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Review

State of the art on tribological behavior of polymer matrix composites reinforced with natural fibers in the green materials world

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ABSTRACT

Natural fiber reinforced polymer composites have emerged as a potential environmentally friendly and cost-effective alternative to synthetic fiber reinforced composites. Therefore, in the past decade, a number of major industries, such as the automotive, construction and packaging industries, have shown a considerable interest in the progress of new natural fiber reinforced composite materials. The availability of natural fibers and the ease of manufacturing have tempted researchers to study their feasibility of their application as reinforcement and the extent to which they satisfy the required specifications in tribological applications. However, less information concerning the tribological performance of natural fiber reinforced composite material is available in the literature. Hence, the aim of this bibliographic review is to demonstrate the tribological behavior of natural fiber reinforced composites and find a knowledge about their usability for various applications that tribology plays a dominant role. This review presents the reported work on natural fiber reinforced composites with special reference to the type of fibers, matrix polymers, treatment of fibers and test parameters. The results show that composites reinforced with natural fibers have an improvement in tribological properties and their properties are comparable with conventional fibers. In addition, fiber treatment and fiber orientation are two important factors can affect tribological properties where treated fibers and normal oriented fibers exhibit better friction and wear behavior. This review is trying to evaluate the effect of test parameter including normal load and sliding speed on tribological properties, and the results vary based on type of reinforcement. Generally, due to their positive economic and environmental aspects, as well as their good tribological properties, natural composites are showing a good potential for employing in several applications.

1. Introduction

In the recent decade, polymers have become attractive materials for various applications due to several attractive properties, including light weight, ease of processing and cost-effectiveness. Hence, attempts have been significantly made to utilize polymers in different industrial applications, using various kinds of reinforcements including fibers that are incorporated into the polymers to increase their physical and mechanical properties. Thus, fiber reinforced polymer matrix composites are extensively attractive due to their light weight, biodegradability [1], high strength [2,3], high stiffness [4], good corrosion resistivity [5], and low friction coefficient [6] in many applications that are important in mechanical and tribological properties, from households to aerospace applications and, today, these materials are used in nearly all areas of daily life [7–16]. Due to increased environmental awareness and having more environmental regulations, the growing demand for using nonconventional materials leads to the development of renewable, recyclable, biodegradable, sustainable and ecofriendly materials [17–22]. There is a drawback in using natural fibers, such as pollution problems of processing, where processing can generate high levels of water pollutants, mainly organic wastes and leave residues. However, most of these residues mainly consist of biodegradable compounds, in contrast to the persistent chemicals, including heavy metals released in the effluent from synthetic fiber processing. On the other hand, the environmental benefits of natural fiber products accrue well beyond the production phase. Since the fibers are lighter in weight, they reduce fuel consumption as well as carbon dioxide emissions and air pollution [23]. Generally, two important advantages of natural fiber composites are recyclability and biodegradability of products, after a useful life.

1.1. Biodegradability

A possible solution to waste-disposal problems is using biodegradable polymers reinforced by natural fibers instead of traditional

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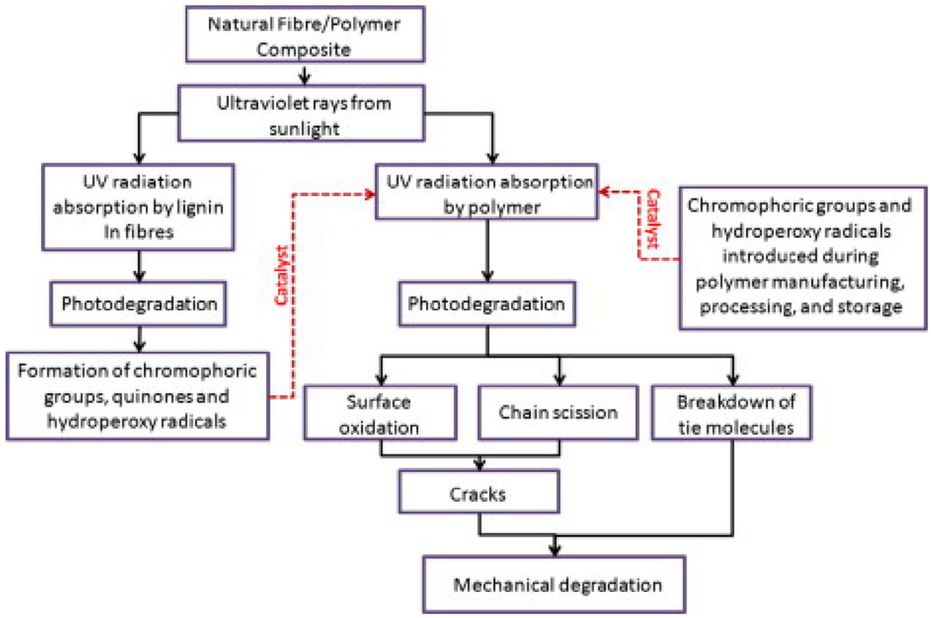

Fig. 1. UV degradation of natural fiber/polymer composite and its components [24].

petroleum-derived plastics. Direct sunlight can break the covalent bonds in organic polymers. It tends to cause yellowing, color fading, weight loss, surface roughening, mechanical property deterioration and embrittlement with more reduction in wetter condition. After weathering periods, because of degradation of fibers and matrix, the tensile strength of a composite is decreased. A schematic diagram of the degradation of natural fiber/polymer composite due to UV exposure is presented in Fig. 1 [24]. Fakhru and Islam [25] used FTIR spectrum to analyze polypropylene/saw dust composite compositions before and after exposure. The FTIR analysis shows the disappearance of functional groups due to breakdown of the corresponding groups. It is an evidence for degradation of polymer composites. Three peaks disappeared at peaks at 1725 cm^{-1}, 1646.9 cm^{-1} and 1376.6 cm^{-1}, which positively indicates the dissociation of the bonds; carbonyl (C=O), carbon–carbon double bond (C=C) and methyl group (CH_3) respectively. Furthermore, pure PP

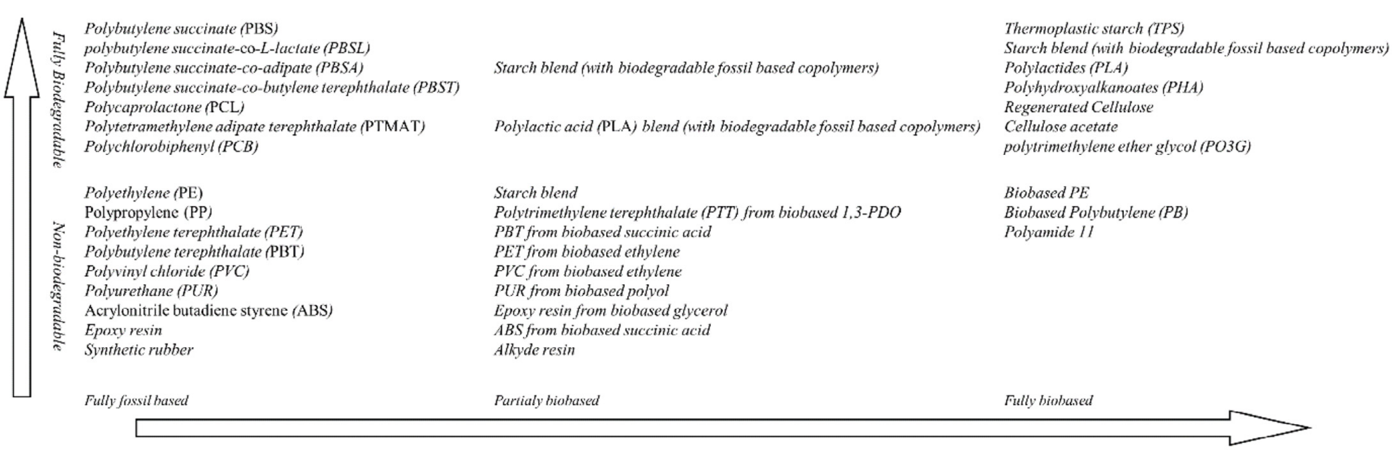

Fig. 2. Current and emerging plastics and their biodegradability [17].

Table 1
Applications of NFC in automobile [33–36].

Manufacturer	Model	Applications
BMW	3, 5, and 7 series	Door panels, headliner panel, boot lining, seat backs, noise insulation panels molded foot, and well linings
Audi	A2,A3, A4, A4, Avant, A6, A6, Avant, A8, Roadster, Coupe	Seat backs, side and back door panel, boot lining, hat rack, and spare tire lining
Ford	Mondeo CD 162, Focus	Door panels, B-pillar, and boot liner
Mercedes-Benz	Trucks	Internal engine cover, engine insulation, sun visor, interior insulation, bumper, wheel box, and roof cover
TOYOTA	Brevis, Harrier, Celsior, RAUM	Door panels, seat backs, and spare tire cover
Volkswagen	Golf, Passat, Variant, Bora, Fox, Polo	Door panel, seat back, boot lid finish panel, and boot liner