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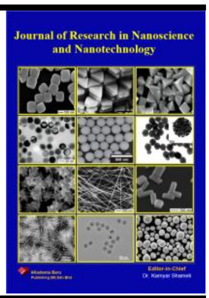

Recent Development of Natural Fibers Reinforced Polylactic Acid Composites

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ABSTRACT

The current research determines the most recent developments in natural fibres reinforced polylactic acid composites. Polylactic acid (PLA) is derived from renewable resources and is capable of degrading microorganisms, eliminating the pollution caused by petrochemical-based plastic. PLA is the most promising biodegradable material among biodegradable polymers since it is easily attacked by bacteria PLA decomposes easily, releasing H_2O, CO_2, and humus, the black material found in soil. PLA is a thermoplastic polymer that is widely used in the production of plastic bags, large planting cups, paper coating, fibres, films, packaging, and as a matrix material in composites. This review also discussed the physical and mechanical properties of several natural fibre reinforced polylactic acid composites. Several natural fibres have been used to reinforce PLA as a reinforcement for natural fibre composites in the field of composite manufacturing.

Keywords:
Natural fibre, Polylactic acid,
Composites, Mechanical properties

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1. Introduction

PLA is the most promising biodegradable material among biodegradable polymers since it is easily attacked by bacteria [1]. The degradation happens by hydrolysis caused by lactic acid, converted by microbial species to water and carbon monoxide. By composting PLA with other biomass waste, the biodegradation process was completed in two weeks, and the materials were degraded and disappeared in three to four weeks [2]. PLA is frequently used to replace synthetic polymers that can harm our environment owing to solid waste pollution.

However, because poly(lactic) polymers are stiff and brittle, it is important to incorporate a portion of natural fibre into them to increase their mechanical properties and yield strength [3, 4]. Other researchers have conducted several investigations on the mechanical properties of natural fibres reinforced with PLA, including kenaf [5–7], cotton gin waste, flax [8], jute [9], and hemp [10, 11], as reinforcement to replace synthetic fibre in polymer composites.

Figure 1 shows the life cycle of PLA. PLA was made by ring opening polymerization of the cyclic lactide. Neat PLA resin can be processed using the traditional extrusion process [12]. As PLA product can be thermally decomposed. Acetaldehyde is a primary thermal decomposition product of poly(lactic acid) and carbon monoxide and hexanal may also exist during decomposition at normal room temperature. This can naturally be degraded after use, without contaminating the environment. Poly(lactic acid) can be hydrolyzed in the body into lactic acid and acetic acid and metabolized by enzymes to CO_2 and H_2O. Siakeng et al. 1, reported that PLA is an environmentally attractive biopolymer with unique properties such as good transparency and processability, a glossy look, and high stiffness, however, it does have certain drawbacks such as brittleness and a high rate of crystallization.

Figure 1: Lifecycle of polylactic acid [13].

Oksman et al. used the extruded product of PLA obtained from compression moulding and compared its properties with polypropylene flax fibre composites (PP/flax). The mechanical properties of PLA are very good for example its composite strength is almost 50% more than the composite strength of PP/flax [14]. And this makes it useful in making Automobile components. The extrusion and compression moulding can be easily done on PLA. Figure 2 shows different PLA products.

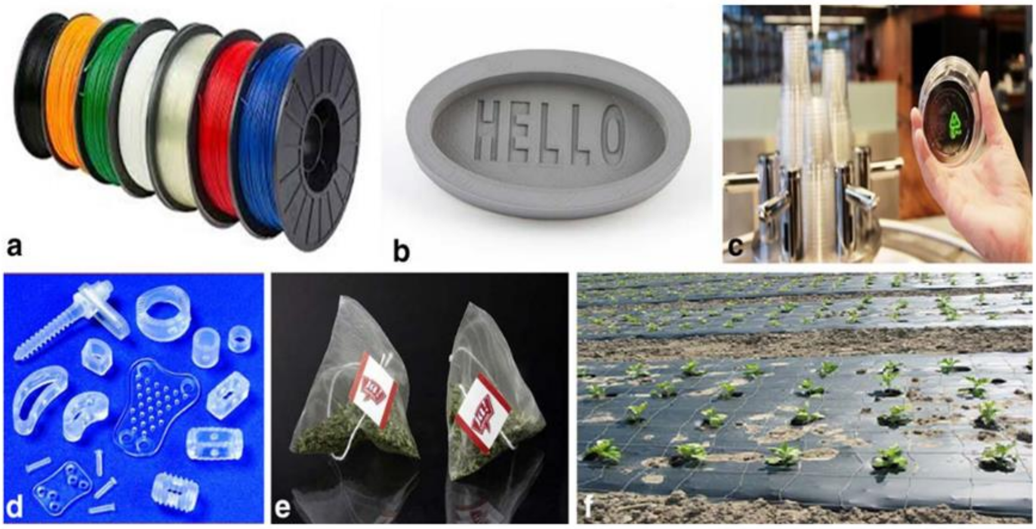

Figure 2: (a) PLA-3D Printing thread (b) 3-D printed soap dish from colored PLA (c) Biodegradable PLA cups used at a restaurant (d) PLA-bio absorbable implants (e) Teabags made of PLA (f) Mulch film made of PLA-blend “bio-flex” [1].

2. Natural fibre reinforced PLA composites

In the field of composite manufacturing, several natural fibres have been used to reinforce PLA as a reinforcement for natural fibre composites (NFC). Table 1 below illustrates the effect of combining natural fibre with PLA on the physical and mechanical properties of entire the NFC.

Table 1 Effect of combining different natural fibres with PLA on the various properties of entire NFC.

	Natural fibre/PLA composite	Processing/ Techniques	Properties	References
.1	Hemp/PLA composites	To develop carded fibre web, hemp and PLA fibres were cleaned and combined using blowing and carding equipment. Because the interfacial binding between PLA and fibres is poor, a needle punching procedure is required.	*Tensile strength* of the produced composites improved by 52% using the new compounding technique while the *flexural strength* increased by up to 100%.	10
.2	Bamboo fibres/PLA composites	A combination of chemical and mechanical treatment was used to extract bamboo microfibrils (BMF) with the help of hot-pressed at 170^{0}C , apply a pressure of 10 MPa for 10 minutes.	The outcome of embedding BMF in PLA was an increase in *tensile strength,* and *elastic modulus* of 100 and 150%, respectively.	15
.3	Jute fibre/ PLA composites	Compression moulding	*Tensile* and *flexural strength* of jute fibre/ PLA composite at 15% fibre loading was 25% and 116% higher than plain PLA, respectively. At 15% fibre loading, the *tensile modulus* and *flexural modulus* of the jute/PLA composite were 1.55 and 1.87 times that of neat PLA.	16
.4	Kenaf core powder (KF)/natural rubber/ PLA composites	Molten metal mixing and compression moulding were used to properly produce the composite.	As KF loading was increased, the *water absorption* % of the composites rose. The impact strength, however, reduced with the addition of KF.	17

.5	Sugarcane leaf fibre (SLF)/PLA composites	Solvent-casting method	The increasing SLF concentration enhances the *water absorption* capabilities, the *young's modulus* and *tensile strength* of PLA/SLF composites.	18
.6	Jute woven fabric/PLA composites	Compression moulding. A thermal-stamping test was used to examine the formability of the composites.	*Modulus* and *thermal* characteristics of the composite increased while the *strength* and other *mechanical* properties decreased after alkaline treatment of the fabric.	19
.7	Woven hemp fabric/PLA composites	Compression moulding process.	*Flexural* and *Charpy impact* tests show that the reinforced bio-polymers have a significant improvement in strength. The bio-composite with 30% reinforcing content exhibits the best *creep* behaviour.	11
.8	Bamboo (B), coir (C) and kenaf (K) fibre/PLA hybrid composites	Compression moulding process.	*Tensile strength* of KBC/PLA composites was 187 MPa, which was about 20 and 78% than BC/PLA and KC/PLA. Both KBC/PLA (199 MPa) and BC/PLA (206 MPa) composites had strong *flexural strength*, which was roughly 16 and 20% greater than KC/PLA.	7
.9	Coir (CF)/ pineapple leaf (PALF)/ PLA hybrid composites.	Hot press at 180^{0}C and Internal Mixer Brabender.	Among all hybrid composites, alkali-treated CF30%PALF 70% hybrid composites had the maximum *tensile strength* (30.29 MPa) and *young's modulus* (5.16 GPa), whereas CF50% PALF50% had the maximum *impact* characteristics. Physical testing revealed that CF30%PALF 70% had the maximum *water absorption* and *thickness swelling*, however, these values were reduced after alkali treatment.	20
.10	Bagasse/ basalt / PLA hybrid composites	Twin screw extruder / Injection moulding	*Water absorption* test result with the increase of fibre content shown that the composites had an excellent degrading property, and the water absorption rate also increased.	21
.11	Jute/flax/ PLA hybrid composites	Compression moulding	*Mechanical* properties improved as a result of the hybridization of jute and flax. The improved interfacial bonding of the matrix with the hybrid reinforcement resulted in enhanced mechanical properties for hybrid composites.	9
.12	Sugar plam fiber (SPF) /glass fibre/ PLA	Compression moulding	*Mechanical* properties improved as a result of the hybridization of SPF and glass fibres. The improved interfacial bonding of the matrix after alkaline treatment resulted in enhanced mechanical properties for hybrid composites.	22

Conclusion

The study concludes that natural fibre reinforced PLA composites are a promising alternative for developing biodegradable hybrid composites when good mechanical or physical properties are required. The addition of natural fibre improved the characteristics. The study also demonstrates the advantages of polylactic acid and its life cycle.

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