International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology

Influence of Novel Fiber Surface Treatment Method on Morphology and Mechanical Properties of Polypropylene Composites Incorporation of Sisal Fibers

Prakash Krishnaiah*1, Anusuya Devi V S2

*12Department of Chemistry, New Horizon College of Engineering Outer Ring Road, Bangalore-560103
ksp.shine@gmail.com1
anukmp@gmail.com2

ABSTRACT

In this study, sisal fibers successfully surface modified by high intensity ultrasound (HIU) and their effects on morphology and mechanical characteristics were investigated for their polypropylene (PP) composites. The SEM analysis shows that after HIU modification, sisal fibers filled PP composites have good compatibility between fibers and PP polymer due to improve the surface roughness. The mechanical properties were significantly enhanced with HIU treated sisal fibers PP composites. The highly cost-effective PP bio-composites reinforced sisal fibers with improved mechanical properties find the potential applications in automotive and other structural engineering industries.

Keywords : Sisalfiber, Polypropylene, Ultrasound, Water Absorption, Morphology

I. INTRODUCTION

In last few years, natural fibers reinforced polymer composites are extensively used in many applications such as home appliances, automotive, etc., owing to their good mechanical properties, biodegradability and economical aspects[1]. Polypropylene (PP) is an important thermoplastic polymer which is extensively used for the production of polymer composites used for applications such as automotive, electrical insulation, home appliances and other structural applications. However, PP has drawbacks such as low tensile, impact and thermal properties[2]. These mechanical and thermal properties of PP polymer can be enhance by filling of fiber materials into the PP matrix[3,4]. It is well known fact that, reinforcement materials such as fibers are withstanding high force applied on the composites. Nowadays natural fibers are very commonly used for preparation of polymer composites owing to their biodegradability, easy availability, and good mechanical and thermal properties[5–7]. However, due to occurrence of amorphous materials such as hemicellulose, lignin, pectin and other waxy materials on the surface of the natural fibers cause high water absorption and low compatibility with hydrophobic polymer matrices[8–10].

Surface modification is frequently the used method for the elimination of amorphous materials from the surface of natural fibres to convert the hydrophilic nature of natural fibres surface into hydrophobic [11]. A wide number of mechanical and chemical methods are available to alter the fibre surface to enhance the interfacial bond between fibres and polmer matrices[12,13]. Physical methods include heat, plasma[12,14] and corona treatments

[15] whereas chemical treatments comprise alkali, silane, acid, benzoylation and peroxide treatments as well as acetylation [16]. In theseyears, high intensity ultrasound (HIU) treatment gaining reputation owing to its ability of the effective elimination of amorphous materials on the surface of natural fibers[17].

In the present work, high intensity ultrasound was applied on the sisal fibers in order to remove the amorphous materials and PP composites were prepared with the addition of dissimilar weight percentage of surface treated sisal fibers into PP matrix. Morphology, mechanical and water absorption properties investigated in order to find out the effects of HIU treatments.

II. EXPERIMENTAL

A. Materials

Polypropylene (Titanpro 6331) with 14 g/cm3 of melt flow index and the density was 0.9 g/cm3. Sisal fibers were purchased from vibrant nature, Chennai, India.

B. High intensity ultrasound treatment

The HIU treatment was applied according to our previous work [18]. Sisal fibers after washing with distill water several times were subjected to high intensity ultrasound treatment. An ultrasonic transducer (Hielscher UIP1000hd, 24 mm of tip diameter) by the frequency of 20 kHz and an output power of 1000 W has been employed. Demineralized water was used as the medium and the ratio between sisal fibers and water was kept at 1:20 (w/v) during treatments.

C. Preparation of PP composites

Untreated and HIU treated sisal fibers filled polymer composites were prepared by taking dissimilar weight percentage of sisal fibers (10%, 15%, 20% and 30%) and mixed with PP matrix by using internal mixer (Brabender PL2000-6 with co-rotating blades and69 cm3of a mixing head). Materials obtained from the internal mixer were compression molded according to ASTM standard. The final samples were stored at room temperature for 24 hrs before characterization.

The surface morphology of impact test fractured surfaces of pure PP, untreated and HIU treated SF/PP composites were examined by using Quanta 400 FE-SEM.Mechanical properties such as tensile strength, modulus, elongation and impact strength were studies for untreated and HIU modified sisal fibers reinforced PP composites according to ASTM D3039 and ASTM D7136 standard for tensile and impact properties respectively. PP composite samples were prepared according to ASTM standard with dumble shape and dried in hot air oven before testing in order to remove moisture. Five specimens were tested in each type of sample and average was reported.

III. RESULTS AND DISCUSSION

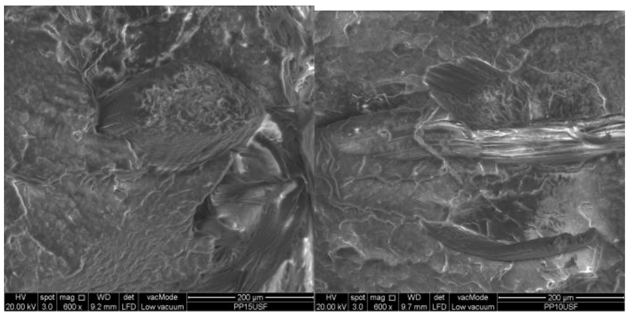

Fig. 1 SEM images of untreated and HIU treated sisal fiber PP composites

FE-SEM was carried out to inspect the effect of surface treatments on morphology of sisal fibers reinforced PP composites. For this purpose, the fractures surfaces of impact tested samples of untreated and HIU treated SF/PP composites were used and represented in Figure. 1.

It could be seen that in the Figure. 1 shows the surface morphology of untreated SF/PP composites, it is very perfect that the large number of voids as well as cracks can be noticed at the fiber-matrix boundary. This is may be due to fiber materials were pulled out from the matrix when impact force was applied which clearly indicates the incompatibility between fiber and matrix material leads to poor surface adhesion between fiber and matrix materials.

HIU treated sisal fiber composites showed good distribution across the PP polymer and the small reduction of voids resulting in improved interfacial adhesion[20].

A. Mechanical Properties

Effect of HIU treatment on the elimination of amorphous materials on the surface of sisal fibers and their mechanical properties were studies. Figure 2 show the tensile strength of unmodified and HIU modified sisal fibers incorporated PP composites.

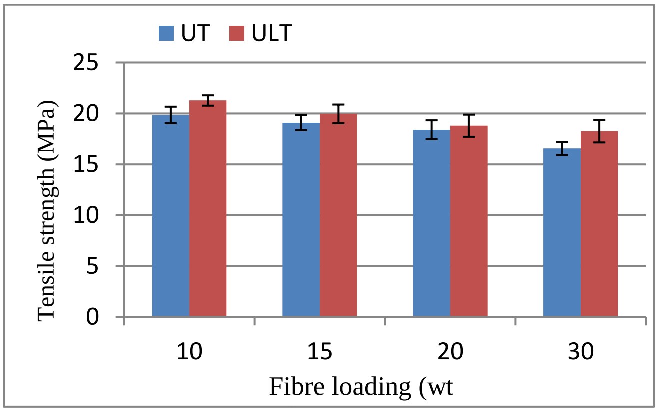

Figure 2 Tensile strength of untreated and HIU treated sisal fibers PP composites

It could be seen that tensile strength was increased significantly by the addition of HIU modified sisal fiber composites as compared with untreated PP composites. This is mainly due to elimination of amorphous materials on the surface of the sisal fibers enhances the compatibility between matrix and filler. However, the trend of tensile strength was reducing by increasing addition of fiber volume. However, in case of tensile modulus, modulus is increasing irrespective of the addition of sisal fibers [21,22].

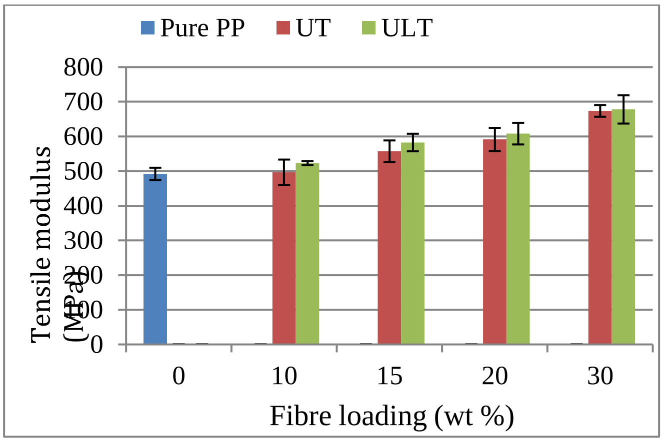

Figure 3 Tensile modulus of unmodified and HIU modified sisal fiber PP composites

The highest tensile modulus is reached by 680 MPa with the increment of 30 wt% of HIU modified sisal fibers into PP matrix. This is may be due to increasing the restrictions of motion between the polymer chains. It is also noticed that the modulus was higher for HIU modified sisal fiber PP composites as compared to untreated sisal fiber PP composites. This could be confirmed that, after the treatment of HIU, compatibility is increased between PP matrix and sisal fibers. Izad impact strength was carried out to find the effect of surface treatment on the sisal fibers and their effects on impact properties of PP composites (Figure 4).

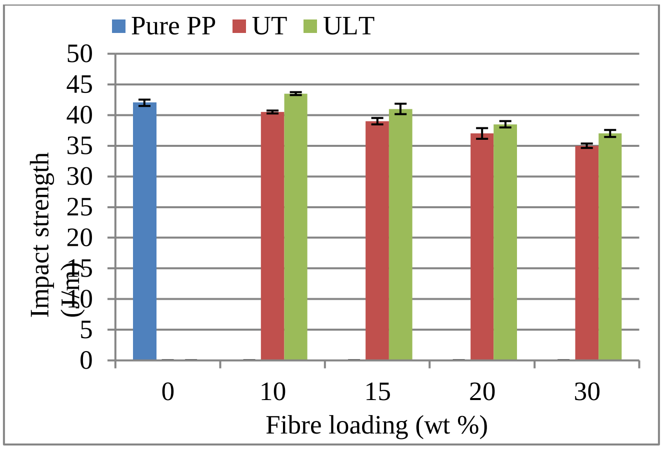

Figure 4 Impact strength of untreated and HIU treated sisal fiber PP composites

It can be seen from the Figure 4 that the impact strength was increased for surface treated sisal fiber PP composites as compared with untreated one by more than 10%. However, it is noticed that impact strength decreased gradually with the increasing the addition of fiber volume[23].

IV. CONCLUSION

In this work, PP composites were prepared by incorporation of untreated and HIU treated sisal fibers with different weight percentage of fiber volume. The effect of surface treatment by HIU on morphology and mechanical properties were investigated. It was noticed that the tensile strength increased significantly for surface modified sisal fiber PP composites when compared to unmodified one. Tensile modulus and impact properties were also increased for the surface treated sisal fiber PP composites as compared to untreated.

V. REFERENCES

[1] T. Xie, W. Liu, T. Chen, R. Qiu, Mechanical and Thermal Properties of Hemp Fiber - Unsaturated Polyester Composites Toughened by Butyl, BioResources. 10 (2015) 2744–2754.

[2] A. Etaati, S. Pather, Z. Fang, H. Wang, The study of fibre/matrix bond strength in short hemp polypropylene composites from dynamic mechanical analysis, Compos. Part B Eng. 62 (2014) 19–28.

[3] F. Vilaseca, A. Valadez-Gonzalez, P.J. Herrera-Franco, M.A. Pelach, J.P. Lopez, P. Mutje, Biocomposites from abaca strands and polypropylene. Part I: Evaluation of the tensile properties, Bioresour. Technol. 101 (2010) 387–395.

[4] F. Z. Arrakhiz, K. Benmoussa, R. Bouhfid, A. Qaiss, Pine cone fiber/clay hybrid composite: Mechanical and thermal properties, Mater. Des. 50 (2013) 376–381. doi:10.1016/j.matdes.2013.03.033.

[5] M. Haameem J.A., M.S. Abdul Majid, M. Afendi, H.F.A. Marzuki, I. Fahmi, A.G. Gibson, Mechanical properties of Napier grass fibre/polyester composites, Compos. Struct. 136 (2016) 1–10.

[6] S. Annie Paul, A. Boudenne, L. Ibos, Y. Candau, K. Joseph, S. Thomas, Effect of fiber loading and chemical treatments on thermophysical properties of banana fiber/polypropylene commingled composite materials, Compos. Part A Appl. Sci. Manuf. 39 (2008) 1582–1588.

[7] M.F. Rosa, B. sen Chiou, E.S. Medeiros, D.F. Wood, T.G. Williams, L.H.C. Mattoso, W.J. Orts, S.H. Imam, Effect of fiber treatments on tensile and thermal properties of starch/ethylene vinyl alcohol copolymers/coir biocomposites, Bioresour. Technol. 100 (2009) 5196–5202.

[8] N. Sgriccia, M.C. Hawley, M. Misra, Characterization of natural fiber surfaces and natural fiber composites, Compos. Part A Appl. Sci. Manuf. 39 (2008) 1632–1637.

[9] Q. Cheng, S. Wang, T.G. Rials, S.H. Lee, Physical and mechanical properties of polyvinyl alcohol and polypropylene composite materials reinforced with fibril aggregates isolated from regenerated cellulose fibers, Cellulose. 14 (2007) 593–602.

[10] V. Vilay, M. Mariatti, R. Mat Taib, M. Todo, Effect of fiber surface treatment and fiber loading on the properties of bagasse fiber-reinforced unsaturated polyester composites, Compos. Sci. Technol. 68 (2008) 631–638.

[11] M. Le Troedec, D. Sedan, C. Peyratout, J.P. Bonnet, A. Smith, R. Guinebretiere, V. Gloaguen, P. Krausz, Influence of various chemical treatments on the composition and structure of hemp fibres, Compos. Part A Appl. Sci. Manuf. 39 (2008) 514–522.

[12] H. Ma, C. Whan Joo, Influence of surface treatments on structural and mechanical properties of bamboo fiber-reinforced poly(lactic acid) biocomposites, J. Compos. Mater. 45 (2011) 2455–2463.

[13] C. Merlini, V. Soldi, G.M.O. Barra, Influence of fiber surface treatment and length on physico-chemical properties of short random banana fiber-reinforced castor oil polyurethane composites, Polym. Test. 30 (2011) 833–840.

[14] S. Kaewkuk, W. Sutapun, K. Jarukumjorn, Effects of interfacial modification and fiber content on physical properties of sisal fiber/polypropylene composites, Compos. Part B Eng. 45 (2013) 544–549.

[15] M. Ragoubi, B. George, S. Molina, D. Bienaimé, A. Merlin, J.M. Hiver, A. Dahoun, Effect of corona discharge treatment on mechanical and thermal properties of composites based on miscanthus fibres and polylactic acid or polypropylene matrix, Compos. Part A Appl. Sci. Manuf. 43 (2012) 675–685.

[16] S. Kalia, K. Thakur, A. Celli, M.A. Kiechel, C.L. Schauer, Surface modification of plant fibers using environment friendly methods for their application in polymer composites, textile industry and antimicrobial activities: A review, J. Environ. Chem. Eng. 1 (2013) 97–112.

[17] P. Krishnaiah, C.T. Ratnam, S. Manickam, Enhancements in crystallinity, thermal stability, tensile modulus and strength of sisal fibres and their PP composites induced by the synergistic effects of alkali and high intensity ultrasound (HIU) treatments, Ultrason. Sonochem. 34 (2017) 729–742.

[18] P. Krishnaiah, Development of polylactide and polypropylene composites reinforced with sisal fibres and halloysite nanotubes for automotive and structural engineering applications . PhD thesis , University of Nottingham ., 2017. http://eprints.nottingham.ac.uk/43498/.

[19] C.P.L. Chow, X.S. Xing, R.K.Y. Li, Moisture absorption studies of sisal fibre reinforced polypropylene composites, Compos. Sci. Technol. 67 (2007) 306–313.
[20] M.Z. Rong, M.Q. Zhang, Y. Liu, G.C. Yang, H.M. Zeng, The effect of fiber treatment on the mechanical properties of unidirectional sisal-reinforced epoxy composites, Compos. Sci. Technol. 61 (2001) 1437–1447.
[21] A. Elkhaoulani, F.Z. Arrakhiz, K. Benmoussa, R. Bouhfid, A. Qaiss, Mechanical and thermal properties of polymer composite based on natural fibers: Moroccan hemp fibers/polypropylene, Mater. Des. 49 (2013) 203–208.
[22] H.N. Dhakal, Z.Y. Zhang, M.O.W. Richardson, A. Alhuthali, I.M. Low, C. Dong, R. Ghosh, A. Ramakrishna, G. Reena, T.P. Mohan, K. Kanny, P. Ramadevi, D. Sampathkumar, C.V. Srinivasa, B. Bennehalli, H.N. Dhakal, Z.Y. Zhang, M.O.W. Richardson, Effect of water absorption on the mechanical properties of hemp fibre reinforced unsaturated polyester composites, Compos. Sci. Technol. 67 (2007) 1674–1683.
[23] F. Yao, Q. Wu, Y. Lei, Y. Xu, Rice straw fiber-reinforced high-density polyethylene composite: Effect of fiber type and loading, Ind. Crops Prod. 28 (2008) 63–72.