

ABSTRACT

The innovation of light weight materials led to important developments in the fields engineering and medicine. Hence, this in turn initiated the development of composite materials to meet the global demands of light weight, high performance and environmental friendly materials with enhanced properties such as strength, stiffness, wear and corrosion resistance. Due to their superior properties such as high strength to weight ratio, stiffness to weight ratio, improved wear and corrosion resistance, fiber reinforced polymer composite materials are widely used for automotive, aerospace and chemical industrial applications. Brakes, clutches, bearings, bushes, gears, bolts and nuts, driving wheels are some of the tribological components used in machineries. In recent times, fiber reinforced polymer matrix composites are normally used as functional parts of the machineries subject to the tribological and mechanical loads. The addition of short fibers, continuous fibers and ceramic particulates/fillers as a first and/or second reinforcement with the fiber reinforced polymer matrix composites as hybrid composites significantly improve the mechanical and tribological properties of the composites considerably.

A comprehensive literature review was carried out to decide the choice of matrix and reinforcement materials. The present work aims at investigating the role of ceramic filler, ie., silane-treated silicon carbide particulates on the tribological characteristics such as wear and friction and mechanical characteristics such as hardness, tensile and flexural strength of carbon fabric reinforced epoxy matrix hybrid composites.

The objectives of the present study are listed below:

- To evaluate the mechanical properties such as hardness, tensile and flexural properties of unfilled and silane-treated SiC particulates filled bi-directional silane-treated carbon fabric reinforced-epoxy (C-E) hybrid composites.
- To evaluate the thermo-mechanical behavior of unfilled and silane- treated SiC particulates filled bi-directional silane-treated carbon fabric reinforced epoxy hybrid composites.
- To evaluate the influence of the various parameters such as sliding distance, applied load and sliding velocity on friction and dry sliding wear behavior of unfilled and silane-treated SiC particulates filled bi-directional silane-treated carbon fabric reinforced-epoxy hybrid composites.
- To evaluate the influence of the abrading distance, abrasive paper grit size and applied load on two-body abrasion and to evaluate the influence of the parameters such as abrading distance and applied load on three-body abrasive wear behavior of unfilled and silane-treated SiC particulates filled bi-directional silane-treated carbon fabric reinforced-epoxy hybrid composites.

All composites were prepared by hand layup technique and followed by compression moulding process. The mechanical tests were conducted using the Universal testing machine and Dynamic Mechanical Analysis setup. The tribological tests were conducted using the Pin-on-Disc wear testing machine and Dry sand rubber wheel abrasive wear testing machine. Tensile and flexural failed surfaces of samples and worn surface of samples were studied using the Scanning Electron Microscope.

The mechanical behaviours such as hardness, tensile strength, tensile modulus, tensile elongation at fracture and flexural strength of the unfilled and silane-treated SiC particulates-filled C-E hybrid composites were studied. The results reveal that silane-treated SiC-filled C-E hybrid composites exhibit higher mechanical properties when compared to unfilled C-E composites. This is probably due to improved adhesion with the matrix, high strength and stiffness of the silane-treated carbon fiber and SiC filler. Hence, the presence of the silane-treated SiC particulates can be said to enhance both adhesion and interfacial bonding between the silane-treated carbon fiber and epoxy matrix, thus proving to be beneficial in C-E hybrid composites. Dynamic mechanical analysis has been used to study the viscoelastic properties such as Glass transition temperature (T_g) and tan delta in response to temperature of the unfilled and silane-treated SiC- filled C-E hybrid composites. The glass transition temperature (T_g) of silane-treated SiC filled C-E hybrid composite increases with an increase of the silane-treated SiC wt. %, as the mobility of the matrix is condensed by hard SiC particles in the case of C-E hybrid composites.

Friction and dry sliding wear characteristics of unfilled and silane-treated SiC particulates-filled C-E hybrid composites for different applied load, sliding velocity and sliding distance were studied. Coefficient of friction of unfilled C-E composites was observed to be less at a minimum load and high at a maximum load, where as silane-treated SiC-filled C-E composites exhibit an almost constant coefficient of friction. Wear loss of both unfilled and silane-treated SiC-filled C-E hybrid composites was found to increase with an increase of applied load/sliding velocity. But silane-treated SiC-filled C-E composites have a minimum wear loss when compared to unfilled C-E composites. This can be attributed to a thin transfer film (consisting of

crushed SiC particles, broken fibers and powdered matrix) formed on the counterface during the dry sliding process, which helps in maintaining an almost constant coefficient of friction and minimum wear loss.

The two-body abrasive wear behaviour of unfilled and silane-treated SiC-filled C-E hybrid composites under the parameters of different applied loads and abrading distances were studied. The wear volume loss was found to increase linearly with the abrading distance/load. It was noticed that the lowest wear volume loss was found in 10% SiC-filled C-E composite. This can be attributed to the presence of SiC particles on the counter surface, which acts as a transfer layer and also as an effective barrier to prevent the large scale fragmentation of epoxy. The three-body abrasive wear experiments were conducted for unfilled C-E, silane-treated SiC-filled C-E samples as a function of various abrading distances under various loads. The wear volume loss of all samples was found to increase with an increase of the load and the abrading distance. 10% SiC-filled C-E composites showed an improved wear resistance when compared to other composites. This occurred due to the difference between the energy levels created on the surface of composite sample by its structure and the energy level generated by the speed/load on the rubber wheel penetration. In the case of silane-treated SiC-filled C-E hybrid composites, SiC particles were found to enhance the interfacial bonding between the fiber and matrix which in turn led to improved wear resistance.

The results of the study reveal that improved tribological properties and mechanical properties of carbon fabric reinforced epoxy matrix composites can be obtained by adding silane-treated SiC fillers.