Chapter 5
Architect of Polymer Nanocomposites for Aerospace Applications

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ABSTRACT

Polymeric nanocomposites are significant engineering materials predominantly due to their enormous potential to meet a spectrum of applications, particularly in improving the strength-stiffness properties, thermal properties, optical and electrical properties. The exploitation of polymer nanocomposites in the aerospace industry is found to be attractive in recent times, since they can provide significant strength to the components with lightweight characteristics. In addition, a wide variety of polymers can be tuned with carbon and non-carbon-based nanomaterials and deployed as archetypes in the structural components of aerospace applications. Accordingly, this chapter consider the key properties of different nanomaterials in polymers as a function of nano-scale approach. Furthermore, this chapter is also dealing with the challenges that need to surmount the technological enduring of the polymer nanocomposites for advancements in the aerospace structural applications in the coming future.

DOI: 10.4018/978-1-5225-7921-2.ch005

INTRODUCTION

Aerospace manufactures are searching for the multifunctional materials which could be appropriate for its component development. In general aviation, cost of the fuel account for the 50% of the operational expenditure. Accordingly, aerospace manufacturers are looking for the suitable materials that could replace the metals in order to reduce the weight. Further, changes in the design and uses of the composite materials have been resulted in decreasing the weight by 30% of the aviation vehicles. Similarly, most of the aircrafts and spacecrafts are working in harsh atmospheric conditions, subsequently aerospace manufacturers and researchers are aiming to develop novel new materials which are durable with higher thermo-mechanical properties (Baur and Silverman; Joshi and Chatterjee, 2016; Wang et al., 2002).

The aerospace structures made up of the polymers are vulnerable to the disintegration of the polymeric chains. Therefore, researchers are attempting various techniques for toughening the polymeric matrix by introducing micro or nanomaterials into it as a filler. In a polymer matrix, reinforcing fillers is bound together by weak intermolecular forces rather than chemical interactions. In such conditions the nanomaterials are capable to serve hundred times better task than microfillers even with lower volumes like 1-5% (Joshi and Chatterjee, 2016). Moreover, due to the high aspect ratio of the nanomaterials, they can provide more surface area to the polymer matrix for the specific interactions. Similarly, if the reinforcement elements were dispersed at the nanoscale, it can attribute strong bonding with the matrix which can eventually result in the discovery of novel composite materials.

Among the different composites, polymer nanocomposites (PNCs) seek enormous attraction owing to its light weight characteristics along with multiple functionalities. Different carbon and inorganic nanomaterials are currently exploiting in the construction of different structural and non-structural components used in the aviation industries. By the proper selection of the nanomaterial as filler, the properties such as mechanical strength, thermal stability, flame retardancy, electrical and optical properties of polymer matrix can be tuned. In the current situation inorganic materials like nanoclay, SiO_2, ZnO are commonly employed for improving thermal stability, conductivity and flammability properties of various polymers (Hajibeygi et al., 2017; Liu et al., 2005; Rathod et al., 2017). Similarly, carbon based nanomaterials like carbon nanotubes (CNTs), carbon nanofibers (CNFs), graphenes and their various modified forms are also used for the generation of different PNCs (Gohardani et al., 2014; Monetta et al., 2015). Recently, such composite materials are applied in various structural parts such as fairing, interior component, primary wings, fuselage and turbine engine fan blade of the aircrafts and space craft's components (Mallick, 2007).