Article

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Improvement of mechanical and thermal properties of hybrid composites through addition of halloysite nanoclay for light weight structural applications

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Abstract

In this work the effect of stacking sequence of Carbon (C)/Glass (G) fibers and halloysites addition (1, 3 and 5 wt.%) on the mechanical and thermal properties of the hybrid composites were explored. The composite laminates were prepared by using Vacuum Assisted Resin Infusion Technique (VARIT). The outcomes disclosed that the hybrid composites having sequence of $C_2G_3C_2$ (2-Carbon/3-Glass/2-Carbon layers) showed better overall properties. Moreover, the addition of halloysites enhanced the mechanical and thermal properties of the $C_2G_3C_2$ hybrid composites. In particular, the hybrid composites added with 3 wt.% of halloysites showed higher overall properties among the other hybrid composites investigated. Finally, the morphological analysis was performed on the fractured surface of mechanical tested composites to study the failure mechanisms occurred. Based on the obtained results it can be concluded that the

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$C_2G_3C_2$ hybrid composites added with 3 wt.% of halloysite could be a suitable alternative light weight material for automobile, aerospace and building structures.

Keywords
Carbon/glass fiber, VARIT, stacking sequence, halloysites, hybrid composites

Introduction

Nowadays the hybrid fiber reinforced composites are extensively used as structural components in aerospace, automotive, wind power sectors, railways and marine, where the heavy weight of conventional materials such as iron and steel etc., is posing as the major obstacle [1,2]. The concept of reinforcement hybridization has made it convenient to customize/tailor the materials according the market/end user requirements. Most importantly, the hybrid composites made up of glass and carbon fibers are superior in terms of strength and have less weight than the plain glass fiber incorporated composites [3,4]. Furthermore, the incorporation of glass fibers along with carbon fibers reduced the cost of the resulting hybrid composites without sacrificing the durability and strength.

Academicians, researchers, scientists and industries have been continuously working on enriching the mechanical properties of the hybrid composites to use it for wide variety of structural and engineering applications. The critical factors which influence the composite properties are type of reinforcements, stacking sequence of reinforcements, volume/weight fraction of reinforcements, type of polymers and type of fillers [5,6]. Dong and Davies [7] explored the flexural properties of carbon and glass fiber composites as a function of stacking sequences and concluded that the bending (flexural) property was stacking sequence dependent. Similarly, Monte Vidal et al. [8] from his findings concluded that the properties of glass fiber composites could be enhanced through hybridization by keeping the carbon fibers at the external (top and bottom) positions or by introducing different stacking sequence of reinforcements. In another work, Hung et al. [9] examined the impact response of carbon/glass hybrid composites having different sequence and concluded that better performance of hybrid composites could be obtained by placing the carbon fibers as top and bottom layers. In this way, some literatures reported about the improvement of mechanical properties using different stacking sequences [10–12]. Moreover, the processing technologies such as hand lay-up, compression molding, autoclave, pultrusion, resin transfer molding, filament winding etc., used for the fabrication of hybrid composites also affect its overall performance. Among these methods, autoclave produces high quality composites with good mechanical properties. However, this method is very expensive with low productivity. In contrast, the VARIT produce composites with similar characteristics like autoclaved composites at relatively low cost [13]. Furthermore, this