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*International Journal for Modern Trends in Science and Technology*
*Volume 12, Issue 05*, pages 278-282
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol12issue05.html
DOI: https://doi.org/10.5281/zenodo.20363799

# Mechanical properties of TKF/PLA fiber hybrid biocomposites: Effect of MMT Clay

**Dr. P. Ramesh | T B Haribabu | M Sudheer**

*Department of Mechanical Engineering, Siddharth Institute of Engineering & Technology, Puttur, AP-517583, India*

**To Cite this Article**
Dr. P. Ramesh, T B Haribabu & M Sudheer (2026). Mechanical properties of TKF/PLA fiber hybrid biocomposites: Effect of MMT Clay. International Journal for Modern Trends in Science and Technology, 12(05), 278-282. https://doi.org/10.5281/zenodo.20363799

**Article Info**
Received: 17 April 2026; Revised: 11 May 2026; Accepted: 15 May 2026.



***KEYWORDS***

*Kenaf Fiber, MMT clay, Poly lactic Acid, Mechanical Properties, SEM, Hybrid biocomposite.*

**ABSTRACT**

*In this paper Treated Kenaf fiber/PLA based hybrid biocomposite are prepared by dispersing the different Montmorillonite clay contents by compression molding process. The PLA based bio-composites are fabricated with 30% of Treated Kenaf fiber and 1%, 2%, 3% nanoclay filler. The fabricated 30TKF-70PLA, 30TKF-1MMT-69PLA, 30TKF-2MMT-68PLA and 30TKF-3MMT-67PLA biocomposite are used to characterize the flexural and tensile properties of hybrid biocomposites. The 1 % MMT clay included PLA/treated Kenaf fiber demonstrates superior mechanical properties than other biocomposite. SEM analysis discloses that MMT clay improves both morphology and load transfer capacity.*

## 1. INTRODUCTION

In UN millennium advancement goal from 2000, it was consented to work for eradication of excessive poverty; to ensure environmental (eco-friendly) sustainability [1]. Green composites are nontoxic and are purely degradation by composting process or in soil [2]. Among the biodegradable thermoplastics (biopolymers) particularly PLA provide a unique opportunity and have been the subject of many studies in the past decade [3, 4]. The renewable resources corn based produced PLA was a promising market available alternative medium to (non biodegradable) conventional polymers [5]. It is a versatile polymer made from renewable sugar and starch (agriculture raw materials), which are fermented to lactic-acid [6]. The PLA (bio polymer) provides good strength and easy processability but more expensive; for various practical applications the modification is required [7]. Hence, a suitable (modification) way to enhance and make it more cost-effective material is the inclusion of natural-fibers, which has recently attained attention to replace (glass and carbon) synthetic fibers [8, 9]. The major drawback of natural fiber composite is incompatibility between hydrophobic polymer matrix and hydrophilic natural fiber [10]. The chemical treatment improves the interfacial adhesion between the (natural) fiber-matrix (polymer) [11]. Ramesh et al. [12] their survey reveals that NaOH concentration, immersion time and temperature influences the properties of composites. In the different types of natural resources, Aloevera plant (Aloe barbadensis Miller) was used for drugs since thousands of years. Aloevera plants were widely cultivated in Florida, India, South Texas, United States (South California), Africa, South and Central America, Australia, Iran and Caribbean [13]. Its look likes a sisal plant, but in reality different in nature; the formers point of view Aloevera fiber provides economic benefit [14]. Several approaches are being considered for improving properties and reducing cost of PLA. The producing PLA based biocomposites has confirmed to be a successful approach to achieve ideal properties [2, 15-23]. Some researchers are achieve the desired properties through hybridization process like adding of fillers and natural fibers into the conventional polymers [24-25]. Chaitanya et al. [14] have reported that treatment and 30% fiber content enhanced mechanical and thermal properties of the PLA/Aloevera fiber biocomposite. All the above researchers some have tried to determine suitable hybrid biocomposites with desired properties. The hybridization with the nano-fillers makes more environmental friendly biocomposite. As for authors knowledge there is no work carried out based on various concentration of MMT (montmorillonite nanoclay in wt %) on Alkaline treated aloevera fiber (30 wt %) / PLA hybrid biocomposites by compression method.

This paper tries to examine the addition of both treated aloevera fiber and MMT clay in a PLA with different proportion. This is compulsory in order to make an eco-friendly biocomposites (green composites) and as well to substitute for the conventional polymer or plastics in terms of availability, price and property.

## 2. EXPERIMENTAL

### A. Materials

In this research PLA 3052D, kenaf fiber and MMT clay was used to develop the hybrid biocomposites.PLA 3052D grade (pellet form) was acquired from Nature Tech, Chennai, India. Its specific gravity, melting and glass transition temperatures were recorded like 1.24 g/cm³, 145-160° C and 55-60° C, respectively. The Aloevera fiber procured from Go Green Products, Chennai, India. After fiber surface modification, the fibers were then chopped to a range of 1-3mm length. The onium ion-modified ≤ 20μm sized powder formed having 1.01 g/cm³ density of MMT (montmorillonite) nano clay (Nanomer® I.31PS) purchased from Sigma-Aldrich, Bangalore, India. It contains 0.5-5 wt % aminopropyltriethoxysilane, and 15 to 35 % (wt %) octadecylamine. And its density is 1.01 g/cm³.

### B. Methods

#### a. Aloevera fiber surface modification

The surface modification of aloevera fiber was done using Alkaline (NaOH) modification method. The pellet formed NaOH (Sodium hydroxide) was supplied by SR-Scientific Chemicals, Tirupati, India. Aloevera fibers were soaked in sodium hydroxide (6% NaOH) solution for 3hrs at room temperature. The fibers then clean with running distilled water up to reach p^H value constant 7. The treated Fibers then kept in oven for dried at 100° C for 8hr.

#### b. Preparation, processing of biocomposite and Hybrid biocomposites

The fabricated composites compositions were presented in Table.1. Before fabrication of samples PLA, aloevera fiber and MMT clay were kept in hot air oven at 110° C for 1 hr (for dry).

**Table.1** Compositions and composite names

| Denotation | Sample | PLA, wt % | NaOH treated Aloevera fiber, wt % | MMT clay, wt % |
|---|---|---|---|---|
| A | PLA-30TAF | 70 | 30 | 0 |
| A1 | PLA-30TAF-1MMT | 69 | 30 | 1 |
| A2 | PLA-30TAF-2MMT | 68 | 30 | 2 |
| A3 | PLA-30TAF-3MMT | 67 | 30 | 3 |

The compositions (PLA, MMT and Aloevera fiber) were manually pre-mixed and compounded followed by Baroda, ZV 20 model twin-screw extruder. Afterwards, the compounded pellets were processed through compression molding machine. During the process keep the temperature 185°C and 30 ton force applied (up stroke); then compacted at 165°C bar pressure for 30 min followed by cool under pressure. When temperature (mold) reached to 90° C the platens are opened from press; then composite sheets (200 mm X 200mm X 3mm) are removed from platens and cut to desired form for mechanical evaluations.

**c. Mechanical Characterization**

Flexural (ASTM D790-03 at 18° C with 50KN, 50mm span length) Tensile Strength (ASTM D638 at 25° C with 10 mm/min cross speed) are evaluated through using UT Machine

**d. SEM Analysis**

Tensile fractured gold coated specimens are used to examine the surface analysis through JSM-IT500 scanning electron microscope (SEM) (Japan Electronics Optic Limited, USA).

## 3. RESULTS AND DISCUSSIONS

The PLA-biocomposite and PLA-hybrid biocomposites obtained flexural (ASTM D790-03) and tensile strengths (ASTM D638) are respectively shown in Fig. 1 and Fig. 2. It is obvious that, the addition of MMT improved the flexural and tensile strength of hybrid biocomposites (Fig.1 and 2). The addition of 1% MMT clay into PLA hybrid biocomposites (A1) flexural and tensile strengths are improved 6.08 % and 10.53 %, respectively than PLA/treated aloevera fiber biocomposites (A).

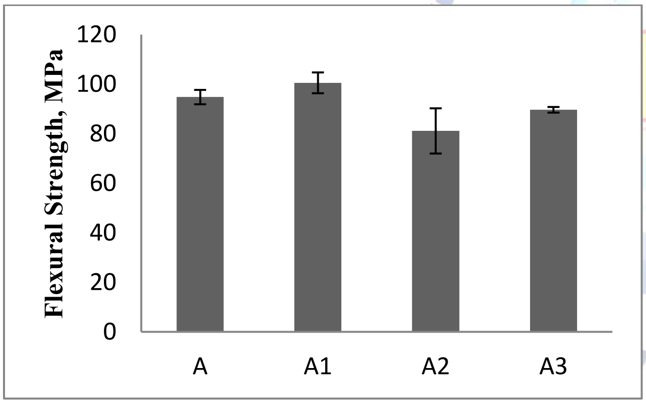


**Fig.1** Flexural Strengths of A, A1, A2 and A3 Bio and Hybrid biocomposites

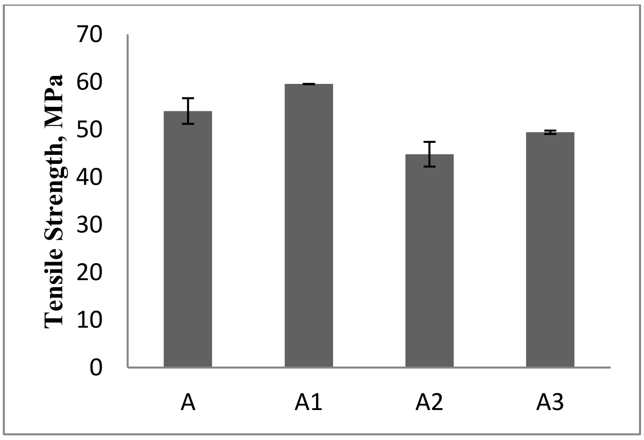


**Fig.2** Tensile Strengths of A, A1, A2 and A3 Bio and Hybrid biocomposites

As the MMT loading beyond 1% (addition of 2 and 3%) by weight the flexural and tensile strengths are decreased. The similar trend observed by H.Alamri et al. [26] they concluded that 1% nano filler epoxy based nanocomposites demonstrate enhanced mechanical properties than other (3% and 5% nano filler) nanocomposites. Kundan et al. [27] found that, bamboo /polyester/ nano clay composites tensile and flexural strength are enhanced with 1% clay; beyond 1% clay the properties are decreased. Ramesh et al. [28] concluded that 1 % clay included PLA/treated kenaf fiber hybrid biocomposite shows enhanced mechanical properties than other composites. This improvement clearly indicates that clay fillings the micro pores (uniform dispersion), improved interface bonding among treated aloevera fiber and PLA in case of 1% MMT clay (A1), as evident from its superior flexural and tensile strength (Fig.1 and Fig.2). The addition of 1% MMT treated aloevera fiber reinforced hybrid biocomposite (A1) shows improved mechanical properties because of high matrix-fiber bonding agent, which enlarge the highest load transfer capacity. Similar mechanism observed in previous study [29].

## 4. SEM ANALYSIS

Fig.3 (a-d) shows the structures of biocomposites. The treated aloevera fiber/PLA biocomposite (Fig.3a) shows very small gaps between the fabrics

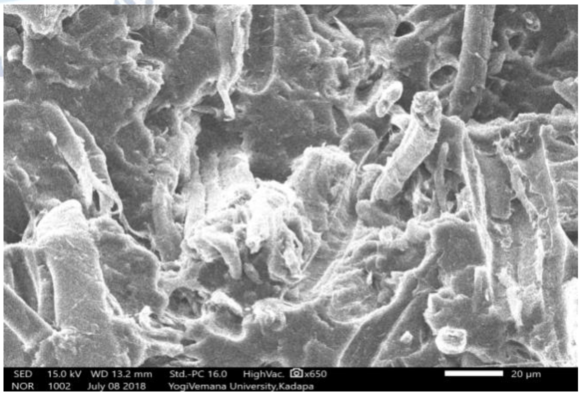


**Fig.3a**SEM images of A biocomposite

and matrix. The addition of 1% MMT clay PLA/treated aloevera fiber hybrid biocomposite shows fine fiber-nano-matrix adhesive bonding (Fig.3b). Similarly the 2% MMT clay based hybrid

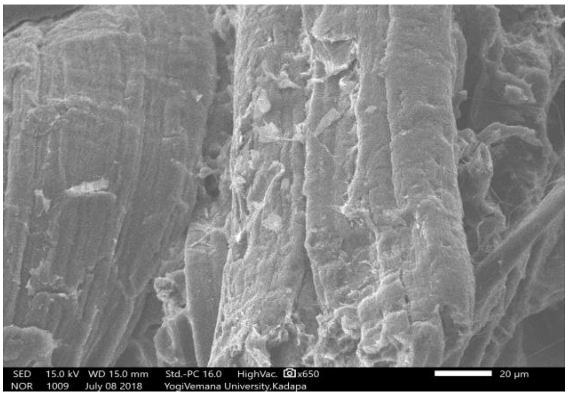


**Fig.3b** SEM images of A1 Hybrid biocomposite

biocomposite shows voids, fiber bending and fiber pullouts (Fig.3c). Addition of 3% MMT clay -PLA/treated aloevera fiber hybrid biocomposites shows more number of voids and pullouts (Fig. 3d). These failure mechanisms of biocomposites are evidence for enhancement of mechanical properties. For example, the addition of 1% MMT clay -PLA/treated aloevera hybrid biocomposites exhibits higher mechanical properties (Fig.1 and 2) which specify better fiber-nano-matrix adhesive bonding which leads to higher load transfer capacity (Fig.3b).

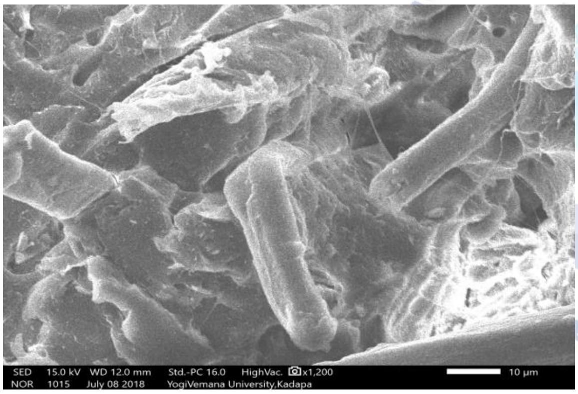


**Fig.3c** SEM images of A2 Hybrid biocomposite

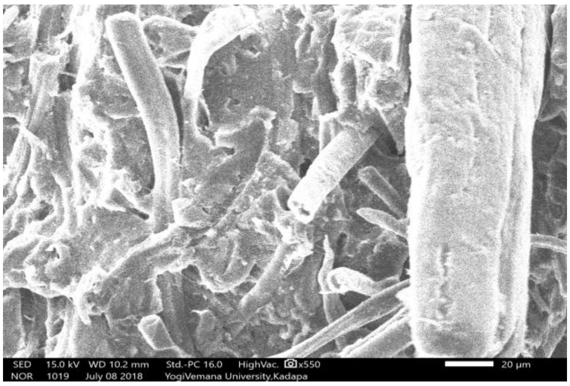


**Fig.3d** SEM images of A3 Hybrid biocomposite

## 5. CONCLUSIONS

The affects of MMT clay on structures and mechanical properties of treated aloevera/PLA hybrid biocomposites have been presented. The flexural and tensile strength of treated aloevera/PLA hybrid biocomposites containing 1% MMT clay (A1) were improved by 6.08 % and 10.53 %, respectively than PLA biocomposites (A). The optimum content of MMT clay was observed to be 1 wt %. It was found from the results that PLA-30TAF-1MMTclay (A1) hybrid biocomposite shows higher properties than other compositions composites. It is a strong competitor to alternate for conventional polymer based composites. The developed hybrid biocomposite has potential to use in automotive, architectures and furniture applications. Further research is under processing to examine the impact strength, micro-hardness, thermal, biodegradable

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

## REFERENCES


[1] Yu, L.; Deana, K.; Li, L. Polymer blends and composites from renewable resources. Prog. Polym. Sci. 2006, 31, 576–602.

[2] Lee, S.H.; Wang, S. Biodegradable polymers/bamboo fiber biocomposite with bio-based coupling agent. Compos. A. 2006, 37 (1), 80–91.

[3] Oksman K, Skrifvars M, Selin JF (2003) Natural fibers as reinforcement in polylactic acid (PLA) composites. Compos Sci Technol 63(9):1317–1324

[4] Huda MS, Drzal LT, Mohanty AK, Misra M (2007) The effect of silane treated- and untreated talc on the mechanical and physicmechanical properties of poly(lactic acid)/newspaper fibers/talc hybrid composites. Composites B 38(3):367–379

[5] Lim LT, Auras R, Rubino M (2008) Processing technologies for poly (lactic acid). Prog Polym Sci 33(8):820–852

[6] Garlotta D (2001) A literature review of polylactic acid (PLA). J Polym Environ 9(2):63–84

[7] Huda MS, Drzal LT, Mohanty AK, Misra M (2006) Chopped glass and recycled newspaper as reinforcement fibers in injection molded poly (lactic acid) (PLA) composites: a comparative study. Compos Sci Technol 66(11–12):1813–1824

[8] Ochi S (2008) Mechanical properties of kenaf fibers and kenaf/ PLA composites. Mech Mater 40(4–5):446–452

[9] Shanks RA, Hodzic A, Ridderhof D (2006) Composites of poly(lactic acid) with flax fibers modified by interstitial polymerization. J Appl Polym Sci 101(6):3620–3629

[10] Jing Zhong, Honghong Li, Jianliang Yu, and Tianwei Tan. Effects of Natural Fiber Surface Modification on Mechanical Properties of Poly (lactic acid) (PLA)/Sweet Sorghum Fiber Composites Polymer-Plastics Technology and Engineering, 50: 1583–1589, 2011

[11] Vilay V, Mariatti M, Mat Taib R, et al. Effect of fiber surface treatment and fiber loading on the properties of bagasse fiber

reinforced unsaturated polyester composites. Compos Sci Technol 2008; 68: 631–638.
[12] P Ramesh, B Durga Prasad, KL Narayana (2018) Characterization of kenaf fiber and its composites: A review. Journal of Reinforced Plastics and Composites vol. 37(11) 731–737.
[13] Moghaddasi, S. M.; Verma, S. K. Int. J. Biol. Med. Res. 2011, 2, 466.
[14] Saurabh chaitanya and Inderdeep Singh. Novel aloevera fiber reinforced biodegradable composites-Development and characterization. Journal of reinforced plastics and composites 2016; 1-13 DOI: 10.1177/0731684416652739.
[15] Ray SS and Bousmina M. (2005) Biodegradable polymers and their layered silicate nanocomposites: in greening the 21st century materials world. Prog Mater Sci 50: 962–1079.
[16] Huda MS, Drzal LT, Misra M and Mohanty AK (2006) Woodfiber- reinforced poly (lactic acid) composites: evaluation of the physicomechanical and morphological properties. J Appl Polym Sci; 102: 4856–4869.
[17] Lee S-Y, Kang I-A, Don G-H, Yoon H-G, Park B-D and Wu Q (2008) . Thermal and mechanical properties of wood flour/ talc-filled polylactic acid composites: effect of filler content and coupling treatment. J Thermoplast Compos Mater; 21: 209–223.
[18] Lin LH, Liu HJ and Yu NK (2007) Morphology and thermal properties of poly (L-lactic acid)/ organoclay nano composites. J Appl Polym Sci 106: 260–266.
[19] Murariu M, Ferreira AD, Degee P, Alexandre M and Dubois P (2007) Polylactide compositions. Part 1: effect of filler content and size on mechanical properties of PLA/ calcium sulfate composites. Polymer 48: 2613–2618.
[20] Paul MA, Alexander M, Degee P, Henris C, Rulmont A and Dubois P (2003) New nanocomposite materials based on plasticized poly(L-lactide) and organo-modified montmorillonites: thermal and morphological study. Polymer; 44: 443–45021.
[21] Pilla S, Gong S, O'Neill E, Rowell RM and Krzysik AM (2008) Polylactide-pine wood flour composites. Polym Eng Sci 48: 578–587.
[22] Pluta M, Jeszka JK and Boiteux G (2007) Polylactide/montmorillonite nanocomposites: structure, dielectric, viscoelastic and thermal properties. Eur Polym J 43: 2819–2835.
[23] Graupner N, Herrmann AS and Mussig J (2009) Natural and man-made cellulose fibre-reinforced poly (lactic acid) (PLA) composites: an overview about mechanical characteristics and application areas. Composites Part A 40: 810–821.
[24] Hapuarachchi TD, Peijs T (2010) Multiwalled carbon nanotubes and sepiolite nanoclays as flame retardants for polylactide and its natural fibre reinforced composites. Composites Part A 41:954–963
[25] Okubo K, Fujii T, Thostenson ET (2009) Multi-scale hybrid biocomposite: processing and mechanical characterization of bamboo fiber reinforced PLA with micro fibrillated cellulose. Composites Part A 40:469–475
[26] H. Alamri, I.M. Low (2012) Effect of water absorption on the mechanical properties of nano-filler reinforced epoxy nanocomposites. Materials and Design 42 214–222
[27] Kundan Patel, Jay Patel, Piyush Gohil, V Chaudhary (2018) Effect of Nano Clay on Mechanical Behaviour of Bamboo Fiber Reinforced Polyester Composites. Applied Mechanics and Materials Vol. 877, pp 294-298
[28] P.Ramesh, B.Durga Prasad, and K.L. Narayana AIP Conference Proceedings 2057, 020035(2019); https://doi.org/10.1063/1.5085606https
[29] A. Hakamy, F.U.A. Shaikh, I.M. Low (2013) Microstructures and mechanical properties of hemp fabric reinforced organoclay–cement nanocomposites, Constr. Build. Mater. 49 298–307.