Characterization of Kenaf/ Aloevera fiber reinforced PLA Hybrid biocomposites

**P Ramesha,\*, B Durga Prasadb, KL Narayanac**

*aResearch scholar*, *JNTUA, Ananthapuramu-515002, AP-India*

*bMechanical Engineering Department, JNTUniversity, Ananthapuramu-515002, AP-India*

*cMechanical Engineering Department, SVCET, Chittoor-517127, AP-India*

\*Corresponding author Email: rameshvgt@gmail.com

------------------------------------------------------------------------------------------------------------------

This paper examines the influence of hybridization on mechanical and thermal properties of biocomposites. Kenaf and Aloevera fibers were treated by NaOH treatment to improve the bonding with PLA. Kenaf (30 wt %) reinforced PLA (70 wt %) and Aloevera (30 wt %) reinforced PLA (70 wt %) biocomposites, and Kenaf/Aloevera (15/15 wt %) reinforced PLA (70 wt %) hybrid biocomposite are prepared by extruder and compression molding process. The fabricated bio and hybrid biocomposites are used to characterize the impact and thermal properties of hybrid biocomposites. The treated Kenaf/Aloevera Fiber (15/15 wt %) reinforced PLA (70 wt %) hybrid biocomposite demonstrates superior mechanical and thermal properties than other biocomposites.

***Keywords*:** Kenaf/Aloevera Fiber, Poly lactic Acid, Mechanical Properties, Hybrid biocomposite.

1. **Introduction**

Green composites are nontoxic and are purely bio degradation by composting process or in soil [1]. Among the biodegradable thermoplastics (biopolymers) particularly PLA provide a unique opportunity and have been the subject of many studies in the past decade [2, 3]. The renewable resources corn based produced PLA was a promising market available alternative medium to (non biodegradable) conventional polymers [4]. The PLA (bio polymer) provides good strength and easy processability but more expensive; for various practical applications the modification is required [5]. 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 [6, 7]. Natural fibers are environmentally superior substitute to synthetic fiber because they are cheaper, biodegradable, recyclable, abundant, permeable, non-toxicity and competitive mechanical properties, capable of non absorbing moisture [8]. The major drawback of natural fiber composite is incompatibility between hydrophobic polymer matrix and hydrophilic natural fiber [9]. The chemical treatment improves the interfacial adhesion between the (natural) fiber-matrix (polymer) [10]. In the different types of natural resources, kenaf plants have rapid development in past years due to their rapid growth with consequence of low cost under wide range of climatic conditions. Kenaf fiber have a potential medium alternate to replace the synthetic fibers as reinforcement composites and also reduces the waste, hence contributes to the healthier environment; It will thus create jobs in urban and rural areas [11]. On the other hand, 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 [12]. Its look likes a sisal plant, but in reality different in nature; the formers point of view Aloevera fiber provides economic benefit [13]. Islam et al. [14] have reported that hybridization (Kenaf/Coir/PP) enhanced mechanical, Water absorption and Biodegradable properties than of the Coir/PP composite. Asaithambi et al. [15] developed and studied the effect of hybridization on mechanical properties of the PLA/Banana/Sisal hybrid biocomposites; the hybridization enhanced the tensile, impact and flexural properties than other biocomposites. Ramesh et al. [16] their survey reveals that more works are needed for purely biobased composites based on kenaf reinforced composites. All the above researchers some have tried to determine suitable hybrid biocomposites with desired properties.

The main key factor of this investigation is to produce a completely eco-friendly green composite through renewable resources using Polylactic acid (matrix) and a grouping of treated Kenaf and Aloevera Fiber (reinforcement). As for instigators knowledge no work is carried out based on PLA-Treated Kenaf/Aloevera Fiber hybrid biocomposites by compression molding Technique. Furthermore, the effect of hybridization of PLA-Treated Kenaf/Aloevera Fiber on impact and thermal properties were examined and evaluated.

**2. Experimental**

**2. 1. Materials**

Pellet formed PLA 3052D grade was acquired from Nature Tech (Chennai, India). Its specific gravity, melting and glass transition temperatures were recorded like 1.24 g/cm3, 145-160o C and 55-60o C, respectively. The Kenaf and Aloevera fiber procured from Go Green Products (Chennai, India). The pellet formed Sodium hydroxide (NaOH) was supplied by SR-Scientific Chemicals, Tirupati (AP, India). The fibers were cut into a range of 1-3mm long.

**2. 1.1. Kenaf and Aloevera fiber surface modification**

The surface modification of aloevera fiber was done using Alkaline (NaOH) modification method. Kenaf and 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 pH value constant 7. The treated Fibers then kept in oven for dried at 100o C for 8hr.

**2. 2. Methods**

**2.2.1 Processing of bio and Hybrid biocomposites**

The fabricated composites compositions were presented in Table.1 Before fabrication of samples PLA, kenaf, aloevera fiber and MMT clay were kept in hot air oven at 110o C for 1 hr (for dry). 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 185oC and 30 ton force applied (up stroke); then compacted at165oC bar pressure for 30 min followed by cool under pressure. When temperature (mold) reached to 90o 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.

Table. 1. Compositions of composites

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample | Code | PLA, wt % | Kenaf fiber, wt % | Aloevera, wt % | NaOH, wt % |
| PLA-30TKF | PLA/K | 70 | 30 | 0 | 6 |
| PLA-30TAF | PLA/A | 69 | 0 | 30 | 6 |
| PLA-30TAKF | PLA/K/A | 68 | 15 | 15 | 6 |

**2. 3. Results and Discussions**

**2.3.1 Mechanical Properties of the Composites**

The PLA-biocomposite and PLA-hybrid biocomposites obtained Impact Strength (ASTM D256) is shown in fig. 1. It is obvious that, PLA/kenaf and Aloevera fiber hybrid biocomposite improved the Impact strength (Fig.1). The PLA/Treated Kenaf (S) and PLA/Treated Aloevera (A) biocomposites impact strengths are 0.0209 and 0.05249 J/mm2, respectively. The PLA/Treated Kenaf and Aloevera fiber hybrid biocomposite (H) impact strength is improved to 0.06929 J/mm2. The fiber hybridization influences the impact strength of biocomposite. The similar trend observed by Zainudin et al. [17] they concluded that hybridized coir/oil palm EFB/PP composite enhanced higher mechanical properties than alone coir or oil palm EFB based composites. Jacob et al. [18] also finding that, sisal/ oil palm reinforced rubber composite shows improved mechanical properties than alone sisal or oil palm based composites.

Fig. 1. Impact Strength of Bio and hybrid bio composites

**2.3.2 Thermal Properties**

Thermal stability of PLA-biocomposite and PLA-hybrid biocomposites were investigated by thermo gravimetric Analysis (TGA). Figure.2 shows PLA-biocomposites and PLA-hybrid biocomposites of the TGa curve.

Fig. 1. TGA curve of PLA/K, PLA/A and PLA/K/A

The fiber hybridization improved thermal stability of biocomposite as evidenced from Thermo gravimetric curve. The T75% of hybrid biocomposite improved 337o C to 343o C (Table. 2). The decomposition takes place in three-stages. In the primary stage moisture evaporation occurred up to 150o C and in second phase due to lignin, cellulose and hemi celluloses. Finally, depolymerisation of PLA takes place. For 10 % mass loss PLA-30TKF, PLA-30TAF and PLA-30TAKF were degraded at 280, 295 and 291respectively. For 75 % loss PLA-30TKF, PLA-30TAF and PLA-30TAKF are decomposed at 337, 338 and 343 respectively. M Boopalan et al [19] concluded that the hybridization enhanced superior thermal stability. The hybridization enhanced better thermal stability of hybrid biocomposite.

Table. 2. TGA Characterization of PLA bio and hybrid biocomposites

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | Denotation | Decomposition Temperature (o C) of the Different Weight Loss (%)  10% 75% | |
| PLA-30TKF | PLA/K | 280 | 337 |
| PLA-30TAF | PLA/A | 295 | 338 |
| PLA-30TAKF | PLA/K/A | 291 | 343 |

**2. Conclusion**

The influences of hybridization on impact and thermal stability (TGA) of PLA/Kenaf/ Aloevera fiber biocomposites have been presented. The higher impact strength 0.06929 J/mm2 obtained for PLA/K/A hybrid biocomposite. TGA curve demonstrates the PLA/K/A hybrid biocomposite exhibits highest decomposition temperature 343oC (75 % weight loss) than other. Finally, concluded that, the hybridization enhanced improved thermal and impact properties of biocomposites.

**References**

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

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

3. 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

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

5. 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

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

7. 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

8. Shekeil YAE; Sapuan SM; Jawaid M; Shuja OMA: Influence of fiber content on mechanical, morphological and Thermal properties of kenaf fibres reinforced poly (vinyl chloride)/thermoplastic polyurethane poly-blend composites. ‘Materials and Design’ 2014; 58:130–135.

9. 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

10. 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.

11. Khalil HPSA; Alwani MS; Rizuan R; Kamarudin H; Khairul A: Chemical composition, morphological characteristics, and cell wall structure of Malaysian oil palm fibres. ‘Polymer-Plastics Technology and Engineering’, 2008; 47(3): 273-280.

12. H.M.Akil; M.F.Omar: Kenaf fiber reinforced composites: A review, ‘Materials and Design’ 32 4107–4121011;

13. Moghaddasi, S. M.; Verma, S. K. Int. *J. Biol. Med. Res*. 2011, 2, 466.

14. S chaitanya and Inderdeep Singh. Novel aloevera fiber reinforced biodegradable composites-

Development and characterization. Journal of reinforced plastics and composites 2016; 1-13

15. Md.S. Islam, NAB Hasbullah, M Hassan, ZA Talib, M Jawaid, MK M Haafiz, Physical and mechanical and biodegradable properties of kenaf/coir hybrid fiber reinforced polymer Nanocomposites. Materials Today Communication 4 (2015) 69-76

16. B. Asaithambi, G Ganesan, and S Anand Kumar Biocomposites: Development and Mechanical Characterization of Banana/Sisal fiber reinforced polylactic acid (PLA) Hybrid composites. Fibers and Polymers 2014, vol. 15, No. 4, 847-854.

17. E.S. Zainudin, LYan, W Haniffah, M. J awaid, O.Y. Alothman, Effect of coir fiber loading on mechanical and morphological properties of oil palm fibers reinforced polypropylene composites, Polym. Compos. 35 (2014) 1418–1425.

18. M. Jacob, S. Thomas, K.T. Varughese, Mechanical properties of sisal/oil palm hybrid fiber reinforced reinforced natural rubber composites, Compos. Sci. Technol. 64(2004) 955–965.

19. Khalil HPSA; M Boopalan, M Niranjanaa, MJ Umapathi, Study on mechanical properties and

thermal properties of jute and banana fiber reinforced epoxy hybrid composites, Composites:

Part B 51 (2013) 54-57