Recent developments in Polymer Matrix Composites – A review

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Abstract This paper presents the recent developments in polymer matrix composites (PMC). Polymer-based composites are widely used materials since the materials have good mechanical properties with low density. Polymer-based materials are used for many applications such as the aerospace industry, automobile industry, sports equipment, construction, and packaging industries. Recently nature fibers have been used as reinforcement materials to synthesize PMCs effectively. Polymer-based materials have been used in biomedical applications. This paper displays the summaries of synthesis, microstructure, and properties of recently reported various PMCs.

1. Introduction

The demands for the materials with specific and special properties are still live. The industries still looking for materials with good properties for various applications in different functioning environments [1]. Composite materials are the one class of materials that satisfy the requirement of industry people [2]. These materials are designed according to the required properties to be obtained [3]. Based on the type of matrix materials, composites are classified as a metal matrix, ceramic matrix, and polymer matrix composites [4]. Among the other type of composite materials, polymer one plays a huge role in the present technology due to its excellent physical, mechanical, and thermal properties [5-10]. Generally, PMCs posses better mechanical property, stiffness, eco-friendly, recyclable, and high surface to volume ratio [11-16]. A variety of fibers is used as reinforcement...
materials for developing the PMCs [17-21]. Recently natural fibers are introduced to develop those composites and much attention is given to natural-based bio-composites [22]. The selection of fibers and polymers is important in developing the PMCs with suitable properties [22-24]. Figure 1 displays the types of polymers used for the fabrication of PMCs.

**Figure 1.** Types of polymers

2. Natural fibers - polymer composites

Recently natural fiber reinforced polymer composites are possessing much attention among researchers. This section focuses on some of the natural fiber composites and their properties. Wang et al developed polymer composite reinforced by natural fibers and studied the machining behavior of the composites. They compared the conventional machining process with the ultrasonic machining process [25]. Fiore et al reported the effect of Na$_2$CO$_3$ treatment on the properties of the polymer-based composite which is reinforced by natural fibers. They tested the composites under marine conditions to apply these materials for marine applications [26]. Arrakhiz et al analyzed the properties of the polyethylene composites reinforced by natural fibers and reported the thermal and mechanical behavior of the composites. They suggested these composites can be used for low-density applications. They reported the alkali-treated fibers provided better bonding and thus the improved properties have been achieved [27]. Yicheng Du et al produced polymer composite (thermoset) with natural fibers and studied the creep behavior of the developed composites. They recommended these composites for light weight applications [28]. Tidarut Jirawattanasomkul et al produced natural fiber reinforced polymer composites and studied the structural characteristics of the same. They also compared their results obtained experimentally with standard codes of Japan [29]. Faissal Chegdani et al studied the impact of the orientation of fibers in natural fiber reinforced polymer composites during machining. They concluded that fiber orientation affects the cutting characteristics and chip formations during the machining of the composites [30]. Behnaz Baghaei et al reported the properties of thermoplastic composites reinforced by natural fibers with various weave patterns. They concluded that the satin fabric composite provided better mechanical and water absorption property [31].
3. Effect of fillers in PMCs
In addition to various fibers, recently filler materials are added to PMCs to improve the properties of the composites. Priyadarshi Tapas Ranjan Swaina and Sandhyarani Biswas reported the wear property of the epoxy-based composites reinforced with jute fibers. They studied the microstructure of the composites. They reported that the chemical treatment of jute fibers improved the wear properties of the composites [32]. Rakshit et al studied the epoxy-based composites reinforced by Mother of Pearl fillers and they reported that the addition of fillers improved the tension, flexural, and vibration property [33]. Ramazan Dalmis et al introduced Hierochloe Odarata fibers as reinforcememt to produce the polymer-based composites. They reported that it has 2.56 GPa of modulus and 105.7 MPa of tensile strength [24]. Hesham Moustafa et al studied the effect of fillers from seashell waste in the ABS composites on the mechanical and other properties. They reported that good mechanical and thermal properties have been obtained for the seashell filled composites [2]. Madhu et al produced Prosopis juliflora fibers reinforced polymer composites and reported that better properties can be achieved when the fibers are alkali-treated [34]. Abinash Panigrahi et al prepared epoxy jute composites with clams shell and reported that the introduction of fillers leads to a reduction of impact strength. They used a hand layup process to manufacture these composites [35]. Arul Sujin Jose et al analyzed the impact of aspect ratio on the mechanical properties of phenol formaldehyde composites fabricated with Prosopis juliflora fibers. They analyzed the microstructure of the composites using SEM [36].

4. Application of PMCs
PMCs have been widely used for various applications because of their excellent properties. The selection of matrix and fibers are important to achieve suitable properties. Figure 2 displays the types of factors that decide the performance of the composites. Faris AL Oqla and Sapuan reported the applicability of date palm fillers reinforced polymer-based composites for the automobile industry. They used natural fibers for fabricating the composites regarding the environmental aspects. Date palm fillers improved the mechanical properties and these have economical advantages also [22]. Mansor et al manufactured polymer-based composites for automobile brake applications. They used analytical methods and sensitivity analysis to find the most influencing parameters for composite fabrication [37]. Manojkumar et al used Prosopis juliflora as reinforcement in Glass-epoxy-based composite and reported that the addition of juliflora improved the mechanical properties and these composites could
be applied in structural applications [38]. Ananthu et al reported the mechanical properties of the PMMA composite which is reinforced by seashell. They recommended this composite for medical applications and suggested these composites are bio-nano composites. They concluded that this composite has better wear properties [39].

5. Conclusions
Properties and development of some recently developed PMCs have been discussed in this review paper. The mechanical properties of natural fiber-reinforced composites have been reported. The effects of various fillers and fibers on the properties of some composites are discussed. The various applications of the PMCs are discussed with respect to the properties and manufacturing methods of the composites. PMCs could be replaced with conventional materials because of their low weight and high strength.

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