ABSTRACT

Current and future waste management and environmental legislation require that all engineering materials from end- of- life products such as automobiles, aircraft, marine boats and wind turbines are recovered and recycled properly. As per European guidelines 2000/53/EC provided by the European commission, 85% of the weight of products especially automobiles had to be recyclable by 2015. This percentage of recyclable will be increased to 95% by 2025. In order to face balancing sustainability and cost, the automakers are invited to use natural fibers in composites. Presently an ecological threat has forced many countries to pass laws for using 95% recyclable materials in transportation industries. The using of natural fiber over synthetic based fiber have been increased in various industries like automotive, aerospace, marine, electrical and electronics, sports, recreation equipments and machinery office equipments due to light weight, recyclability, biodegradability, low processing cost, good relative mechanical properties and resistance to corrosion and fatigue.

This research work aims at studying the possibility of using flax fiber and bamboo fiber a natural fibers obtained from the bast of a plant of the Linaceae family (LinumUsitatissimum) and bamboo culm followed by removal of diaphragm and nodes respectively. This fiber is rich in cellulose, less density, less abrasion, low cost and abundant. Flax fiber is subjected to chemical treatment such as alkaline method and effect of this treatment on various properties of the fibers was studied. Composites were fabricated by using hand

layup followed by compression moulding techniques with the following investigations (i) Flax and bamboo fibers reinforced hybrid composites with different volume fraction (ii) Flax fiber reinforced epoxy composites filled with varying weight percentage of different fillers such as silicon carbide, alumina and graphite (iii) Flax fiber reinforced epoxy composites filled with varying weight percentage of silicon carbide and alumina.

The mechanical and physical properties such as tensile, flexural, impact, interlaminar shear strength, void content and water absorption of flax and bamboo fibers reinforced hybrid epoxy composites were studied. The hybrid composites were fabricated with different volume fraction of fibers. The results showed that the tensile, impact, flexural and ILSS are maximum for 40:0 (flax: bamboo) hybrid composites. The enhancement in the tensile and flexural strength of the hybrid composites were due to the addition of high modulus flax fibers compared to the bamboo fibers. It is observed that the presence of flax fiber in the epoxy resin raises the composite strength and modulus. The impact strength increases with increasing flax fiber. The reason being natural fibers contains higher cellulose content and lower micro fibril angle results in higher work of fracture in impact testing. Excellent bonding between the reinforcement and matrix is also responsible for the good resistance to crack propagation during impact test. The maximum Interlaminar Shear Strength (ILSS) of 3.52 MPa is obtained for 40:0 (flax: bamboo) hybrid composite among all hybrid composites due to increase in values with respect to fiber volume fraction. The void content decreased for 20:20 (flax: bamboo) composites due to tightly packed flax fiber and more compatibility towards epoxy resin. The percentage of water uptake capacity was higher in the hybrid composites with higher bamboo fiber content. The lower water absorption percentage of hybrid composites recorded less than 3.5% may be due to through encapsulation of flax fiber in the epoxy matrix.

The FTIR analysis is used to observe functional groups and to identify the changes in chemical compound of natural fibers. The effect of chemical treatment of flax and bamboo fibers was verified by FTIR analysis. The observation from the FTIR analysis confirms that the removal of lignin and hemicellulose is affected by chemical treatments. The SEM micrographs are used to observe the internal cracks, fractured surfaces and internal structure of the tested samples of the composite materials. From the SEM analysis, that the maximized strength values for 40% flax fiber volume fraction of composite which have good bonding strength, less fiber pull out and poor intra fiber delamination.

To overcome the drawbacks of polymers, for example, low strength and low stiffness and expand their applications in many fields, ceramic fillers such as silicon carbide (SiC), alumina (Al_2O_3) and graphite can be added to process polymer composites, which usually combine the advantages of their constituent phase. Composites were fabricated with varying weight percentage of different fillers such as silicon carbide, alumina and graphite. The mechanical properties of composites increase with increase in SiC up to 7 wt. %. Hence the optimum SiC for better mechanical properties of this present composite is found to be 7 wt. %. Likewise, optimally 5% NaOH treatment of flax fiber highly enhanced the interfacial bonding between fiber and resin. This phenomenon was examined by FTIR analysis and it leads to better mechanical properties related to the flax fiber.

The third part of the investigation was effect of SiC and Al_2O_3 on the mechanical and morphological properties of flax fiber reinforced epoxy composites. The incorporation of 2 to 10 wt.% of SiC and Al_2O_3 with flax fiber to form composites indicates that 8 wt.% of SiC yields the maximum mechanical properties. Beyond 8 wt.% of SiC content results in decreased

mechanical properties. The incorporation of SiC with flax fiber from 2 wt. % to 8 wt. % increases the ILSS, but in contrast a decrease in ILSS has been observed with increase in Al_2O_3. Thus it can be concluded that the obtained composites will acts as a low cost, lightweight and eco friendly composites to be used for a brake pad, on account of their better mechanical properties.