MECHANICAL AND MORPHOLOGICAL PROPERTIES OF DIFFERENT NATURAL FIBRE REINFORCED POLYLACTIC ACID COMPOSITES: A REVIEW

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ABSTRACT

The determination of mechanical and morphological properties of polylactic acid (PLA) reinforced with different natural fibre were studied in this paper. Tensile, impact, percentage elongation, flexural properties were found out of various composite material like Nettle fibre reinforced PLA, Grewia optiva fibre reinforced PLA, sisal fibre reinforced PLA, composite foams of PLA/bagasse fibre, PLA/flax composites, PLA/ cellulosic natural fibres, Wood fibre reinforced PLA composites. The value of tensile strength was found to be enhanced when compared neat PLA with natural fibre blend PLA. Since PLA is brittle, its nature also changes when natural fibre is applied and the percentage elongations increases as well. Up to 30% improvement in impact strength also noted in previous experiment on different PLA composites. Morphological analysis reveals strong adhesion rates between natural fibre and matrix PLA.

Keywords: Polylactic acid, Natural fibre reinforced, Mechanical properties, Lifecycle of PLA.

INTRODUCTION

As pollution caused by non-degradable material like synthetic fibres has led to research on environmentally friendly material production. In finding the solution of such a problem, researcher switched from synthetic fibres (non-degradable material) to natural fibres (biodegradable material). The main advantages of using natural fibres are renewability, easily availability, biodegradability, non-toxic, cheap, low specific gravity, high toughness and good strength[1]. By the using biodegradable material the effect of environmental pollution can also be reduced.

Polylactic acid (PLA) polymers have been commercially attempted to incorporate in the field o f biodegradable materials since the last decay. PLA is obtained from the fermentation processes of natural agricultural raw material. This process initially gives lactic acid which has a cyclic dilactone, lactide, ring open structures. The polymerization of lactic acid is known as polylactic acid. It is a renewable polymer that has better stability in temperature and less residual material. The thermal stability can be enhanced by using different synthetic or natural fibres as reinforcing material. PLA is brittle in nature. The mechanical properties mainly percent elongation and impact can be improved by adding plasticizers into PLA. The decomposition takes place by hydrolysis of lactic acid, which is metabolized by micro-organisms into H_2O and CO. Biodegradation occurs within two weeks by composting with other biomass, and the material has completely disappeared within 3–4 weeks. Fig.1 shows lifecycle of PLA.

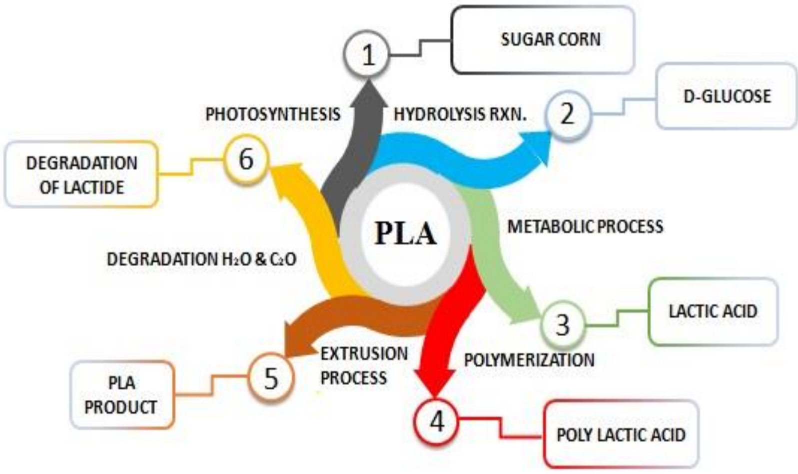

Figure 1. Lifecycle of Polylactic acid (current study)

MATERIALS AND DISCUSSIONS

Table 1. Mechanical and Morphological Properties of Natural Fiber reinforced polylactic acid composites

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
Bajpai et al.,[2]	Nettle, Grewia optiva and sisal fibres	Tensile strength	• Only PLA - 39.18 MPa • PLA/sisal- 80.6MPa • PLA/nettle- 50.32MPa • PLA/ G. Optiva- 73.9MPa • Young modulus of pure PLA-3.02GPa • Tensile strength of biocomposites is not good because of poor adhesion between fibre and matrix.
		% elongation	• PLA- 3.98% and polypropylene (PP) –more than 25% because it is more ductile than PLA. • PLA/G. Optiva- 5.74%; PLA/nettle- 4.63%; PLA/sisal-3.42% • These start propagating very rapidly in the matrix as soon as cracks are started and induce bulk failure as shear stress is localized at the interface of the fiber – matrix.

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			• The natural fibres are supposed to behave as hurdles to delay the composite fracture process, thus reducing the risk of sudden composite failure.
		SEM	• During tensile test, SEM micrographs show that the bio-composite has matrix splitting, fibre fracturing and fibre pullout. • Tensile properties of composite depend upon adhesion level, bonding character and fibre pullout. • Different surface roughness visible for different natural fibres. Sisal fibres shows good wetting with PLA than G. Optiva fibres as well as Nettle fibre.
		Flexural test	• The value of flexural strength is 249.8MPa and 1044MPa for PLA/sisal composite and neat PLA. • The value of flexural modulus is 9.75GPa and 3.79GPa for PLA/sisal composite and neat PLA. • The value of flexural strength is 202MPa and 164.8MPa for PLA/G. Optiva and PLA/nettle composite. • The value of flexural modulus is 10.97GPa and 7.88GPa for PLA/G. Optiva and PLA/ nettle composite. • The flexural properties of bio-composites are also depending upon the interfacial characteri-stics of the fibres and the matrix.
		Charpy impact strength	• The impact strength- PLA/sisal and PLA/G. optiva composite increases while the impact strength of PLA/nettle composite decreases. • Because of brittle nature of PLA matrix, the composite specimens were broken into two parts fully during charpy test. • Impact strength decreases because the stress were concentrated over a region on adding natural fibres into PLA matrix which required low energy for creating crack. • The value of impact strength of PLA/nettle composite is less than neat PLA because of

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			developing stress concentration area around the natural bundles which required less energy to create cracks. • Impact strength of PLA / carbon fibre composites improved by up to 30 percent fibre volume fraction.
Nampitch[3]	Composite foams of PLA/bagasse fiber (Thailand)	Tensile strength	• Neat PLA- 25.63MPa • Composite 7wt%- 45.27MPa • Addition of bagasse fibre (till 7 %) increase tensile strength because of the chemical interaction between the ester group of PLA and the OH group. • After 7% its strength decreases, due to the fibres weakening the composites.
		% elongation	• After 7% fibre, further adding show decrease in elongation because of the fibre's natural effect of reducing mobility in composites, making the material stiffer and harder.
		Impact strength	• Bagasse fibres with high content could be aggregated because of fibre-fibre interaction, which causes the mechanical properties to worsen. • Exhibit 15 and 20%wt bagasse fibres minimum mechanical properties, • 10% wt bagasse fibres enhance optimum mechanical properties. • As on addition of natural fibre, the mobility of polymer chains reduces because of which absorbing energy ability decrease in composite. That's why impact strength decrease.
		SEM	• Shows neat PLA showed a smooth surface and smooth bubble in the middle of the specimen • composite showed a rougher surface and bubbles that looked like cracks increased fibre content in the matrix showed an even rougher surface with the bubble likely more deformed • This phenomenon could be due to the bubble dispersion in the PLA sample where

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			they could easily move and coalesce without obstacles, while in the composite sample they could not.
K.Oksman[4]	PLA/flax composites	Tensile stress	• PLA only - 50MPa and a modulus of 3.4GPa. • Adding of flax fibres into PLA will decreases the tensile strength of whole composite, which shows weak adhesion between fibres and matrix. The stress does not pass from the matrix to the stronger fibres. • The addition of flax fibre increases the tensile modulus; the tensile modulus depends on fibre orientation.
Yicheng Du[5]	PLA/ cellulosic natural fibers	Tensile strength	• There was a variation in tensile modulus and strength when fibre loading changes. After 50% of fibre loading, the dry spots or a void increases because of which tensile strength decreases.
M.S.Huda[6]	Wood fiber (WF) reinforced PLA composites	Flexural strength and modulus	• Comparing flexural strength and modulus of Neat PLA - 98.8MPa and 3.3GPa and PLA/WF (60 wt %/40 wt %) composite - 114.3MPa and 10.2GPa
		Tensile strength (MPa) Tensile Modulus (GPa)	• Neat PLA 62.8 ± 4.9 and 2.7 ± 0.4 • Tensile strength value on adding WF increases till 30% loading and then decreases. • Tensile strength of Wood fibre (WF) reinforced PLA composites depends upon the orientation of wood fibre. Well alignment shows higher tensile strength. • Up to 30%wt of wood fibre loading, the tensile strength increases. This was because of increasing wetting of fibres with matrix resin. • If the wetting of natural fibre is not appropriate strength become week and composite can fail also. • The value of tensile modulus of composite increases as the quantity of wood fibre increases.

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			• The modulus of PLA increases proportionately as the amount of WFs in the composite increases. • Raising the tensile module is also depends upon the compatible with the mixture law, which stipulates that the matrix is reinforced by fibres capable of transmitting tension through the fibre-matrix interface.
M. Chalid[7]	Ijuk Fiber/ PLA Biocomposites	Tensile strength	• Addition of ijuk fibre would enhance both young's modulus and tensile strength. • Alkaline treatment increases the compatibility of ijuk and PLA. • Low surface adhesion between fibre and matrix without treatment. Some small gaps were also visible. • Elastic modulus and tensile strength decrease after 20% of ijuk fibre volume fraction, this is because of voids or fibres pull-out in the biocomposite. • Uniform distribution of ijuk fibre by stirring can solved these above two problems.

RESULTS AND CONCLUSION

Mechanical Properties of PLA were improved on addition of various natural fibres. From the table we can summarized that, As PLA is brittle, but on loading of natural fibre it shows ductile nature, because of the adhesion between fibre and PLA matrix, the tensile property of PLA composite has been improved. Morphological studies show the smooth surface on addition of natural fiber but at certain limit it was mainly 40% of natural fibre loading.

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