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Polypropylene/olive pit & almond shell polymer composites: wear and friction

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Abstract: Wood plastic composites (WPC) are made from wood and annual plant fiber or flours, mixing with plastics materials. WPC provide better properties than resources that form it. This renewable material has many utilization areas because of outstanding properties such as enhanced strength, stiffness, creep, physical and mechanical properties and dimension stability. In the present work, series of filled Polypropylene (PP) composites with olive pit and almond shell flour loading (between 0–40 wt %) were prepared, to study the effect of the filler content on the mechanical, wear and friction properties of polypropylene polymer composites.

1. Introduction

Particularly, researches with regard to wood plastic composite materials have been continuously increased within the last 20 years because of the advantageous characteristics of each constituent in composite materials [1]. It is believed that source of petroleum based products are limited and uncertain. So an alternative with cheap sustainable and easily available raw material is required. The countries growing plant and fruit are not for only agricultural purpose but also to generate raw materials for industries. Most of the developing countries trade lignocellulosic fibers for improving economic condition of poor farmers as much as country support. Recently polymer composites containing cellulosic fibers are under focus in literature as well as industries [2]. The olive oil extraction processes generates huge amounts of solid lignocellulosic waste, representing 30-35% by weight of the olive fruit. The chemical composition of which; mainly composed of lignin, hemicellulose and cellulose. Olive waste has a growing potential as a reinforcement filler materials among many other uses [3-8]. Qutaiba studied of a new range of sustainable reinforced polymer composite materials using powdered olive pits as a novel filler material to be used with epoxy resin. Also the influence of the untreated and treated powder loading (weight fraction) on the void content and the mechanical properties of the composites was examined. The results show significant improvements in mechanical properties for composites reinforced with treated olive pits than composites reinforced with untreated olive pits [9]. An investigation was carried out on the effects of olive pit and almond shell powder ratio on the mechanical, wear and friction properties of polypropylene polymer composites. Olive pit and almond shell powder, in four different concentrations (10, 20, 30 and 40 wt %), was added to PP to produce composites. The properties, including density, water absorption, Vicat softening point, heat deflection temperature, wear rate, friction of the composites were investigated.

2. Experimental

Nine different polymer composites were prepared. Compositions of PP/olive pit and almond shell flour polymer composites that were formed are given in Table 1. PP (Moplen EP 3307) supplied by

LyondellBasell. Its density is 0.900 g/cm^3. Olive pit and almond shell were pulverized (about 40 nm size) with Siemens simatic C7-621 control system device. Polypropylene (PP), olive pit and almond shell flour were dried overnight at 105 ^oC in a vacuum oven prior to melt blending. Mechanical premixing of solid compositions was done using a LB-5601 liquid-solids blender for 15 min. Samples with various proportions of polymer composites were produced between 180-220 ^oC at 12 bar pressure, and a rotation rate of 28-32 rpm, with a Microsan extruder. Polymer composites were also dried in vacuum oven at 105 ^oC for 24 hours after extrusion. Subsequently, test samples were manufactured by injection molding. Injection temperature was 180-220 ^oC, pressure was 100-120 bar and screw speed was 20 rpm.

Table 1. Composition of the PP polymer composites formulations

Groups	PP content (wt %)	Olive pit powder content (wt %)	Almond shell powder content (wt %)
1	100	-	-
2	90	10	-
3	80	20	-
4	70	30	-
5	60	40	-
6	90	-	10
7	80	-	20
8	70	-	30
9	60	-	40

Heat deflection temperature (HDT) and Vicat softening point tests were done according to ISO 75 and ISO 307 standard with determined by CEAST 6521. HDT-Vicat test equipment. Water absorption (WA) test was carried out according to ISO 62. Three specimens for each type of composite were used in the WA test. The conditioned specimens were entirely immersed for 1 day in a container of water at 23±2 ^oC. At the end of immersion time, the specimens were taken out from the water and all surface water was removed with a clean dry cloth. The specimens were immediately weighed to the nearest 0.01 g. The densities of specimens were evaluated according to the test method specified in ISO 1183-1 (Method A). Three specimens for each type of composite were used in the density measurement. Static and dynamic coefficient of friction test was done according to the ISO 8295 method with Devotrans friction coefficient measurement equipment. The dimensions of the tested specimens were 80x200x4 mm and the dimensions of the sled specimens were 63x63x4 mm. Speed was selected as 100 mm/min. The static coefficient of friction µs is given by the equation,

$$\mu s = F_S / F_P \quad (1)$$

Where F_S is the static frictional force, expressed in Newton, F_P is the normal force exerted by the mass of the sled, expressed in Newton (=1.96 N).

The dynamic frictional force using the equation,

$$\mu_D = F_D / F_P \quad (2)$$

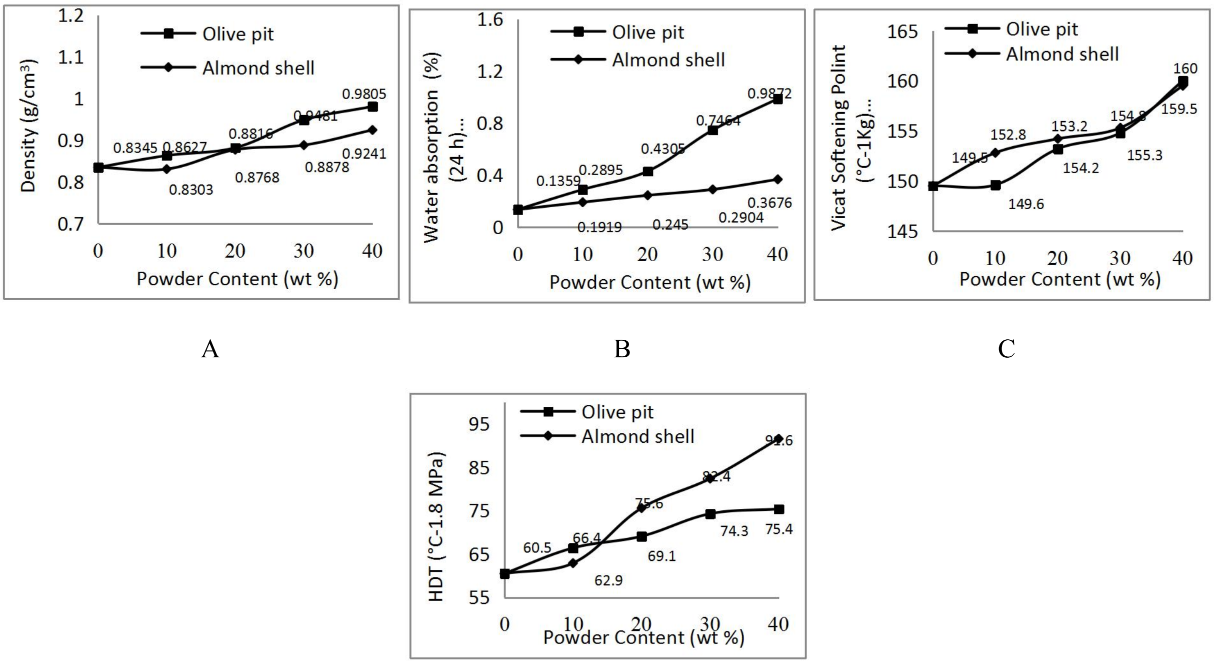
Where F_D is the dynamic frictional force, expressed in Newton, F_P is the normal force exerted by the mass of the sled, expressed in Newton (=1.96 N) [10]. The wear tests were done according to the DIN 53 516 method with Devotrans DA5 abrasion test equipment. The thickness of the test specimens was 7.0 mm and diameter was 15.5 mm. Cylinder rotational speed was selected as 40 rpm and normal load (F_N) of 5, 10, 15 and 20N were used. Total sliding distance (L) of 20, 40, 60 and 80 m were used. The mass loss of the samples (Δm) was measured after the wear process, and the specific wear rates (Ws) were calculated using the following equation:

$$Ws = (\Delta m) / \rho . F_N . L \text{ (mm}^3\text{/Nm)} \quad (3)$$

Where Δm is the specimen's mass loss, ρ is the density of specimen, F_N is the normal load applied, and L is the total sliding distance. The friction coefficients and wear rates reported in the present study were the averages of at three measurements. The fractured surfaces of the PP polymer composites were coated to an approximate thickness of 10 nm of a gold (Au) (80%)/palladium (Pd) (20%) alloys to prevent electrical charging by Polaron SC 7620. The surfaces of the prepared samples were observed by the JEOL-JSM 5910 LV scanning electron microscopy (SEM) at an acceleration voltage of 20 kV.

3. Result and discussion:

The relationship between the filler content and the density of the polymer composites is shown in fig. 1-A. The density of the composites increased (from 0 to 40wt %) linearly with an increase weight percentage of filler. In comparison with the density of virgin PP, the density increased by 17% for the composites at a 40 wt % olive pits flour concentration. Water absorption % at different filler loading level is shown in fig. 1/B The maximum water absorption is observed at the 40 wt % olive pits flour concentration for PP. In comparison with the water absorption of virgin PP, the water absorption increased by 626% for the composites at a 40 wt % olive pits flour concentration. Fig. 1-C illustrates the effect of filler on the Vicat softening point of PP composites. The Vicat softening point increased as the olive pits and almond shell flour concentration increased from 0 to 40 wt %. The maximum Vicat softening point is observed at the 40 wt % olive pits and almond shell flour concentration.



A B C

D

Figure 1. Properties of the PP polymer composites

The relationship between the filler content and the HDT of the polymer composites is shown in fig.1-D. The HDT of the composites increased (from 0 to 40wt %) linearly with an increase weight percentage of filler. The maximum HDT is observed at the 40 wt % almond shell flour concentration for PP. The effects of applied load, sliding distance and fillers content on the tribological behaviors of PP composites were examined. The results of the wear rate of PP/olive pit and PP/almond shell flour polymer composites at different loads and sliding distances are presented in Figure 2. It is seen that the applied load and sliding distance had a great effect on the wear rate of composites. Wear rate increased gradually with the increase of the load from 5 N to 20 N. Also, wear rate increased with the increase of the sliding distance from 20 to 40 m. It was consistent that the sliding distance and applied load affected on the wear rate of PP polymer composites. The weak bond led to the filler particles detaching from the matrix and the matrix pulling out more easily, which could increase the wear rate of the composites. Friction performance is shown in fig. 6 when speed was 100 mm/min; load separately was 1.96, 2.94, 3.92, 4.42 and 6.86 N respectively.

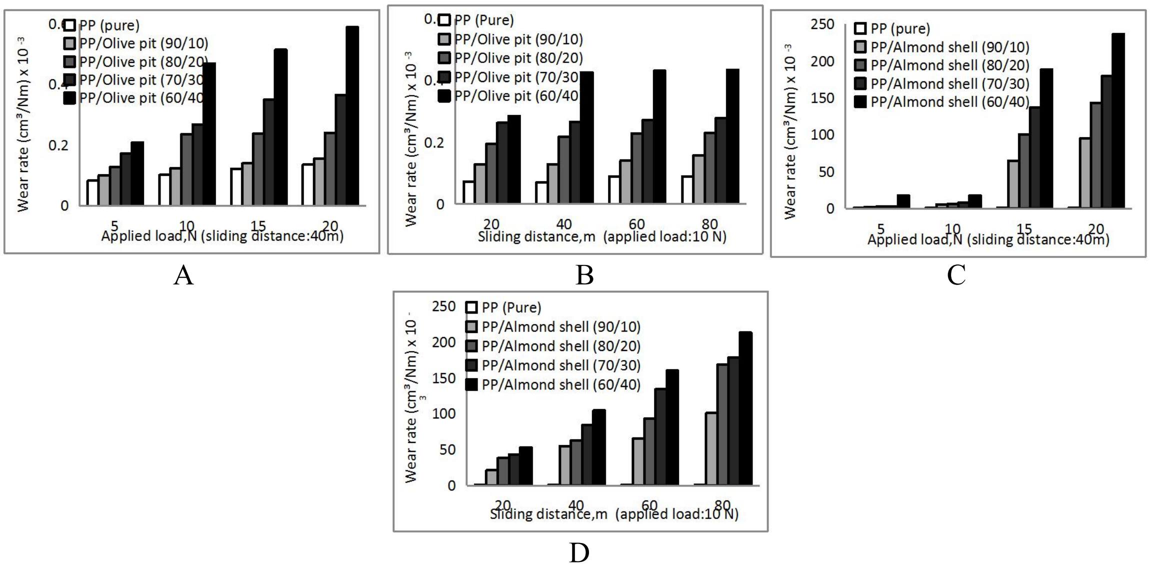


Figure 2. Wear rate of the PP/olive pit and almond shell flour polymer composites

It is seen that the load had a great effect on the static and dynamic friction coefficient of the PP/olive pits and almond shell flour composite. As the load increases, the friction coefficient of all kinds of composites increases. Fig. 3-A/B illustrates the effect of olive pit flour on the static and dynamic coefficient of friction of PP composites.

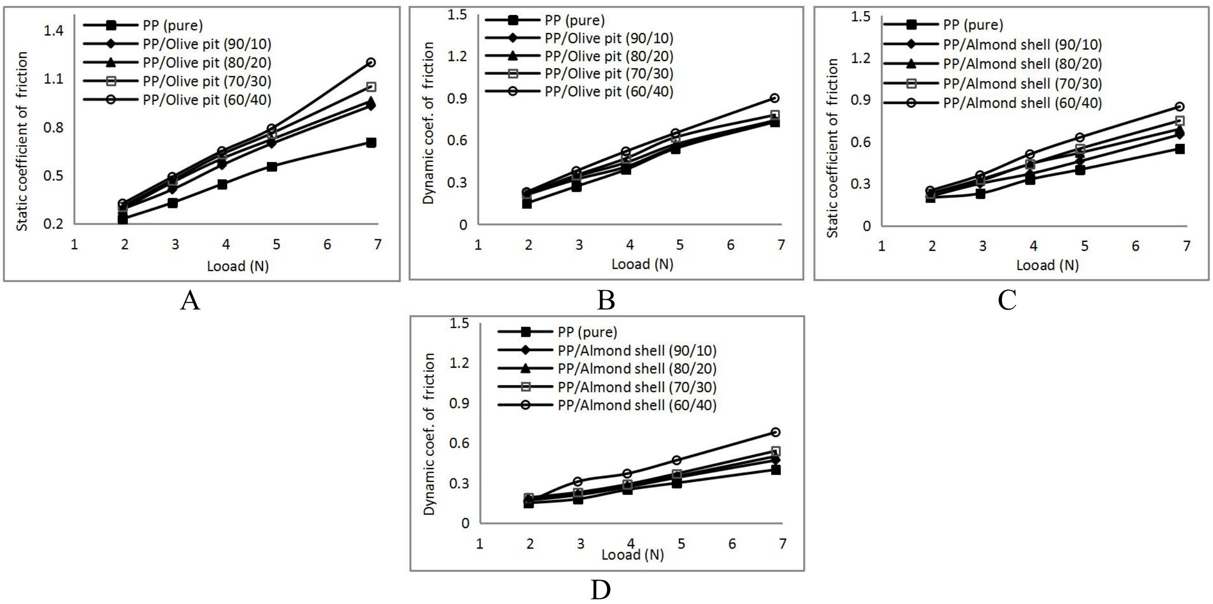
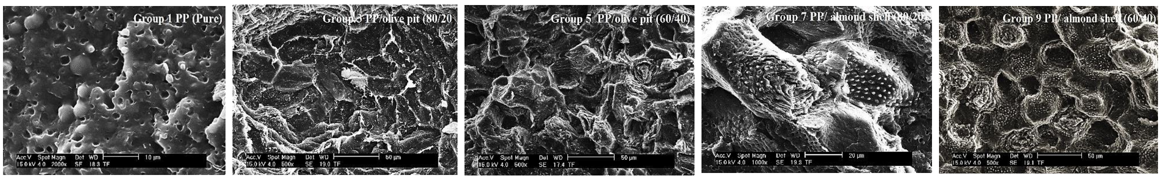


Figure 3. Coefficient of friction of the PP/olive pit and almond shell flour polymer composites

The static coefficient of friction increased as the olive pits flour concentration increased from 0 to 40 wt %. The static coefficient of friction increased as the load increased from 1.96 to 6.86 N as well. The maximum static coefficient of friction is observed at the 40 wt % olive pits flour concentration and 6.86 N load. On the other hand, the dynamic coefficient of friction increased as the olive pits flour concentration increased from 0 to 40 wt %. Also, the dynamic coefficient of friction increased as the load increased from 1.96 to 6.86 N. The maximum dynamic coefficient of friction is observed at the 40 wt % olive pits flour concentration and 6.86 N load. Fig. 3-C/D illustrates the effect of almond shell flour on the static and dynamic coefficient of friction of PP composites. The static coefficient of friction increased as the almond shell flour concentration increased from 0 to 40 wt %. The static coefficient of friction increased as the load increased from 1.96 to 6.86 N as well. On the other hand, the dynamic coefficient of friction increased as the almond shell flour concentration increased from 0 to 40 wt %. Also, the dynamic coefficient of friction increased as the load increased from 1.96 to 6.86 N.

The fractured surfaces of polymer composites were examined with SEM are presented in fig. 4. It is clear that the filler at low loading level (20%) (Fig. 4/B and D) morphology slightly differs from that of pure PP polymer (fig. 4/A). At high olive and almond shell flour loading, (%40) as shown in fig. 4C and E respectively, more filler pullout and deponding were observed. This was probably due to poor adhesion between olive and almond shell flour and polymer matrix.



A B C D E

Figure 4. SEM micrographs of PP composite at different filler contents

4. Conclusions

The aim of this study was to investigate the effect of olive and almond shell flour at different weight fractions without coupling agent on mechanical, morphological, and water uptake properties of PP matrix composite. PP/olive and almond shell flour composite with 10,20, 30, and 40 wt. % olive and almond shell flour contents are under taken in an extrusion and compression molding processes. Substantial improvements in the mechanical properties were obtained by the addition of olive pits and almond shell flour in the PP polymer matrix. The results showed that the density, Vicat softening temperature, and HDT of composites improved with increasing powder content. On the other hand, applied load and sliding distance had a great effect on the wear rate of PP/olive pits and almond shell flour composites. Wear rate increased gradually with the increase of the load and sliding distance. Load had a great effect on the static and dynamic friction coefficient of the PP/olive pits and almond shell composite. As the load increases, the friction coefficient of all kinds of composites increases.

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References

[1] Gwon, JG, Lee SY, Chun SJ, Doh GH, Kim JH, *Compos. Part A Eng*., 2010 **41** p 1491
[2] Asim M, Abdan K, Jawaid M, Nasir M, Dashtizadeh Z, Ishak MR, Enamul HM, *Journal of Polymer Science*, 2015 **1** p 16
[3] Azwa ZN, Yousif BF, Manalo AC, Karunasena W, *Mater Des*. 2013 **47** p 424
[4] Ashori A, *Bioresour Technol*., 2008 **99** p 4661
[5] John MJ, Thomas S, *Biofibres and biocomposites Carbohydr Polym* 2008 **71** p 343
[6] Koutsomitopoulou AF, Benezet JC, Bergeret A, Papanicolaou GC, *Powder Techn* 2014 **255** p10
[7] Banat R, Fares M M, *Int. J. of Composite Materials* 2015 **5(5)** p 133
[8] Asim M, Abdan K, Jawaid M, Nasir M, Dasgtizadeh Z, *Int. J. of Poly. Sci*. 2015 **2015** p 1
[9] Qutaiba A, "Investigation into The Modes of Damage and Failure in Natural Fiber Reinforced Epoxy Composite Materials", Ph.D. Thesis, University of East London 2011
[10] ISO 8295:1995(E) test standard: Plastics-Film and sheeting-Determination of the coefficients of friction