Investigation of Dynamic Mechanical Behavior of Nanosilica Filled Carbon-Kevlar-Epoxy Polymer Hybrid Nanocomposite

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ABSTRACT

Reinforcement of epoxy-carbon-Kevlar fabric composite with the addition of nanosilica has resulted in the evolution of new hybrid polymer nanocomposite, which results in the improved mechanical properties of polymer hybrid nanocomposite. The current investigation concentrated on the dynamic mechanical behavior of unfilled and nanosilica filled carbon-Kevlar-epoxy polymer composite with five and four layers of carbon and Kevlar woven fibers respectively with epoxy matrix (5C4K). Nanosilica was mixed into the epoxy at different weight percentages (wt.%) of 0, 0.5, 1.0, and 1.5. The laminates were fabricated using the vacuum-assisted resin infusion moulding (VARIM) technique. The dynamic mechanical properties, storage modulus, loss modulus, damping factor (tan delta), and glass transition temperature was investigated using a dynamic-mechanical analyzer at temperature ranging from 25 to 165 degrees Celsius. The test specimens were prepared in accordance with the ASTM D4065 standard to investigate dynamic mechanical analysis (DMA) of the hybrid polymer nanocomposite. The results of the tested specimens for dynamic mechanical behaviors of carbon-Kevlar-epoxy hybrid nanocomposites are very much influenced by the presence of nanosilica. The storage modulus, loss modulus for nanosilica added hybrid polymer composites were more than the unfilled ones and the damping factor (tan delta) was observed more in an unfilled composite.

1. INTRODUCTION

Polymer composites with nanofiller find extensive engineering applications in aerospace, space, automobile, marine, infrastructure, sports, oil and pipe industries due to enhancement in mechanical, electrical and thermal properties compared with the conventional materials [1, 2]. These properties of polymer composites still can be enhanced by hybrid polymer composites with nanofillers. The selection of matrix material and reinforcement material plays an important role for the production of polymer composite material which will have higher mechanical, electrical and thermal properties than the conventional one.

The commonly used matrix material for the fabrication of polymer composite is epoxy resin, which has low shrinkage after curing, impact resistance, low weight, ease of manufacturing and processing, excellent chemical resistant, excellent adhesion, electrical resistant, and heat resistant properties. Reinforcement of epoxy matrix with nanofillers improves crack propagation resistance as well as the thermomechanical properties of nanocomposites [3].

Fibers are a powerful strengthening material in polymer composites. Carbon fibers has good properties like high strength, high modulus, good electrical and thermal properties. Kevlar fibers possess better properties like good impact resistance, low density and good toughness. These fibers are hydrophobic, the moisture absorption content is low [4-6].

A composite with at least two different types of fibres reinforced in a single matrix is referred to as a "hybrid polymer composite", which provide a synergistic effect such as enhanced mechanical properties. Hybrid composites offered, strength and stiffness, reduced weight/cost, better fatigue resistance, balanced thermal stability, fracture toughness, impact resistance compared to mono fiber composite [6, 7].

Hybrid Polymer nanocomposites have received very much attention from nanoscience academics and industries due to their great physical, mechanical, and tribological properties. The addition of nano-sized inorganic fillers such as silica, titania, aluminium oxide, multiwall carbon nanotube, halloysite, nanoclay has reformed the mechanical and physical properties of the hybrid polymer composites extensively [8-17].

Nanosilica is white and comes in crystalline and amorphous forms. Nanosilica is porous, has a large surface area, containing several hydroxyl groups as well as unsaturated residual bonds. The addition of nanosilica can enhance the strength, flexibility and durability of polymers composite [18-20].

The mechanical properties of polymer composites are significantly influenced by manufacturing procedures. The methods like hand layup, vacuum bagging method, vacuum assisted resin infusion molding, autoclave are mainly used for manufacturing the polymer composite. Among these methods, the mechanical properties are found to be high in autoclave method, but it is an expensive method of manufacturing. On the other hand, vacuum assisted resin infusion molding