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Evaluation of Mechanical Properties of Date Palm Fronds Polymer Composites

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Abstract : Now a day's researchers are focusing on wood based composites as alternative to conventional composites materials because woods are available in nature which areeco friendly, can be easily processed and also have superior strength. Many of the wood materials like coconut, palm, rubber, wood etc are considered as waste product after yielding. The researchers have extracted fibers from these materials and developed many natural fiber composites. The date palm wood fronds were used as reinforcement and polyester was used as matrix in this study. The date palm fronds were collected from five different regions of Sultanate of Oman. The composite laminates were prepared using hand layup method and tested for different mechanical properties like tensile, impact and bending strengths in order to evaluate the strength of the composites as per the ASTM standards. The Fourier transform infrared spectroscopies (FTIR) were used to analyse the functional groups.
Key words : Date palmfronts, Fiber polymer composite, Tensile strength, Impact strength, Bending strength.

1. Introduction

Natural fiber reinforced composites replace conventional materials like wood and metal due to their superior properties like light weight, high strength to weight ratio, stiffness etc[1-5].The natural fibers are selected as reinforcement because they are available abundantly in nature which are easy to process and environmental friendly. Major drawback of these natural fibers is poor resistance to water absorption due to their presence of cellulose content. This can be overcome using physical and chemical treatments of fibers[6-10].

Now a days,the natural fibers are substitute for glass fibers in the manufacturing industries. They are being used in many areas like automobile, marine, aerospace, furniture sector,etc.However,there are some limitations in the usage of naturalfibers. The properties of the natural fibersmay change depending on the factors like processing techniques, rainfall and other growing conditions[11-15]. In addition, the processing temperature of natural fiber reinforced composite is limited to 200^0C due to thermal degradation.Moreover,high moisture absorption of natural fibers leads to swelling and dimensional variations in the final shape[16-20].

Date palm trees are found abundantly in the Middle East countries compared to other region. Many research works have been carried out for developing composites using these date palm fronds and fibers[21-25]. It has been estimated that approximately 1,00,000 ton of date palm fronds and leaves has been produced from Saudi Arabia alone and utilized for the development of composites[26-28].The objectives of this study are to produce laminates of date palm frond fibers with polyester resin and to evaluate the mechanical properties of the produced laminates.

2. Materials and Methods

An attempt has been made for the development of date palm fronds polymer composite with the combination of 30:70 and 50:50 % volume ratio. The date palm fronds were collected from different regions of Oman. They were cleaned for the removal of dust and sand contents on the surface. Therefore, shaving of the fronds to an extent of 3 to 5mm was done to remove dust and to collect the best samples. The fibers were extracted from the fronds by using mechanical retting machine which was indigenously built for laboratory purpose. They were made to pass between the rollers till the fibers were separated by individual fibers. These were tested for both physical and mechanical properties. The date palm fiber composite was prepared using cured polyester resin having the tensile strength of 50-60 N/mm^{2}supplied by Atul Polymer Division Ltd., Gujarat, India.

2.1 Fiber Preparation

The fibers were then chopped to length of 10 mm. The fibers from the mid ribs of date palm treewere selected for the study, whose average diameter is 250 µm and density of 1.4 gcm^{-3}.The chemical constituents and physical properties of palm fibers are given in Table1.

Table1 Chemical constituents and physical properties of palmfiber

Chemical constituents		Physical properties	
Cellulose (%)	65	Diameter (µm)	150-500
Hemi cellulose (%)	4	Tensile strength (MPa)	248
Lignin (%)	19	Young's modulus (GPa)	3.2
Wax (%)	0.4	Elongation at beak (%)	14

2.2 Alkali Treatment of Fibers

The palm fibers which were cleaned, were dipped in 10 % solution of NaOH for 6 hours and then washed in very dilute acid to remove all particles of alkali. The washing was continued till the fibres were free from alkali. The washed fibres were then dried in the oven at 70^{0}C for 3 hours.

Most of the authors have reported about the change in crystallinity of alkali treated fibres because the removal of the cementing materials lead to a better packing of cellulose chains. More than that, an increase in surface area of the fibre occurs due to the dissolution of lignin and hemicellulose in the fibre. This results in larger area of contact between the fibre and the matrix, which leads tomoretensile strength[29-30].

The tensile test was conducted with universal testing machine (Model: KIC-2-100-C) at a test speed of 1.5mm/min. The bending test as per ASTM D5942-96 was conducted using(KIC-2-100-C) UTM machine at test speed of 1mm/min. Izod impact test was conducted on the specimen using Izod impact tester. The geometry of the specimen was 64 x 12.7 x 4 mm.

FTIR analysis was carried out using Perkin Elmer RXI FTIR spectrometer. Spectra were recorded from Fourier infrared spectrophotometer in the range of 400-4000 cm^{-1}.The surface Morphology was carried out on the fracture surfaces of the tested samples. For this purpose, the samples were coated with gold and then morphology was observed by means of Zeiss scanning electron microscope (SEM) with operation condition of 15keV.

3. Results and Discussion

3.1 FTIR Analysis

Figure 1 shows the FTIR spectra of the date palm fibers used in this study.The broad band at 3500-3200 cm^{-1} is a characteristic stretching from vibrations of the bonded hydroxyl groups of carbohydrate (hemicellulose and cellulose) and lignin of palm fiber.

The spectrum band around 2900 cm^{-1}showedthe presence of aliphatic chain in the fiber components. The peak at 1740-1750 cm^{-1} signified the carbonyl group stretching of the acetyl and carboxylic acid groups of lignin and hemicelluloses components. The peaks at 1630 cm^{-1} and 1520 cm^{-1}displayed CH and -C=C vibrations in the fiber whereas the peak at 1310cm^{-1}exhibited-C=H stretching of methyl groups of lignin. A peak at 1238 cm^{-1} and 1032 cm^{-1}displayed-C-O-C- and C–H stretching of cellulose and lignin respectively. Most of the peaks in the spectrum were found to be similar and slight shifting of wavelength was absorbed due to the reduction or increase in intensity of absorbance peak at certain points. The overall characteristics of stretching exhibited the structure of palm fiber.

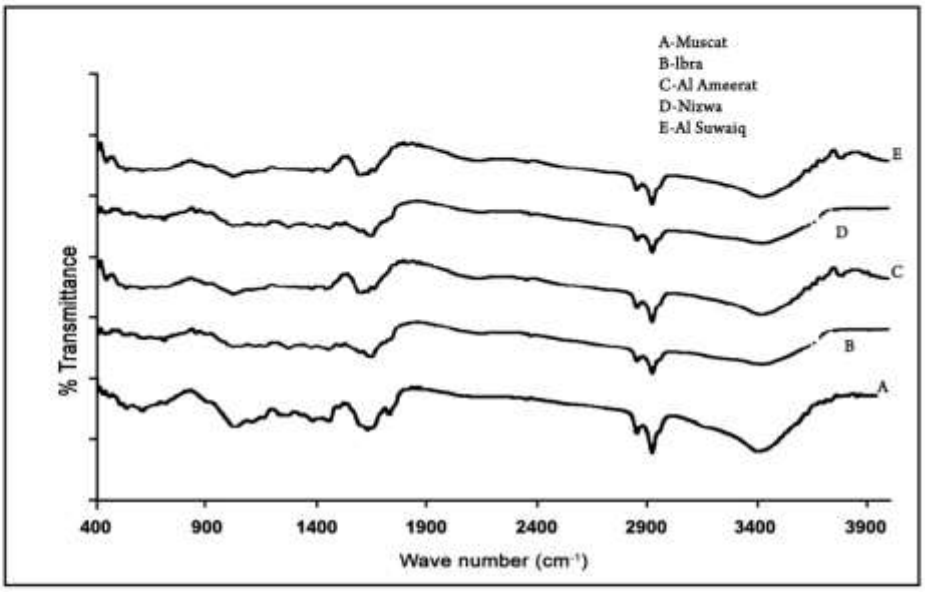


Figure1 Fourier transform infrared (FTIR) spectra of the different palm fibers

3.2 Tensile Strength

Tensile strength is one of the important properties of load bearing materials. Table 2 and Table 3 shows the variation of the ultimate tensile strength of the samples. It was noticed from the Table 2and Table 3that the ultimate tensile strength of all the samples except sample B was found to be same for 70% &50%vol date palm fibers content. This behaviour was due to the increase of fibers content that led to a low density of samples. This can be attributed to the fact that the density of fibre is lower than the resin. If the fiber content is more, the packing of the fiber becomes difficult and voids are introduced into the composite. The tensile strength of sample B was increased by 39.9% from Table 3 and 19.52% from Table 2 in comparison with neat matrix (UTS neat matrix) whereas sample A was increased by 38.4% and 15.33% from Table 2 & 3 . The remaining samples C, D and E were increased by marginally when compared to neat matrix. Table 2&3 shows the variation of ultimate tensile strength with the increase in percentage of fibre volume fraction (i.e. 50% fiber and %50% matrix). There is no significant increase in tensile strength.as compare to (30% :70% fiber & matrix)ratio. This shows that the load is not properly transmitted to the fibres. The sole purpose of reinforcement is not properly served at lower volume fractions.

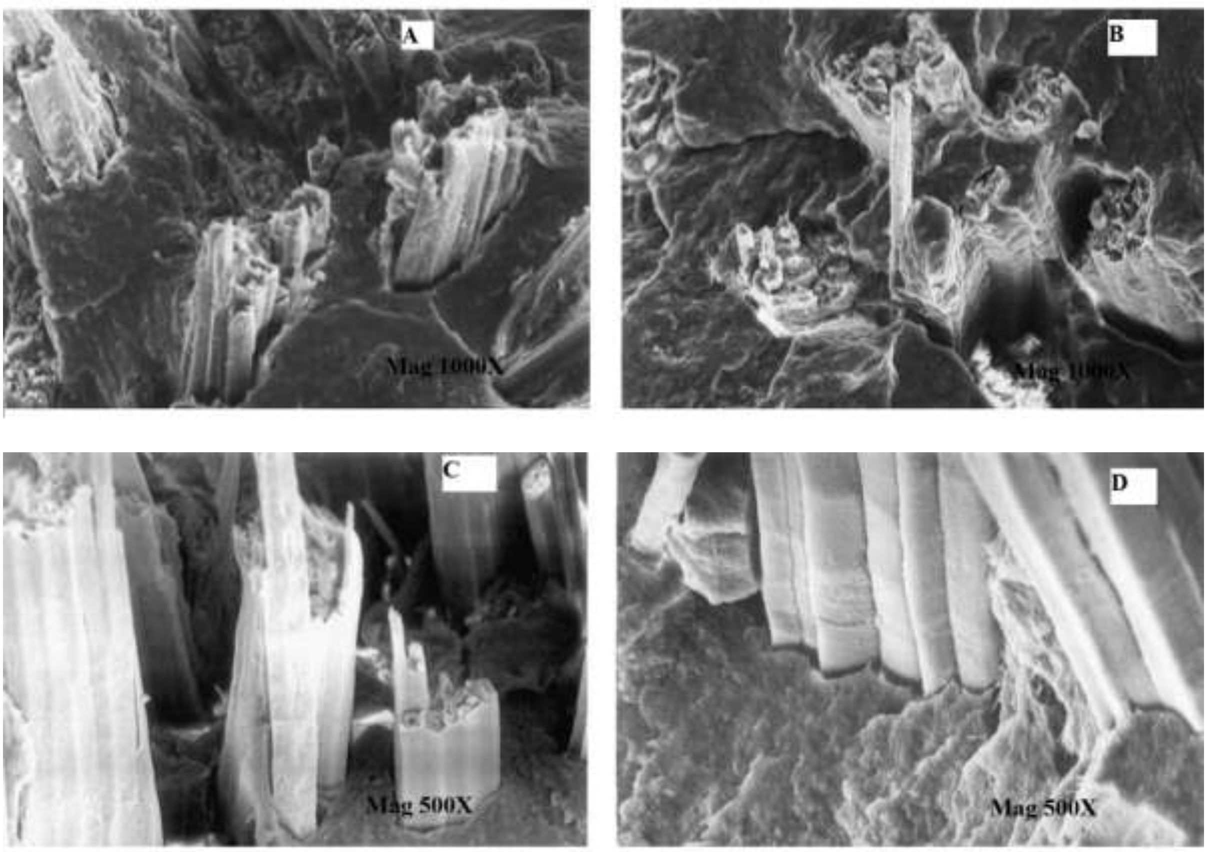

Fig Dog bone shape Fig flat shape

Table2 Mechanical properties of palm fiberpolyester composites weight% ratio 50:50

S.No	Sample type	Tensile strength (MPa)	Elongation (%)	bending strength (MPa)	Impact strength (J/mm^2)
1	A sample (Fiber50+polyester 50)	13.31	1.16	37.12	10.43
2	B sample (Fiber 50 +polyester 50)	14.34	1.09	43.42	11.23
3	C sample(Fiber 50+ polyester 50)	12.76	1.64	39.68	11.12
4	D sample(Fiber 50 + polyester 50)	10.94	1.71	37.56	10.04
5	E sample(Fiber50 + polyester50)	12.42	1.13	42.87	11.07
6	Neat matrix Polyester	11.54	1.47	22.65	6.15

Table 3 Mechanical properties of palm fiberpolyestercomposites weight% ratio 30:70

Sl no	Sample type	Tensile strength MPa	% elongation	Flexural strength MPa	Impact strength KJ/m^2
1	A sample (Fiber30+polyester70)	16.29	1.85	37.12	10.43
2	B sample (Fiber 30 +polyester 70)	19.12	1.92	43.42	11.23
3	C sample(Fiber30+ polyester 70)	16.32	2.04	39.68	11.12
4	D sample(Fiber 30 + polyester 70)	16.34	2.06	37.56	10.04
5	E sample(Fiber30 + polyester70)	18.76	1.93	42.87	11.07



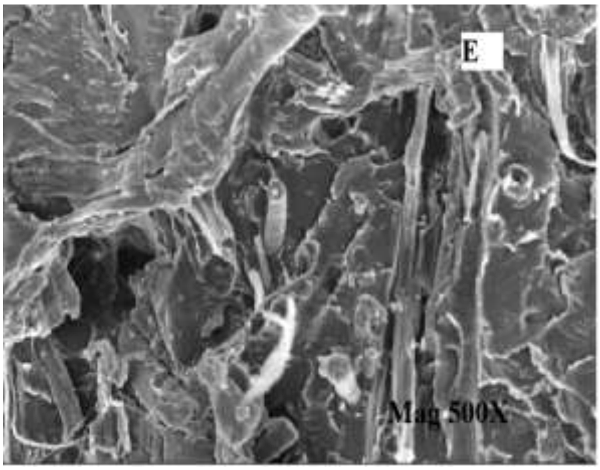


Figure 2 SEM images of thetensile test fractured samples (a)Sample A (b)Sample B (c)Sample C (d)Sample D (e) Sample E

The SEM images of the tensile test fractured specimens are shown in Figure 2. The overall surface topography of all the samples indicated that close packing of palm fibers reduced the ultimate tensile strength of all the samples. The fiber pull out was observed from the sample A region which may be due to close packing of palm fibers. The samples C and D regions exhibited the poor bonding between fiber and matrix, which was again attributed to fiber pull out. From the sample Eregionit was noticed that fiber were bonded by matrix due to alkali treatment.

3.3 Bending Strength

On alkali treatment, bending strength of the composite was found to be improved. The maximum flexural strength of the composite from **Table 2 &3**was achieved in the sample B by 91.69% compared to neat matrix bending strength(neat matrix bending strength 22.65MPa).The increase in bending strength during alkali treatment of fibre can be attributed to the formation of rough fibre surface leading to the improved wetting of fibres with the matrix.

3.4 Impact Strength

The effect of alkali treatment on the impact strength of the composite is given in the Table 2 and Table 3. The lowering of impact strength of the alkali treated fibre composite may be attributed to the weak interfacial bonding between the fibre and the resin. The matrix are not completely bounded on a fiber surface due to heavier fiber fraction, because the impact load will not be completely absorbed by the composites.

4. Conclusion

Many research communities have stated that the fibres like flax, hemp, jute and sisal are ideal candidates in the development of polymers matrix composites. The palm fibres are available in Middle East countries and are finding numerous applications in various fields. Fibers are chopped to smaller length in the range of 900microns to 3 mm length, and the average diameter of fibers is 0.022mm dia. So the fiber aspect ratio in range of 40.90- 136.From the literature it is observed that as aspect ratio decreases the mechanical properties will increases. The mechanical properties of palm fibre composites were investigated in this study to learn more about the fibre matrix adhesion. In this paper, an attempt wasmadecomparingfor30:70 wt ratio with 50:50 wt ratio fiber –matrix composites. It was found that tensile, bending and impact strengths were enhanced much as observed in the 30:70 weight ratio than in 50:50 ratio. This may be the important factor that composites showing good results.

It is evident from SEM images that the poor adhesion between fiber and matrix reduced the strength of the composites.

References

1. Sornakumar, T., Ravindran, D. and Seshanandan, G., 2015. Studies on Effect of Nano TiO2 Ceramic Fillers of Polymer Matrix Composites. International Journal of ChemTech Research, 7(2).
2. Rajkumar, K., Kumari, N., Ranjith, P., Chakraborty, S.K., Thavamani, P., Pazhanisamy, P. and Jeyanthi, P., 2011. High temperature resistance properties of NBR based polymer nanocomposites. International Journal of ChemTech Research ,3(3), pp.1343-1348.
3. Sangeetha, K., Vasugi, G. and Girija, E.K., 2015. Removal of lead ions from aqueous solution by novel hydroxyapatite/alginate/gelatin composites. International Journal of ChemTech Research, 8(5), pp.117-125.
4. Al-Khanbashi, A., Al-Kaabi, K. and Hammami, A. (2005) Date Palm Fibres as Polymeric Matrix Reinforcement: FibreCharacterisation. Polymer Composites, 26, 486-497.
5. Mwaikambo, L.Y. and Ansell, M.P. (2002) Chemical Modification of Hemp, Sisal, Jute, and Kapok Fibers by Alkalization.Journal of Applied Polymer Science, 84, 2222-2234.
6. Raghavendra,S. The Effect of Fiber Length on Tensile Properties of Epoxy Resin Composites Reinforced by the Fiber of Banana, International Journal of Engineering Research & Technology (IJERT), 2012.
7. Killmann, W. and Choon, L.S. 1985. Anatomy and properties of oil palm stem. Bulletin PORIM 11: 18-42.
8. Bakar, E.S., Rachman, O., Hermawan, D., Karlinasari, L. and Rosdiana, N. 1998. Utilization of oil palm trees as building and furniture material (1): physical and chemical properties and durability of oil palm trunk. Journal of Forest Products Technology 11.
9. Machaka, M., Basha, H., Chakra, H.A. and Elkordi, A., 2014. Alkali Treatment of Fan Palm Natural Fibers For Use In Fiber Reinforced Concrete. European Scientific Journal, 10(12), p.186-195.
10. Asadzadeh, M., 2012. Bending properties of date palm fiber and jute fiber reinforced polymeric composite. International Journal of Advanced Design and Manufacturing Technology, 5(4), p.59-63.
11. Almi, K., Lakel, S., Benchabane, A. and Kriker, A., 2016. Characterization of date palm wood used as composites reinforcement. ACTA PhysicaPolonica, 127(4), p.1072-1074.
12. AlMaadeed, M.A., Kahraman, R., Khanam, P.N. and Al-Maadeed, S., 2013. Characterization of untreated and treated male and female date palm leaves. Materials & Design, 43, pp.526-531.
13. Hegazy, S.S. and Ahmed, K., 2015. Effect of date palm cultivar, particle size, panel density and hot water extraction on particleboards manufactured from date palm fronds. Agriculture, 5(2), pp.267-285.
14. Hammood, A.S., Effect of Erosion on Water Absorption and Morphology for Treated Date Palm Fiber-Reinforced Polyester Composites. International Journal of Mechanical & Mechatronics Engineering, 15(6), p.108-114.
15. Kishor, B.S. and Ankegowda, V.B.N., Effect of Fiber Length on the Mechanical Properties of Coir and Wild Date Palm Reinforced Epoxy Composites. International Journal of Science Technology & Engineering, 2(11), p.555-559.
16. Dubey, N. and Agnihotri, G., 2015. Evaluation of Tensile and Interfacial Strength of Coconut Palm Leaf Midrib as a potential Reinforcement for Plastics. International Journal of Scientific and Research Publications, 5(2), p.116-125.
17. Ibrahem, R.A., 2016. Friction and wear behaviour of fibre/particles reinforced polyester composites. Int. J. Adv. Mater. Res, 2, pp.22-26.
18. Rafeeq, S.N., Abdulmajeed, I.M. and Saeed, A.R., 2013. Mechanical and Thermal Properties of Date Palm Fiber and Coconut Shell Particulate Filler Reinforced Epoxy Composite. Indian Journal of Applied Research, 3(4), p.89-92.
19. Aly, N.M. and Nashar, D.E., Polyester/Flax Biocomposites Reinforced Using Date Palm Leaves and Wood Flour As Fillers. International Journal of Engineering and Technology, 8(3), p.1579-1588.
20. Zayed, S.E., Adam, A.A., Entesar, A.H. and Elkady, M.A., 2014. Properties of particleboard based on Date palm fronds as renewable Egyptian lignocellulosic materials. International Journal of Innovation and Scientific Research, 9(2), p. 326-334.
21. Shamsi, M. and Mazloumzadeh, S.M., 2009. Some physical and mechanical properties of date palm trees related to cultural operations industry mechanization. Journal of Agricultural Technology, 5(1), pp.17-31.

22. Hosseinkhani, H., Euring, M. and Kharazipour, A., 2015. Utilization of date palm (Phoenix dactylifera L.) pruning residues as raw material for MDF manufacturing. Journal of Materials Science Research, 4(1), p.46-62.
23. Udhayasankar, R. and Karthikeyan, B., 2015. A Review on Coconut Shell Reinforced Composites. International Journal of ChemTech Research, 8(11), pp.624-637.
24. Davallo, M. and Pasdar, H., 2009. Comparison of Mechanical Properties of Glass-Polyester Composites Formed by Resin Transfer Moulding and Hand Lay-Up Technique. International Journal of Chem Tech Research CODEN (USA): IJCRGG, 1(3), pp.470-475.
25. Prithivirajan, R., Jayabal, S., Sundaram, S.K. and Kumar, A.P., 2016. Hybrid Bio Composites from Agricultural Residues: Mechanical and Thickness Swelling Behavior. International Journal of Chem Tech Research,9(3), pp.609-615.
26. Davallo, M., Pasdar, H. and Mohseni, M., 2010. Effects of laminate thickness and ply-stacking sequence on the mechanical properties and failure mechanism of unidirectional glass-polyester composites International Journal of ChemTech Research, 2(4), pp.2118-2124.
27. Pang, X.Y. and Weng, M.Q., 2014. Preparation of expandable graphite composite under the auxiliary intercalation of Zinc sulfate and its flame retardancy for ethylene/vinyl acetate copolymer. International Journal of ChemTech Research, 6(2), pp.1291-1298.
28. Chaudhari, J.A. and Patel, R.P., 2010. Synthesis, characterization, composites fabrication and antimicrobial activity of piperazinylobisarylhydrazino-s-triazine derivatives. Int J Chem Tech Res, 2, pp.1949-1954.
29. Karthikeyan, S., Xavior, M.A., Jeeva, P.A. and Raja, K., 2015. A green approach on the corrosion studies of Al-Si Ccomposites in Sea water. International Journal of ChemTech Research, 8(3), pp.1109-1113.
30. Pandey, M. and Joshi, G.M., 2015. Effect of DC-bias on electrical properties of polymer/Nafion Composites. International Journal of ChemTech Research, 8(10), pp.245-248.

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