTs not only creates more filler surface for bonding with the epoxy, but also prevents aggregated filler from acting as a stress concentrator which can be detrimental to mechanical performance of the synthesis. The addition of amino-functionalized CNTs into the carbon fiber reinforced composites has capacity to improve flexural strength and interlaminar shear strength of the composites. Noteworthy, some researchers proposed the multi-scale hybridization of CNTs with various types of microparticles, the CNT structure and hybrid organization can be tailored by adjusting synthesis parameters. With the addition of hybrids into poly matrix, CNT dispersion is uniform and improved interfacial properties were achieved . It is more recently that the CNT–graphene nanoplatelet (GnP) and CNT–silicon carbide (SiC) hybrids were used as high-performance reinforcements in the composites. Nevertheless, the introduction of CNT-micro particle hybrids into the traditional glass fabric composites to prepare multi-scale fibrous composites has not yet been fully reported. Prompted by this, we focus on the potential synergistic reinforcing mechanism between microfibers and hierarchical hybrid fillers, which can facilitate the design and production of high performance composite materials. Bearing in mind the above deficiencies of existing techniques, the present review aims to develop an insight into the influence of CNT–Al2O3 addition on incorporated properties of traditional glass fabric reinforced composites. As a major ceramic material commonly used for structural applications due to its high specific stiffness, Al2O3 was selected as the binder for CNTs. CNT–Al2O3 hybrids comprised of well-aligned CNTs forming six-orthogonal branches on spherical Al2O3 micro particles were synthesized by chemical vapor deposition (CVD). Combining Al2O3 with CNTs may be helpful with the dispersion of CNTs in the polymer matrix. Hence, with using help of ceramic micro-beads ‘vehicles’, it may be much easier to disperse CNTs by conventional methods. Multi-scale glass fabric/epoxy composites were prepared by incorporating plain woven glass fabric into the epoxy matrix modified with CNT–Al2O3 hybrids.

II. GLASS FIBRES EPOXY COMPOSITES

Glass fabric reinforced composites are becoming of great importance in many applications such as in the automotive and aerospace industry. This type of composite material is of great importance because of its unique properties compared to metals used in the industry today. Some of the advantages of using this material are its high strength, ease of fabrication, low cost, and impact resistance.

Figure.1.Glass Fabric Epoxy Composites

III. CARBON NANOTUBES-CNTs

Carbon nanotubes (CNTs) are allotropes of carbon with a nanostructure that can have a length-to-diameter ratio greater than 1,000,000. These cylindrical carbon molecules have many properties that make them potentially useful in many applications in nanotechnology. Their area of surface, strength, stiffness and resilience has led to much excitement in the field of composites. Nanotubes are two types. They are single-walled nanotubes and multiple walled nanotubes. Several Techniques have developed to produce nanotubes in different size, including, chemical vapor deposition, saline solution method, flame synthesis method,etc. The properties and characteristics of CNTs are being researched heavily by scientists. Overall, recent studies regarding CNTs have shown a very promising glimpse of what lies ahead in the future of nanocomposites.

The last few years have witnessed the discovery, development and, in some cases, large-scale manufacturing and production of novel materials that lie within the nanometer scale. Such novel nonmaterial’s consist of inorganic or organic matter and in most cases have never been studied in the context composites. Carbon nanotubes (CNTs) are one of them. CNTs are allotropes of carbon. They are tubular in shape, graphite made. CNTs have various properties that make them useful in the field of nano technology. They are nanometers in diameter and several millimeters in length and have a very broad range of properties of thermal properties vary with kind of nanotubes defined by its diameter, length and wall nature. Their unique surface area, stiffness, strength and resilience have led to much excitement in the field of nanotechnology.

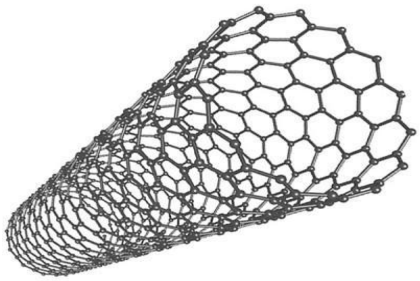

Figure.2.singlewall carbon nanotubes

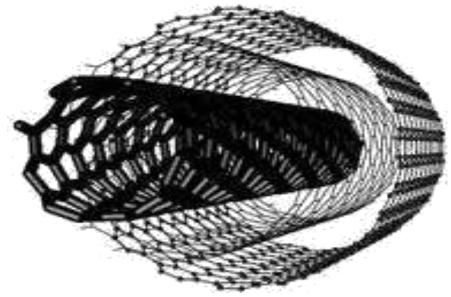

Figure.3.multiwall carbon nanotubes

IV. EXPERIMENT

The CNT–Al2O3 hybrids with multi-walled CNTs grown on the Al2O3 particles were synthesized by CVD Epoxy resin was used as matrix material.The multi-scale glass fabric/epoxy composites were respectively prepared by introducing glass fabric into the epoxy matrix and with fillers, namely,CNT–Al2O3 hybrids. The fabrication includes: (1) preparation of the epoxy/particle suspension; and (2) impregnation of the suspension into a mold containing the glass fiber performs. For comparison, the glass fabric/neat epoxy composites were also prepared using neat epoxy to serve as reference samples. The fillers were dispersed into the matrix using three-roll-milling based on a well-established protocol. The gap size between the adjacent rollers was set to 50 lm and rotation speed was set to 80 rpm. The dwell time of the obtained suspension on the rolls was about 10 min.After collecting the suspensions, the curing agent was added at a mass ratio of 3:1 (epoxy: hardener) and then mixed for 10 min under mechanical stirring. The glass fabric/epoxy composites were prepared using a combination of hand lay-up and hot compression. The glass fabric layers were properly stacked into four plies and the fiber orientation was kept constant without alternating warp direction. The degassed epoxy suspensions above were spread uniformly over each fabric layer and the preformed composite laminates were put into a vacuum bag. After degassing, the temperature was increased to 50 °C at a rate of 5°C/min and the laminates were cured under 3 MPa at 60°C for two hours in the mold. After curing process, the system was cooled gradually down to the room temperature at a rate of 2°Cmin, so as to avoid the unwanted shrinkage in the laminates. Finally, the cured panel was taken out and post cured in an oven for 15 h at 60 °C under atmospheric pressure.

V. HEAT TREATMENT-CRYOGENIC PROCESS

Heat Treatment is the controlled heating and cooling of metals to alter their physical and mechanical properties without changing the product shape. Heat treatment is sometimes done inadvertently due to manufacturing processes that either heat or cool the metal such as welding or forming.

Cryogenics: A low-temperature environment is termed a cryogenic environment when the temperature range is below the point at which permanent gases begin to liquefy. Cryogenics, deals with producing and maintaining environments at temperatures below about 173K (-148°F [-100°C]).liquid nitrogen is used as a cryogenic element due to availability. Shallow cryogenic treatment method is used for the composite materials.

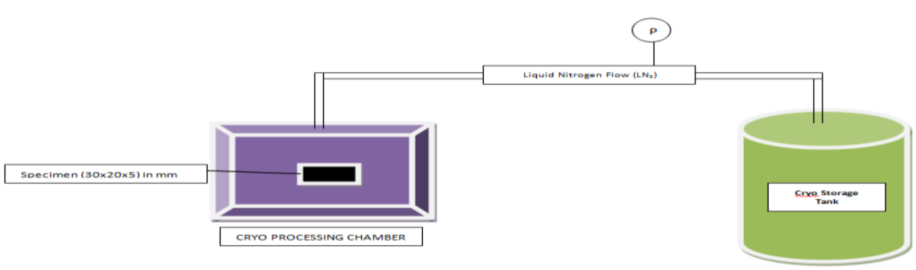

Figure.4 Cryo - processing layout.

VI. CONCLUSION

According to previous journals and reviews, applications of cryogenics on composites will improve the mechanical properties of CNT-AL2O3 hybrids on glass fabric. Well definitely noticed that the crack growth resistance, toughness are improved 12% and 11% than normal composites. It will effect on good mechanical and thermo-mechanical properties. This can be revealed by testing it. Although further optimizations are still required, the introduction of multiscale hybrids endows the fibrous composites with enhancement of properties, which provides greater development for applications.

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