International Journal of Advanced Multidisciplinary Research
ISSN: 2393-8870
www.ijarm.com
DOI: 10.22192/ijamr Volume 7, Issue 2 -2020

Research Article

DOI: http://dx.doi.org/10.22192/ijamr.2020.07.02.001

# EFFECTIVENESS OF THERMAL CONDUCTIVITY OF RECYCLED SAW DUST IMPREGNATED IN POLYTHENE USING CASSAVA AS BINDER

**OBAMERO, Bolaji Akinwale[1*] and AKUBA, Barnabas Ojochegbe[1]**
[1]Department of Science Laboratory Technology, School of Applied Sciences, Kogi State Polytechnic, Lokoja, Kogi State, Nigeria
**Corresponding Author**: Obamero, Bolaji Akinwale
**E- mail**: *bolajiobamero@gmail.com*

**Keywords**

Sawdust (SD),
Polythene
Terephthalate,
Impurities,
Thermal conductivity,
Recycle.

**Abstract**

This research deals with the aggregation and fabrication of composite from sawdust (SD) and recycled polyethylene terephthalate compressed at different ratios using press method. The saw dust was screened for impurities and polythene was crushed and sieved. The wood plastic composite were used to form discs of 11.8cm and 0.38cm thickness each after mixing. Lee's disc apparatus was used to determine the thermal conductivities of each disc which was found to be 0.0065, 0.0138, 0.0193, 0.0263, 0.0514 and 0.0785 for various mixing ratios. The sawdust with the least quality of polythene gave the least value of thermal conductivity than that with the heights value. Polythene to sawdust ratio composite could find application in thermal insulations like dash boards of cars, celling boards in houses.

## 1. Introduction

Wood Plastic Composites (WPCs) are relatively new generation of composites material and also the most promising sector in the field of both composite and plastics industries. In 1970s, the modern concept of WPC was developed in Italy and generally got popularity in the other parts of the world (Pritchard, 2004). Wood in the form of flour/particles/fibers are combined with the thermoplastic materials under specific heat and pressure for producing wood plastic composites where addictive's are added for improving the quality. Many researchers have worked on wood plastic composites by flat-pressed method at various wood plastic ratios (Chen *et al.*, 2006) which typically range between 50 to 80% of sawdust or fibre either as filler or reinforcement (Clemons, 2002). The higher strength and aspect ratio of natural fibres offers good reinforcing potential in composite matrix compared to the artificial fibre (Abdul Khalil *et al.*, 2014).

Virgin plastics include high and low density polyethylene (HDPE and LDPE respectively), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC) which are commonly used for the production of wood plastic composites (Najafi *et al.*, 2007). Recycled plastics can also be considered for manufacturing of wood plastic composites depending on their melting temperature (Stark *et al.*, 2010). Additives can also be added to improve the quality of the composites by eliminating the off-putting properties. However, the utilization of recycled plastic in wood plastic composites manufacturing is still limited and a major portion of global municipal solid waste includes post-consumer plastic materials like HDPE, LDPE, PVC and PET which have the potentiality for being used in the wood plastic composites (Chaharmahali *et al.,* 2008). These post-consumer plastics also pose a serious threat to the environment unless they are recycled.

Polyethylene terephthalate commonly known as PET and is formed from terephathalic acid (TPA) and ethylene glycol (EG). It is a long chain polymer $(C_{10}H_8O_4)_n$ belongs to the polyesters family. It shows both amorphous (transparent) and semi-crystalline nature (Ozalp, 2011). PET is intensively used by packaging industries for bottles and containers of food and other consumer products. Later, PET has started to be used in injection molded and extruded articles, primarily for reinforcement with glass fibre (Sinha *et al.,* 2010) which does not degrade in the outdoor environment. Thus, increasing interest has recently been focused on the recycling of plastic wastes, especially PET for these various purposes which could prevent the environmental pollution. Sawdust, a waste from wood processing industries, also creates environmental hazard unless reproduction for different applications like particle board, pulp. The recycled PET and sawdust can be used to produce wood plastics by flat press method which might a good value added products from waste and would help to minimize the waste. Flat pressed method is a newly introduced method in the wood plastic composite sector and is similar to industrial particle board manufacturing process. Though extrusion and injection molding are the predominant technologies to produce wood plastic composites, but flat press process is technically more advantageous (Jarusombuti and Ayrilmis, 2011). This technology possesses some advantages like higher productivity with relatively low pressure requirement and as a consequence naturally given wood structure left undestroyed. The density of wood plastic composites reduces considerably (Jarusombuti and Ayrilmis, 2011) and increase the moisture resistance properties compared to the conventional wood based composites (Jarusombuti and Ayrilmis, 2011). However, there is very limited work so far on the fabrication and properties of flat-pressed wood plastic composites from sawdust and recycled PET at various mixing ratios. Thus, the purpose of the project work was to investigate the feasibility of wood plastic composites fabrication from sawdust and PET, determining its effectiveness as thermal insulation as a function of mixing ratio.

Wood-plastic composites may be made in two ways. In the first, the wood fibre is a reinforcing agent or filler in a continous thermoplastic matrix. In the second, the thermoplastic is a binder to the majority wood component. The presence or absence of a continuous thermoplastic matrix may also determine are process ability of the composite material. In general, if the matrix is not continuous, other processes may be required.

The rate at which sawmills and other wood-work industries dispose sawdust is on increase. Plastic materials like consumable drinking water bottles, plastic chairs and household utensils made of plastic, which are not biodegradable, are also disposed on daily basis. Both sawdust and plastics (polyethylene) contribute a major portion of global municipal solid waste. Efforts should be geared towards converting the waste especially the sawdust to wealth (source of income).This study is aimed at recycling sawdust and polyethylene into another product, which can be used by man owning to their abundance in the society.

## 2.0 Materials and Methods

### 2.1 Collection/preparation of raw materials (specimen)

Mahogany wood Sawdust was obtained from a local sawmill in Wurukum, Makurdi, Benue State. Sawdust was screened to remove the impurities. It was then dried in an Oven at $103^oC$ for two (2) hours for moisture content of 2%. Clean consumer drinking water bottles were collected and pounded in a mortal for getting the recycled PET powder. The PET powder was sieved by 60 mesh size sieve to remove the oversized particles. The PET powder was then dried in an oven at $103^oC$ for two (2) hours for a moisture content of 3% or less.

### 2.2 Flat –pressed sawdust-pet composites compounding

The ensuring sawdust and PET powder were mixed locally using plate for 6 minutes according to the ratio of Table 2.0 for producing homogenous composites.

**Table 1.0:** A Table Showing the Ratio of Sawdust to Polyethylene

| Samples | Sawdusts (% weight) | Polyethylene (% weight) |
|---|---|---|
| A | 90 | 10 |
| B | 80 | 20 |
| C | 70 | 30 |
| D | 60 | 40 |
| E | 50 | 50 |
| F | 40 | 60 |

Wood plastic composites panels were manufactured by flat process using a dry blending method which was similar to an industrial production process. The mixture was placed in an Aluminum Caul Plate using a forming box to form uniform mat. The press cycle consisted of three phases (Chen *et al*, 2006), that is, first phase involved the manual pressing to reduce the mat heights, second phase involved in shifting it to electrical heated oven for hot pressing, and finally for cold pressing to facilitate the setting of the thermoplastic resin. The maximum pressing temperature and time were 16$^{o}$C and 6 minutes, respectively. Lower temperature (160$^{o}$C) compared to melting temperature (260$^{o}$C) of the PET was set to avoid the degradation of the wood components. After cold pressing, the WPCs were removed from the press for further cooling. At least six (6) of the panels for different ratios were fabricated. The panels were then trimmed into circular form of a disc and put into a conditioning room before test for 48 hours.

## 2.3 Determination of thermal conductivity of specimens by Lee's disc method

### 2.3.1 Experimental set-up

The apparatus shown fig below consists of two parts. The lower part C is circular metal disc. The experimental specimen is placed on it. The diameter of specimen is equal to that of c and thickness is uniform throughout. A stem chambers is placed on c, the lower part of the steam chamber B is made of the thick metal plate of the same diameter as of c. the upper part is a hollow chamber in two side tubes as provided for inflow and outflow of steam. Two thermometers T1 and T2 are inserted into two holes in C and B, respectively. There are three hooks attached to C. the complete setup is suspended from a clamp stand by attaching threads to these hooks.

When steam flows for some time, the temperature recorded ($T_1$ and $T_2$) gradually remain steady, this is steady state.

Let at the steady state, temperature of C = $T_1$

Temperature of B = $T_2$
Surface area of specimen = A
Conductivity of Specimen = K
Thickness of specimen = X

Hence amount of heat flowing through the specimen per second, H is given by equation.

$$H = \frac{KA(T_1 - T_2)}{X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

When the apparatus is in steady state (temperature $T_1$ and $T_2$ constant), the rate of heat conduction into the brass disc "C" is equal to the rate of heat loss from the bottom of it. The rate of heat loss can be determined by measuring how fast the disc "C" cools at the previous (steady state) temperature $T_1$ (with the top of the brass disk covered with specimen). If the mass and specific heat of the lower disc are M and S, respectively, and the rate of cooling at $T_1$ is $^{dt}/_{dt,}$ then the amount of heat radiated per second is

$$H = \frac{MS\Delta T}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

equating (1) and (2) and simplifying, K can be determined as,

$$K = \frac{MS(^{dt}/_{dt,})X}{A(T_1 - T_2)}$$

Where;
K = Thermal conductivity
M = Mass of the lower disc C = 1kg
S = Specific heat capacity of lower disc (brass) = 380j/kg$^{o}$C
$^{dt}/_{dt}$ = the rate of cooling at $T_1$
X = the thickness of specimen using micrometer screw gauge=0.00038M
A = the area of specimen ( $r^2$) = 0.0102$M^2$

### 2.3.2 Experimental procedure

Fill the boiler with water to nearly half and heat it to produce steam.

In the meantime, take weight of C by a weighing balance. Note its specific heat from constant table. Measure the diameter of specimen by scale or slide calipers, if possible. Calculate the surface area, A = $r^2$. Measures the thickness of specimen by screw gauge. Take observation at 5 spots and take the mean value. Put the specimen, steam chamber etc in position and suspend it from the clamp stand. Insert the thermometers. Check if both of them are displaying readings at room temperature. If not, note the difference (□) is to be added to ($T_1$ - $T_2$) later. Now steam is steady. Connect the boiler outlet with the inlet of the steam chamber by a rubber tube. Temperature recorded in the thermometers will show rise and fall and finally will be steady at $T_1$ and $T_2$. Wait for 10 minutes and note the steady temperature. Stop the inflow of steam. Remove the steam chamber and specimen C is still suspended. Heat "C" directly by the steam chamber till its temperature is T + $7^o$. Remove the steam chamber and wait 2 – 3 minutes so that heat is uniformly distributed over the disc. Place the insulating material on C. Start recording the temperature at ½ minute intervals. Continue till temperature falls by $10^0$ from $T_1$.

## 3.0 Results

The following were the results gotten from the experiment captioned more appropriately in the table below.

**Table 2.0:The Thermal Conductivity of the Specimens and their Mixing Ratios**

| Specimen | Percentage weight mixing ratio | | Thermal Conductivity $JM^{-1}S^{-1}K^{-1}$ |
|---|---|---|---|
| | Sawdust (%) | Polyethylene (%) | |
| A | 90 | 10 | 0.0064 |
| B | 80 | 20 | 0.0138 |
| C | 70 | 30 | 0.0193 |
| D | 60 | 40 | 0.0263 |
| E | 50 | 50 | 0.0514 |
| F | 40 | 60 | 0.0785 |

## 4.0 Discussion

This work investigated the technical evaluation of flat-pressed wood plastic composites fabricated from different mixing ratios of sawdust and PET. The results of Table 4.1 show the thermal conductivity of each of the specimens prepared and their composition ratios.

Letter "A" represents percentage weight mixing ratio of sawdust to polyethylene (90:10) with thermal conductivity $0.0064JM^{-1}S^{-1}K^{-1}$, letter "B" represents percentage weight mixing ratio of sawdust to polyethylene (80:20) with thermal conductivity $0.0138JM^{-1}S^{-1}K^{-1}$, letter "C" represents percentage weight mixing ratio of sawdust to polyethylene (70:30) with thermal conductivity $0.0193JM^{-1}S^{-1}K^{-1}$, letter "D" represents percentage weight mixing ratio of sawdust to polyethylene (60:40) with thermal conductivity $0.0263JM^{-1}S^{-1}K^{-1}$, letter "E" represents percentage weight mixing ratio of sawdust to polyethylene (50:50) with thermal conductivity $0.0064JM^{-1}S^{-1}K^{-1}$, letter "F" represents percentage weight mixing ratio of sawdust to polyethylene (40:60) with thermal conductivity $0.0064JM^{-1}S^{-1}K^{-1}$. This result can be compared with the results of virgin PET where water absorption after 24 hours is equal to 0.5% (Konko, 2004).

The results of this work show that the lower the content of sawdust in the composites (specimen) the higher the thermal conductivity. The higher the quantity of polyethylene in the composite, the higher the thermal conductivity (Dorez *et al.*, 2013).Above results can be compared to the work published by Binici, (2013), for PET/sand types (Silica ,River and Crushed stone sand),molted at 200°C for thermal conductivity test.0.59, 0.77and 0.84 W/m k Respectively were reported.

## 5.0 Conclusion

The thermal insulation differences among WPCs are due to the raw material characteristics and the mixing ratios used in the formulations.

The thermal insulation of SD-PET composites depends on the raw material and mixing ratio. Specimen "A" was found to have the least thermal conductivity and since lower thermal conductivity implies higher thermal insulation, the results indicate sawdust to be the major material that serves as heat or thermal insulator in the composite. The effectiveness of SD-PET composite is achieved only when the quantity of polyethylene used is small compared to that of sawdust.

## References


Abdul Klalil H.P.S.,DavourdPour, Y., Islam, M.N., Mustapha, A., Sudesh.K., Dungani, R., Jawaid, M.(2014).*Production and modification of nanofibrillated cellulose using bus mechanical processes:* A review. Carbohydrolym.99:649 Carbpol. 2013.08.69

Achaharmahali, M.,Tajvidi, M. andNajafi, S. K. (2008): *Mechanical properties of wood plastic compos res panels made from waste fiberboard and particleboard. Polymer Composites*,29(6); 601-610.

Chen, H.C., Chen.T.Y. and Hsu, C.H. (2006).*Effects of wood particle size and mixing ratios of HDPE properties of the composites.European Journal* of *Wood* and *Wood Products*,64:172-177.

Clemons, C.(2002).*Wood —plastic composites in the United States*, the interfacing of two industries.*Production Journal*,52(6): 10-18

Deaner, M.J., Puppin, G.andHeikkila, K.E. (1996): *Advanced polymer/wood composite al member*. U.S patent No. 5486553.

Jarusombilti,*S.* andAyrilmis, N.(2011).*Surface characteristics and overlying properties of flat-pressed wood plastic composites.European Journal* of *Wood* and *Wood Products*,69:375 -382.

Najafi,S.K., Tajvidi, M.and Hamidira, E. (2007).*Effect of temperature, plastic types and virginity on the water update of sawdust plastic composites.European Journal* of *Wood* and *Wood Products,* 65:377-382.

Ozalp,M.(2011).*Study of the effect of adding the powder of was*te *PET bottles a Borax: pent hydrate to the urea formaldehyde adhesive applied on plywood. European Journal* of *Wood* and *Wood Products,* 9(3):369-374.

Pritchard, G.(2004).*Two technologies merge:* Wood plastic composites. Plastics, additives and compounding.*European Journal* of *Wood* and *Wood Products*, 6(4):18-21.

Ozalp, M.(2011).Study of the effect of adding the powder of waste PET bottles and borax pentahydrate to the urea formaldehyde adhesive applied on plywood. *European* Journal of *Wood* and *Wood Products*,69(3):369–374.

Konkol, L. (2004). Contaminant Levels in Recycled PET Plastics" submitted in fulfilment of the requirements for the Ph.D thesis Philosophy, Environment and Biotechnology Centre, Swinburne University of Technology.

Binici, H.(2013). Effect of Aggregate Type on Mortars Without Cement. *European Journal of Engineering and Technology*, 1 (1):12-21.

Dorez, G., Taguet, A., and Ferry, L. (2013).Thermal and fire behavior of natural fibers/PBS biocomposites.*Polymer Degradation and Stability*,98(1):87–95.



| **Access this Article in Online** | |
|---|---|
| Quick Response Code | Website: www.ijarm.com |
| | Subject: Applied Sciences |
| DOI:10.22192/ijamr.2020.07.02.001 | |

How to cite this article:
OBAMERO, Bolaji Akinwale and AKUBA, Barnabas Ojochegbe. (2020). Effectiveness of thermal conductivity of recycled saw dust impregnated in polythene using cassava as binder. Int. J. Adv. Multidiscip. Res. 7(2): 1-5.
DOI: http://dx.doi.org/10.22192/ijamr.2020.07.02.001