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Effect of mercerized melon (*Citrullus lanatus*) husk on the mechanical properties of polypropylene composite

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Abstract
Effect of mercerized melon husks on the mechanical properties of polypropylene was studied. Melon husk was mercerized using NaOH, dried and reduced to ultra-fine particles using sieve size of 75µm and used for compounding polypropylene. The result of the filler characteristics showed that mercerized melon husks (MMH) had better and improved properties compared to the unmercerized (UMH) in terms of pH (UMH; 5.16 and MMH; 8.25), lignin contents (UMH; 11.50% and MMH; 5.69%), moisture content (UMH; 3.30% and MMH; 1.95%) and bulk density (UMH; 0.87g/ml and MMH; 0.64g/ml) respectively. The mechanical properties investigated showed increased tensile strength for both fillers at 40g loadings in terms of tensile strength (UMH; 31.85-45.88MPa) and (MMH; 31.85-52.16MPa) before decreasing, tensile modulus (UMH; 1005.17-1042.23MPa) and (MMH; 1005.17-1069.94MPa), hardness (UMH; 67.50-115.67Shore A) and (MMH; 67.50-133.42Shore A),while there was quite noticeable decrease in properties such as elongation at break (UMH; 290.11-180.35%) and (MMH; 290.11-172.55%), impact strength (UMH; 136.55-93.29J/mm^2) and (MMH; 136.55-102.17J/mm^2) and abrasion resistance (UMH; 95.65-54.25%) and (MMH; 95.65-63.26%) as filler loadings increases. However, mercerized melon husk filled composites showed excellent and enhanced performance when compared with unmercerized and unfilled polypropylene matrices revealing the effectiveness of chemical modification on natural fibres.

Keywords: Mercerized, polypropylene, NaOH, unfilled, C*itrulus lanatus*

1. Introduction
Composite material is a material consisting of two or more constituents (phases) that are combined at the macroscopic level and are not soluble in each other and it has been discovered too long ago. Polymeric composite is a combination of polymer with another material, such as glass, carbon, or another polymer. They are used in many different areas such as: boats and marine use, military, constructions and cars. In addition, there are many factors that affect the mechanical and physical properties of polymeric composites. Also, there are three main processes to manufacture the composite and each one includes different methods and each one of them includes several processes (Hussain *et al.*, 2010) [6]. By combining a polymer with another material, such as glass, carbon, or another polymer, it is often possible to obtain unique combinations or levels of properties. Furthermore, there are many examples of polymeric composite such as glass, carbon, fibre reinforced thermoplastics, carbon reinforced rubber, polymer blends, and silica or mica reinforced resins (Ray, *et al*., 2001) [12]. Therefore, the objectives of producing such a material like polymeric composites are because of high strength, stiffness, dimensional stability by embedding particles or fibers in a matrix. Moreover, a cost is playing a very important term in economic side since it is available in good prices in the markets. This goal is increasingly important as petroleum supplies become costlier and less reliable. There still exists a need for polymeric compositions that, in terms of process ability, performance and recyclability are similar to polyolefin but contain renewable polymers (Sukru, *et al*., 2008) [13]. This research investigates the effect of melon husks on the mechanical properties of polypropylene composite which was achieved by chemically modifying the melon husks before compounding the polypropylene composite

2. Materials and Method
2.1 Materials
The major raw materials required include melon husks and polypropylene. Preparation of melon husks, characterization of the fillers, compounding, molding and the various mechanical tests.

Table 2.1: Materials and their Sources

Materials	Sources
Melon Husks	Polytechnic Staff Quarters, Auchi.
Polypropylene	Vulnax International, England
Water	Standard Water Industries, Auchi
Sodium Hydroxide (NaOH)	Siegma Andriech Co. Germany

2.2 Method

2.2.1 Collection and Characterization of Filler

Melon husks were collected from Polytechnic Staff Quarters, Auchi. The husks were washed to remove possible impurities, dried, crushed and sieved using a 75µm screen gauge and were characterized in terms of;

i. Moisture Content ii. Bulk Density iii. pH iv. Lignin Content

2.2.2 Mercerization Process

The fillers were soaked into 20% sodium hydroxide (NaOH) solutions for 3hrs at room temperature. After which the fillers were thoroughly washed with distilled water, dried for 36hrs, followed by oven drying at 150°C for 1hr.

2.3 Processing of Composites

This involves the compounding of polypropylene with melon husks presented in Table 2.2

Table 2.2: Formulation for Compounding

Samples	PP	UMH	MMH
A	100	-	-
B	90	10	10
C	80	20	20
D	70	30	30
E	60	40	40
F	50	50	50

2.3.1 Mixing Procedure

The polypropylene mix was carried out on a laboratory size two roll mill according to ASTMD Standard.

2.3.2 Moulding

The molding of tests samples was done in a compression moulding machine at a temperature of 160°C for 7 minutes in each case.

2.4 Mechanical Properties of Composite

The mechanical properties of the polypropylene composites determined using standard test procedures include:

2.4.1 Tensile Properties

The tensile properties were determined on a universal tensile tester model at a cross speed of 450mm/min using dumbbell test pieces of dimension (100 × 10 × 4mm). The test samples were tested in the machine giving straight tensile pull, without any bending or twisting. The machine measures both the tensile stress and the tensile strain. The tensile stress is the strength of pull in the area between the notch marks. It is based on original cross sectional area. The tensile strain is a measure of how the test sample has been stretched by the pull.

2.4.2 Hardness

The hardness of the samples was determined by adopting the standard dead load method. The test was carried out using the Wallace Hardness Tester in accordance with shore A.

2.4.3 Impact Test

The impact test was carried out by supporting the sample at both ends placed horizontally with the impact applied midway between the two supports. A pendulum of a known mass was allowed to fall through a known height and strike the specimen as it continues swinging. The difference between the heights was proportional to the energy absorbed. The difference between the initial height and the height reached after impact on the test sample was recorded as the impact strength of the sample.

2.4.4 Abrasion Resistance

Wallace Akron abrasion tester was used. The angle between the test sample and the wheel was adjusted to an angle of 15°. The abrasion was carried out per 1000 revolutions and the material loss for each run was noted. The specimen was re-reweighed between each test run. The mean of the four revolutions of the abrasive wheel was calculated.

$$Abrasion\ \text{Re}sis\tan ce = \frac{Weight\ \ Loss\ \ of\ \ the\ S\tan dard}{Weight\ \ Loss of\ \ the\ \ Sample} \times 100$$

2.5 Micro-Structural Analysis

The micro-structural analysis was carried out using Phenom Scanning Electron Microscope model PoX in accordance to ASTM E2809-13. Specimen samples usually non-conductive were made conductive by coating with gold metal and into specified dimension of 5-nm thick by 2mm x 2mm square meter using a sputter cutting machine (Daenabi and Korayem, 2011) [5]. The sample was placed on the column of the Scanning Electron Microscope (SEM) where the image was focused using navigation camera and was transferred to electron mode in accordance to the desired magnification, which reveals the cracks areas, pores, bundles and voids present in the sample. The specimens were scanned, namely, the unfilled polypropylene which served as the control, UMH and MMH at 30g using a sieve size of 75µm.

3. Results and Discussion

3.1 Results

The results of the effects of mercerized melon husk on the mechanical properties of Polypropylene Composite are presented in Tables 1 - 2 and Figures 1 - 6 respectively.

Table 1: Mechanical Properties of PP filled Composites

Property	Filler Loadings (g)					
	CT	10	20	30	40	50
Tensile Strength(MPa)	31.85	(37.22) [39.43]	(41.19) [44.38]	(45.88) [51.35]	(39.74) [52.16]	(38.05) [47.97]
Modulus (MPa)	1005.17	(1022.13) [1033.15]	(1039.96) [1059.93]	(1042.23) [1064.47]	(1036.68) [1069.94]	(1023.01) [1056.38]
Elongation at Break (%)	290.11	(225.09) [208.91]	(221.07) [201.63]	(213.96) [194.36]	(189.12) [187.43]	(180.35) [172.55]
Hardness (Shore A)	67.50	(78.09) [84.46]	(87.76) [98.24]	(93.30) [121.54]	(95.18) [127.38]	(115.67) [133.42]
Abrasion Resist. (%)	95.65	(89.12) [94.28]	(87.47) [91.96]	(71.13) [85.27]	(62.86) [79.15]	(54.25) [63.26]
Impact Strength (J/mm^2)	136.55	(125.87) [132.46]	(121.54) [126.53]	(111.67) [126.16]	(95.16) [113.48]	(93.29) [102.17]

Key: Untreated Melon Husk filled PP-Composite; UMH ( ), Mercerized Melon Husk filled PP-Composite; MMH [ ]

Table 2: Characteristics of the Powdered Melon Husks

Parameter	UMH	MMH
Lignin Content (%)	11.50	5.69
Moisture content (%)	3.30	1.95
pH of slurry	5.16	8.25
Particle size distribution (µm)	75	75
Bulk Density (g/ml)	0.87	0.64

Key: Untreated Melon Husk (UMH), Mercerized Melon Husk [MMH]

3.2 Discussion

3.2.1 Results of Filler Characteristics

Most natural fibres are derived from lignocelluloses containing strongly polarized hydroxyl group, hence hydrophilic in nature. Most fibres contain cellulose, lignin, water-soluble compounds, waxes, hemicelluloses etc., where lignin, hemicelluloses and celluloses are the major constituents (Jorts, *et al*., 2005) [8]. The hydrophilic nature of fibres causes the fibre to swell considerably and ultimately rotten through fungi attack. The major causes of this biodegradation are the presence of hemicelluloses in the fibres (Jorts, *et al*., 2005) [8].

Table 2 showed the moisture content of the fillers which is often used to predict the degree of defects arising from shrinkage during curing particularly for products processed at elevated temperatures. The moisture content of the treated filler was 1.95% while that of the untreated filler was 3.30%.

Table 2 showed a reduction in percentage of lignin for the treated melon husks filler when compared to the untreated fillers. The percentage lignin content of the treated filler was 5.69% while that of the untreated was 11.50% which is expected because more lignin are gradually removed as a result of the chemical treatment thereby increasing the yield of cellulose in the fibre (Mishra, *et al*., 2002) [10].

The bulk density of the filler presented in Table 2 for both treated and untreated fillers was 0.64g/ml and 0.87g/ml. Bulk density is principally influenced by the particle size and structure of the fibre and the lower the particle size, the lower the bulk density and therefore better the interaction between the polymer matrix and the reinforcing fibre which will thus enhance the composite processing and improve quality of the final product as desirable properties for fibre include excellent tensile strength and modulus, high durability, low bulk density, good mould ability and recyclability (Jorts, *et al*., 2005) [8].

The pH of the powdered fillers presented in Table 2 for both treated and untreated fillers was 8.25 and 5.16 respectively. However, pH at acidity level tends to slow cure rate and hence reduce the cross-links density which in forms the choice of fast accelerators and activators in the mixing formulation (Mohanty *et al*., 2001).

3.2.2 Results of Mechanical Properties

Table 1 and Figure 1 showed the increase in tensile strength is as a result of high surface area of melon husks for both treated and untreated fillers before it starts decreasing at loading level above 30g for untreated filler and 40g for treated filler suggesting better polymer filler interaction and hence enhanced better tensile properties. However, the treated melon husks filled PP-composites showed better and improve tensile strength when compared with the untreated samples. The factors that affect the reinforcing potentials of fillers include filler dispersions, surface area, surface reactivity, bonding capacity (quality), particle size between the filled and the elastomeric matrix (Iannace, *et al*., 2001) [7].

Table 1 and Figure 2 showed that modulus of filled composites depends on the level of filler dispersion in the polymer matrix. The reduction in particle size accounts for the moderate moduli and tensile strength since high particle size reduces modulus and tensile strength because it impedes polymer-filler interaction which consequently decreases the ability of the filler to restrain gross deformation of the composite matrix. At filler loading beyond 30g there may not be adequate polymer material to hold the filler particle together leading to a phenomenon refer to as phase inversion (Ray, *et al*., 2001) [12]. However, the treated PP-composite samples showed enhanced moduli than the untreated samples.

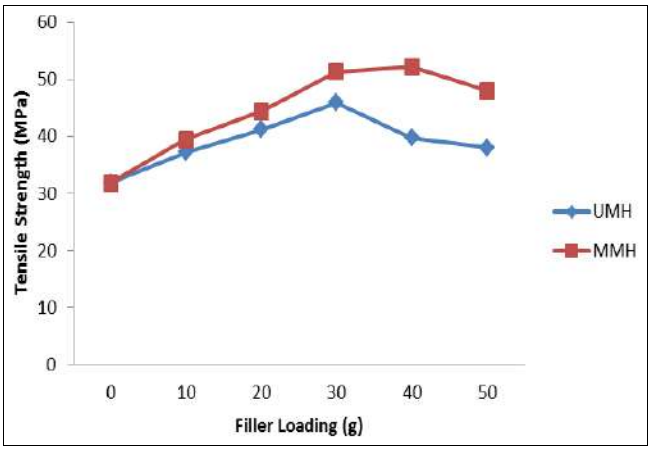

Fig 1: Tensile Strength of filled PP-Composites

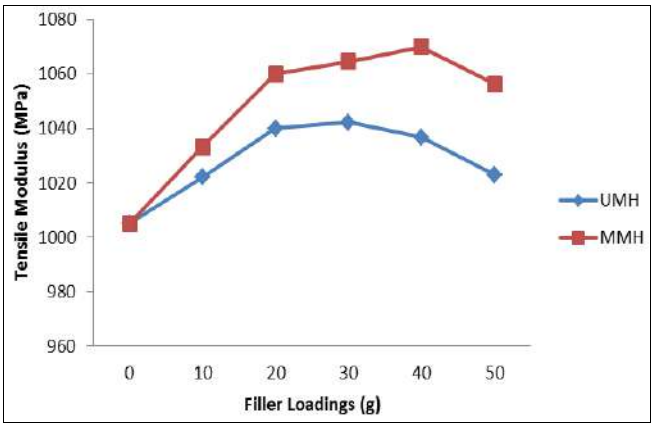

Fig 2: Tensile Modulus of filled PP-Composites

Table 1 and Figure 3 showed that elongation at break (EAB) decreases with increasing fillers loading due to a high interaction between the filler and polymer matrix leading to stiffening of the chains with highly stressed chains break first and their loads are then distributed to other chains forcing them to either break or slip so as to relieve the stress on them. A decrease in EAB has been explained in terms of adherence of the filler to the polymer phase leading to the stiffening of the polymer chain and hence resistance to stretch when the strain is applied.

The hardness of melon husks filled polypropylene is showed in Table 1 and Figure 4 respectively. The hardness increases with increasing filler loading for both treated and untreated samples. Since hardness measures small deformation at the

surface of the polymer matrix and an approximate index of stiffness, longer shelf service life may be expected of products. This result is expected because as more filler particles get into the matrix, the more stiffen are chain and thus increased hardness (Nemour, 1986) [11].

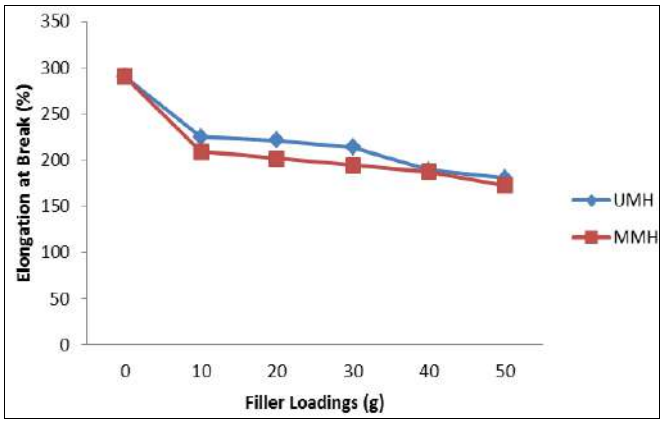

Fig 3: Elongation at Break of filled PP-Composites

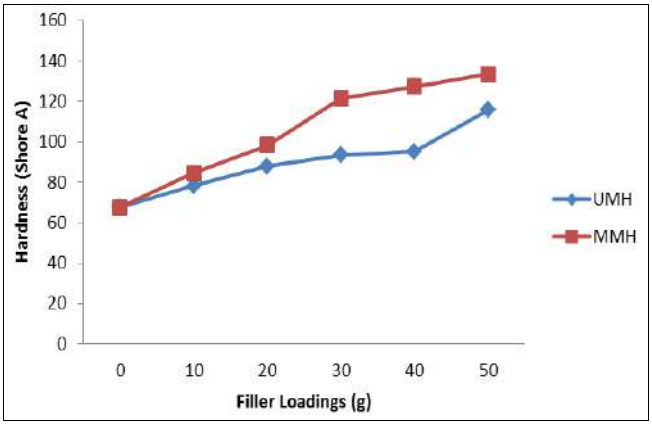

Fig 4: Hardness of filled PP-Composites

The impact result presented in Table 1 and Figure 5 revealed that as the moulded material gets stiffened there is the tendency that they require more energy to break it or to cause failure within the composite material. Thus impact is the resistance to indentation by sudden blow or fracture in a material. The result also predicts the higher the filler loading the lower the average degree of energy requires breaking the sample (Ahmedna, *et al*., 1997) [1]. However, treated PP-composite samples showed better resistance to indentation by the sudden blow in each case.

The abrasion resistance of a solid body is defined as its ability to withstand the progressive removal of the material from its surface as a result of the mechanical action of rubbing, scraping or erosive nature. The trend of abrasion resistance with filler loading presented in Table 1 and Figure 6 showed a regular pattern of decreasing with increasing the filler loading melon husks for both treated and untreated filled PP-composite samples. This indicates that filler loading is a function of the measured parameter attributed to the degree of dispersion of the fillers (Asore, 2000) [2].

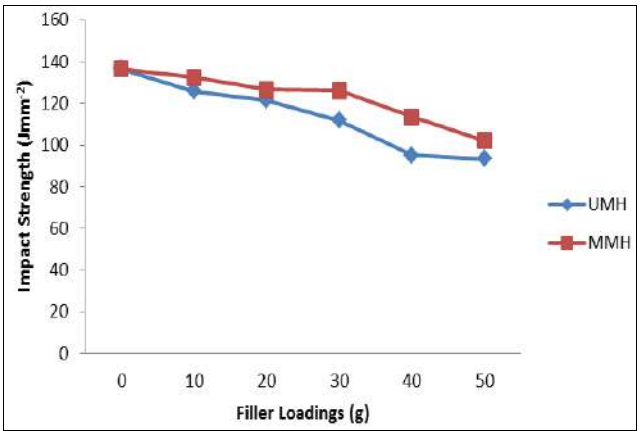

Fig 5: Impact Strength of filled PP-Composites

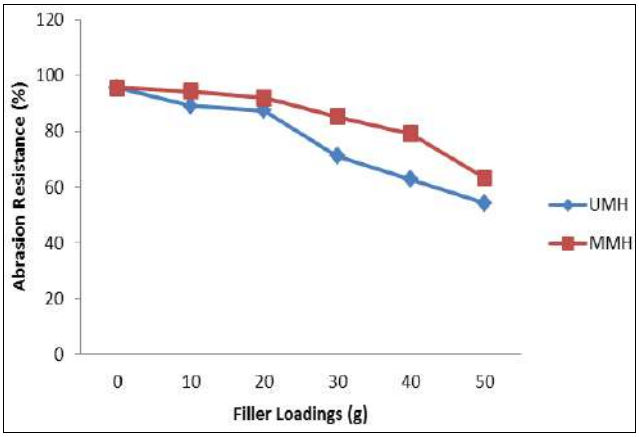

Fig 6: Abrasion Resistance of filled PP-Composites

3.2.3 Results of Morphological Properties

The micro-structural result obtained revealed similar pore areas but relatively lower than the filled matrices. For both filled composites there was irregular surface defects and cracks while the unfilled polypropylene (PP) matrix was quite plane. The observation may be due to complex filler interactions and compaction within the composite material (Balani, Harimkar, Keshri, Chen, Dahotre & Agarwal, 2008) [3]. The morphologies of the filled matrices at 30g loadings were examined for unmercerized melon husks (UMH) and mercerized melon husks (MMH) powder filled composites. Plate I showed micro-graph of unfilled PP with clear surface which is expected due to the absence of reinforcement of fillers in the matrix. The results in Plate II showed micro-graph of UMH filled composite revealing micro-cracks with pores formation, which may be caused by lack of proper adherence of the fillers in the polymer matrices (Bokobza and Chauvin, 2005) [4]. The noticeable voids could be points of possible crack formation when stress development set into the matrix. The results in Plate III showed proper distribution of MMH within the filled matrix revealing proper interlocking potentials between MMH and the matrix, which was predominantly observed due to chemical treatment, which opened up the fibre surface structure for interaction and compaction, which led to the improved mechanical properties investigated. The results demonstrated that the fracture surface of PP/UMH was the roughest with deeper tearing lines and angular cracking. However, the fracture surface of PP/MMH composites was a few fibre bundles, which indicated that the interfacial adhesion was very strong. Higher crack propagation energy was required to fracture such composite

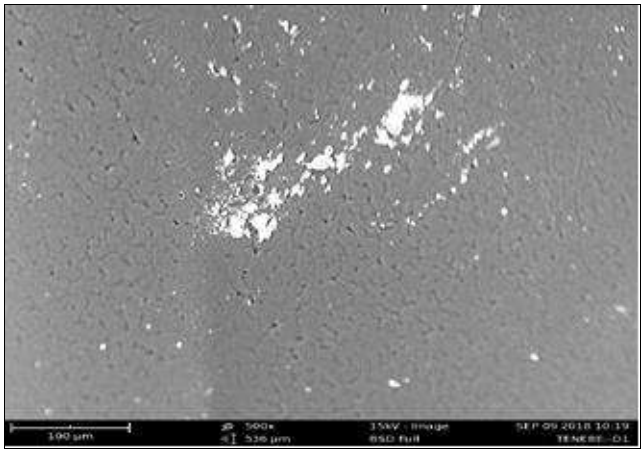

Fig 7: Micro-graph of Unfilled Polypropylene Matrix

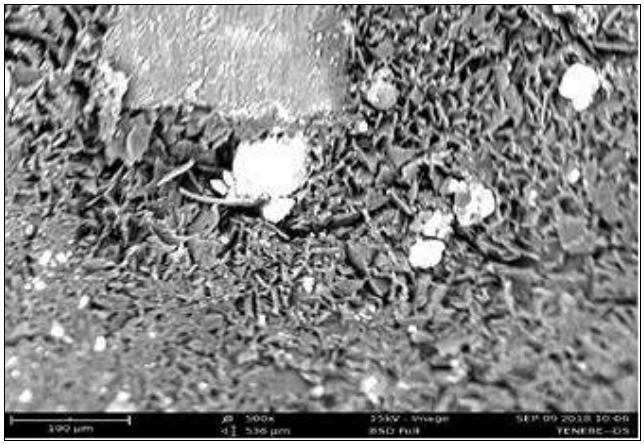

Fig 8: Micro-graph of 30g UMH-filled Polypropylene

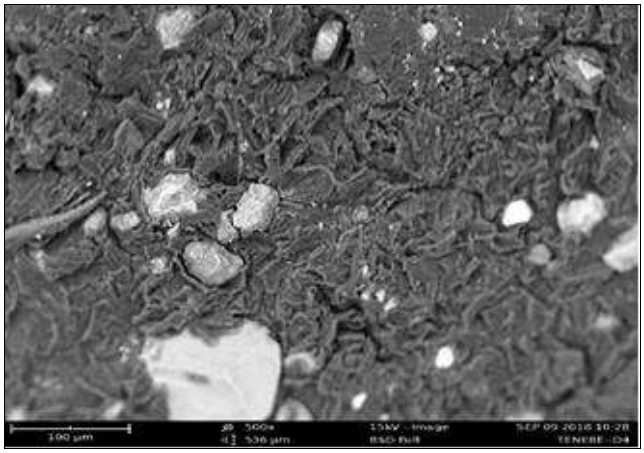

Fig 9: Micro-graph of 30g MMH-filled Polypropylene

4. Conclusion

This research work has examined how filler loading influences the mechanical properties of melon husks filled polypropylene composites. The result showed that treated melon husks can serve as reinforcing filler for polymer composites. The results indicate that mechanical properties of composites are greatly influenced by filler loading and are therefore significant factors in determining the application of such polymer materials (Zareiropoulosa, *et al*., 2002) [14]. The result also predicts the potential applications of melon husks as low cost fillers in polymer products. The morphological properties investigated reveal proper filler dispersion in the MMH composite than the UMH filled which exhibits surface defeats and micro-cracks. The results revealed the potential application of MMH for use in the manufacture of PP products for some engineering applications.

5. References

1. Ahmedna M, Johnson M, Clarke SJ, Marshal WE, Rao RM. Potentials of Agricultural By-product Based Activated Carbon for use in Raw Sugar Decolonization, Journal of Science and Food Agriculture 1997;75:117-124.
2. Asore EJ. An Introduction to Rubber Technology, 1st Edition, Joseg book Limited, Benin City, Nigeria 2000, 45-56.
3. Balani K, Harimkar SP, Keshri A, Chen Y, Dahotre NB, Agarwal A. Multi-scale Wear of Plasma-Sprayed Carbon Nanotube Reinforced Aluminum Oxide Nano-Composite Coating: Acta Materialia 2008;56(20):5984-5994.
4. Bokobza L, Chauvin PJ. Reinforcement of Natural Rubber; Use of in-situ Generated Silicas and Nano-fibres of Sepiolite, Polymer Journal 2005;46(12):4144-4151.
5. Daeinabi K, Korayem MH. Indentation Analysis of Nano-particles Using Nano-Contact Mechanics Models During Nano-manipulation Based on Atomic Force Microscopy, Journal of Nano-particles Res 2011;13:1075-1091.
6. Hussain AI, Abdel K, Ibrahim A. Effect of Modified Linen Fibre Waste on Physic-mechanical Properties of Polar and Non-polar Rubber, Journal of natural science 2010;8(8):82-90.
7. Iannace S, Ali R, Nicolaise LE. Processing Conditions on Dimensions of Sisal Bers in Thermoplastic Biodegradable Composites. Journal of Applied Polymer Science 2001;7c:6.
8. Jorts JW, Shay J, Imam SH, Glem GM, Guttmenn ME, Rovel JF. Application of Cellulose Microfibrills in Polymer Nanocomposites, Journal of polymers and the Environment 2005;13(4):301-306.
9. Mohanty AK, Misra M, Aizal LT, Kellys. Surface Modification of Natural Fibres and Performance of the Resulting Bio composites, An Overview of Composite Interfaces 2004;8:5.
10. Mishra S, Misra M, Tripathy SS, Nayak SK, Mohanty AK. Polymer Composite 2002;23(2):164.
11. Nemour EI. Polymer Products Technology, Department of Languages of Rubber, 1st Edition Washington 1986, 120.
12. Ray D, Sarkan BK, Rama AK, Bose NR. Natural Fibre Reinforced Thermo-Plastics Composites in Natural Polymer, Material Science Journal 2001;24:129.
13. Sukru YO, Zlem C, Ahmet C. The Effects of Fibre Contents on the Mechanical Properties of Adobes, Construction and Building Materials 2008;6:22.
14. Zareiropoulosa NE, Williams DR, Bailliea CA, Matthewsa FL, Janti ZC. Engineering and Characterization of the Interface in Fibre/Polypropylene Composite Materials, Development and Investigation of Surface Treatments Composites part A 2002;3:106.