



# Biodegradation and Physical Properties of the Polymer Blends Prepared from Cashew Nut Flour and Polyethylene-Based Waste Material

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**Abstract:** Plastic litters arising from polyethylene-based materials such as shopping bags, water sachets, bottles, medical wastes etc., are non-biodegradable and increasingly becoming environmental problems in the major cities of Nigeria. A possible solution is to enhance their biodegradation through addition of decomposable material. In this work, polymer blends were prepared *via* melt-blending approach, using polyethylene (PE), Cashew nut Flour (CNF) at a different weight percent mixing formulations. Dimensional stability test conducted revealed that the 70% PE and 30% CNF provided the best results. Thereafter, gum Arabic (GA) binder was introduced into the Polymer blend at various weight percent mixing between CNF and GA while keeping the amount of PE constant at 70%. Characterizations of the PE, CNF and GA polymer blends through Biodegradation by Composting and bench-scale stimulation methods, Fourier Transform Infrared (FTIR), Scanning Electron Microscopy (SEM) and thermogravimetric Analysis (TGA) analytical techniques were conducted. The results revealed that the polymer blend i.e. 70%PE, 5%CNF and 25%GA presented the highest weight lost in the two biodegradation methods which are 52.9% and 57.89%. The FTIR disclosed that the composites have almost similar spectra and peaks in the same regions with little drifts. The SEM micrographs showed some arrays of broken parts, presences of some cavities and agglomeration of the matrices in the composites. However, the blend (i.e. 70%PE, 5%CNF and 25%GA) showed that the components are more evenly distributed and resulted in little agglomeration. The study revealed that polymer blends were prepared which provided promising distinct characteristics from the original materials and with faster biodegradation rate than pure PE.

**Keywords:** Polyethylene, Cashew Nut, Biodegradation, Physical, Properties

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## 1. Introduction

Synthetic petroleum-based plastics such as polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC) and Polyethylene Terephthalate (PET) are widely used in daily life such as food packaging, biomedical and agriculture. However, synthetic plastics are non-degradable and are causing serious environmental problems and challenges. The environmental, economic, and

safety challenges have motivated material scientists and polymer industries to partially substitute petrochemical-based polymers with biodegradable ones [1]. The accumulation of plastics in the natural environment will only decompose over hundreds, or even thousands of years, during which time they fragment into smaller microplastics and nanoplastics which continually causes environmental and health problems. Significant quantities of plastic wastes are repeatedly being introduced into the natural environment on a daily basis. Moreover, the full impact on marine and terrestrial

ecosystems will only emerge in the longer term, some environmental effects of plastics pollution are already clearly visible [2].

However, huge efforts have been made to recycle commodity plastics and reduce the landfill, it is still not cost-effective. Therefore, alternatives are sought for, which can be produced from renewable resources and can degrade in a natural environment without generating harmful and toxic residues [3]. Numerous studies over the decades have led to the discovery of many biodegradable polymers with distinctive properties, such as polysaccharides, proteins and polyesters [1, 4]. This research intends to incorporate Cashew nut flour into polyethylene using gum Arabic as a binder through melt-blending aiming at enhancing the biodegradability and physical properties of the polymer blends.

## 2. Materials and Methods

### 2.1. Materials

The materials used in this research include waste polyethylene in the form of used table water sachet, Cashew nut, gum arabic Laboratory equipment and apparatus (such as oven, weighing balance, hot plate, scissors, furnace, mortar, pestle etc.), and analytical grade laboratory chemicals and reagents obtained from BDH England, used as received without further modification.

### 2.2. Methods

#### 2.2.1. Sample Collection

The Cashew nut was collected from Jega town, Kebbi State, Nigeria. Waste polyethylene material in the form of used table water sachet was collected from dumpsite in Aliero, Kebbi State, Nigeria. The gum Arabic was procured from Kontagora old market, Kontagora, Niger State, Nigeria.

#### 2.2.2. Sample Preparation

The Cashew nut was prepared using roasting method as explained by Dendena B and Corse S. [5]. The Cashewnut was dried and pulverized into powder form using pestle and mortar. The polyethylene material was washed and dried under ambient condition and reduced to small sizes using pair of scissors. Impurities were carefully removed from the gum Arabic and then air-dried until it became sufficiently brittle. Then, the raw gum Arabic was reduced to smaller particle size using mortar and pastel to fine powder.

#### 2.2.3. Determination of Moisture Contents of Cashew Nut and Gum Arabic

Moisture content of the Cashew nut powder and gum Arabic were determined by oven-drying method. An empty crucible was clean, dried and weighed as  $W_1$ . Then, 2 g of well-mixed sample was accurately weighed in the clean, dried crucible ( $W_2$ ). The crucible was placed in an oven at 130°C for 1 hr. (the 1hr begun when the oven temperature was exactly 130 °C) until a constant weight was obtained. Thereafter, the crucible was placed in desiccators for 30 min to cool. After the

cooling, it was weighed again ( $W_3$ ). The percent moisture was calculated by the following equation 1 (AOAC, 2016).

$$\% \text{ Moisture} = \frac{(W_2 - W_1) - (W_3 - W_2)}{W_2 - W_3} \times 100 \quad (1)$$

Where:  $W_1$  = Weight of the empty crucible,  $W_2$  = Weight of the crucible + Sample,  $W_3$  = Weight of the crucible after cooling.

#### 2.2.4. Determination of Ash Contents of Cashew Nut and Gum Arabic

For the determination of ash, clean empty crucible was placed in an oven at 105°C for about 30 minutes, cooled in a desiccators to reach room temperature and then weight of empty crucible will be noted ( $W_1$ ), 4 grams of the sample was added in the crucible ( $W_2$ ). Then, the crucible was placed on a "STUART" hot plate in a fumed cupboard to decarbonize at 60°C until sample is completely burnt. Thereafter, the burn sample was transferred into a muffle furnace at 550°C for 3 hrs. The appearances of gray white ash indicate complete oxidation of all organic matter in the sample. The crucible was cooled and weighed ( $W_3$ ). Percent ash was calculated by the following equation 2 (AOAC, 2016).

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2} \times 100 \quad (2)$$

Where;  $W_1$  = weight of empty crucible,  $W_2$  = weight of crucible + sample,  $W_3$  = weight after cooling.

#### 2.2.5. Determination of Crude Protein

Protein in the sample was determined by Kjeldahl method. One gram of the dried samples each was taken in digestion flask. 10-15 ml of  $H_2SO_4$  was added and 8g of digestion mixture i.e.  $K_2SO_4$ : $CuSO_4$  (8:1). The flask was swirl in order to mix the contents thoroughly then placed on heater to start digestion till the mixture became clear (blue green in color). The digest was cooled and transferred to 100ml volumetric flask and volume was made up to the mark by the addition of distilled water. Distillation of the digest was performed in distillation apparatus [6]. Ten milliliters of digest was introduced in the distillation tube then 10 ml of 0.5 N NaOH was gradually added through the same way.

Distillation was continued for at least 10 min and  $NH_3$  produced was collected as  $NH_4OH$  in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator. During distillation, yellowish color appeared due to  $NH_4OH$ . The distillate was then titrated against standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percent crude protein content of the sample was calculated by using the following equation 3:

$$\% \text{ Crude Protein} = 6.25 * x \%N (*\text{Correction factor})$$

$$\% N = \frac{(S - B) \times N \times 0.014 \times D \times 100}{\text{Wt of sample} \times V} \quad (3)$$

Where: S = Sample titration reading, B = Blank titration reading, N = Normality of HCl, D = Dilution of sample after digestion, V = Volume taken for distillation, 0.014 = Milli

equivalent weight of Nitrogen

$$\text{Therefore, \%P} = \frac{\%N}{1000} \times F, \text{ Where } F = 6.25$$

### 2.2.6. Determination of Crude Fat

The crude fat was determined by Soxhlet extraction method. Approximately, 3g of moisture free sample was weighed  $W_1$  and wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Then, 150ml of petroleum ether was measured into pre-weighted round bottom flask  $W_1$  and fit the neck of the round bottom flask into a Soxhlet extractor, the neck of the soxhlet extractor was then fit into a condenser, thereafter, the entire settings was placed on heating mantle. After 4-6 siphoning the petroleum ether was allowed to evaporate. Then, transferred extract into clean glass dish with washing using ether and evaporated ether on water bath. Then, the extract was placed on a dish in an oven at 100°C for 2 hrs and cooled in a desiccators at room temperature and then weighed as  $W_2$  (AOAC, 2016). The percent crude fat was determined by using the following equation 4:

$$\% \text{ Crude fat} = \frac{W_2 - W_1}{W} \times 100 \quad (4)$$

Where:  $W$  = Weight of the sample,  $W_1$  = Weight of the empty round bottom flask,  $W_2$  = Weight of the sample after cooling.

### 2.2.7. Determination of Crude Fibre

A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute  $H_2SO_4$  and then with dilute KOH solution. The undigested residues collected after digestion was ignited and loss in weight after ignition was recorded as crude fiber. A 0.153 g of the sample was weighed ( $W_0$ ) and transferred to a porous crucible. Thereafter, 150ml of  $H_2SO_4$  was added to 150 ml of preheated solution and some drops of foam-suppresser. The sample was then dried in an oven at 150°C for 1 hr. Thereafter, the sample was allowed to cool in a desiccator and weighed ( $W_1$ ). The sample was pour in the crucible and kept in a furnace at 55°C for 3-4 hrs. Then it was cool in a desiccator and re-weighed ( $W_2$ ). Calculation was done by using the equation 5 below:

$$\% \text{Crude fiber} = \frac{W_1 - W_2}{W_0} \quad (5)$$

Where:  $W_0$  = Initial weight of the sample,  $W_1$  = Weight of sample after first cooling,  $W_2$  = Weight of the sample after second cooling.

## 2.3. Preparation of Polymer Blends

The polymer blends were prepared by initially melting a measured amount of polyethylene in a metal plate using hot plate set at 120°C, followed by carefully adding appropriate weighed amounts of the Cashew nut flour to make 100% blends as indicated in Table 1. In each case, the molten blends were molded into a rectangular shaped structure having a dimension of 1mm × 1mm × 1mm (length × breadth × width), and these blends were used for dimensional stability analysis to establish the best suitable blend

formulation.

However, the percentage of PE of the best blend obtained from Table 1 was held constant throughout, while CNF and GA were varies to make 100% blend (B1, B2, B3, B4, B5) and molded into a flat sheet. The resulting sheets were oven-dried at 40°C to reduce the moisture and then cut into 1mm x1mm and kept for further use.

Table 1. Sample formulations between PE and CNF.

Composites	Polyethylene (PE wt %)	Cashew Nut Shell Flour (wt%)
A1	10	90
A2	30	70
A3	50	50
A4	70	30
A5	90	10

Table 2. Sample formulations between PE, CNF and GA.

Blend Code	PE (wt %)	CNF (wt %)	GA (%)
B1	70	25	5
B2	70	20	10
B3	70	15	15
B4	70	10	20
B5	70	5	25

### 2.3.1. Analysis of Dimensional Stability of PE/CNF Blends

The entire blends made in Table 1 were used for water absorption and thickness swelling tests as per ASMT D-570-98 with slight modifications. The samples were firstly oven-dried at 60 °C for 30 minutes in order to remove any remnant moisture that may be present and then cooled to room temperature for 1 hour. The initial weights and the corresponding thicknesses were taken using weighing balance and Vernier caliper with precision of 0.001g and 0.001mm respectively. Thereafter, the blends were immersed in distilled water at predetermined time interval of 24 hours daily, then the specimens were removed and the surface water was wipe off using tissue paper and their weights and thickness were reweighed. Water absorption and thickness swelling were calculated using the following equations 6 and 7 respectively.

$$WA (\%) = \frac{w_f - w_i}{w_i} \times 100 \quad (6)$$

$$TS (\%) = \frac{t_f - t_i}{t_i} \times 100 \quad (7)$$

Where:  $w_f$  and  $w_i$  are final and initial weight respectively. While  $t_f$  and  $t_i$  are final and initial thickness respectively.

### 2.3.2. Analysis of Biodegradation of Biocomposites by Composting Methods

Biodegradation by composting method was employed to test the biodegradability of the prepared polymer blends. Two grams of the prepared blends were vacuum-dried for 24hrs at 45°C and buried into a municipal solid waste (for 100 days) for possible biodegradation. The contents were kept in an oven for 55°C, at which the maximum growth of thermophiles microorganisms occurred. The buried samples of the blends were then weighed for 20 days interval up to 100 days and the weight losses for each sample were recorded. The total

percentage weight loss was calculated as function of number of days as reported previously by Sha *et al* (2016) [7], using the equation 8 below for every blend samples after every 20 days of observation.

$$\% \text{ weight loss} = \frac{\text{Initial weight loss} - \text{final weight loss}}{\text{Initial weight loss}} \times 100 \quad (8)$$

**2.3.3. Analysis of Biodegradation of Biocomposites by Bench-Scale Simulated Composting Methods**

In this analysis, the compost consist of 50% (w/w) cow manure and garden soil. The samples of the 5 blends each of 2g were used for this analysis and the samples were buried in a separate reaction vessel container consisting of inoculums 50% (w/w) cow manure and garden soil. For characterization, the blend samples were removed from the compost at three day intervals in order to calculate the weight loss. The average weight loss of the three blend samples were observed and recorded. Also, the temperature of the compost was recorded on daily basis. Percentage weight loss for the materials were measured following equation 9 in accordance with the reported literature [8].

$$\% \text{ Weight loss} = \frac{W_1 - W_2}{W_1} \times 100 \quad (9)$$

Where:  $W_1$  and  $W_2$  would be the samples weight before and after treatment.

**2.4. Instrumental Characterizations of Polymer Blends**

**2.4.1. Fourier Transform Infrared Spectroscopy (FTIR)**

The infra-red spectra of Cashew nut flour, gum Arabic and the prepared blends were recorded using a SHIMADZU spectrophotometer. Firstly, some powdered samples were collected by scratching of the blends with a knife. Then, potassium bromide (KBr) was mixed at a ratio of (KBr: Sample = 100:1) in a mortar and pestle. The mixture was then taken in a dice of specific dimensions (13 mm dia). The pellets were formed by pressing (mechanical presser at 8 tons of pressure) and were placed on the sample holder and the spectroscopy was conducted.

**2.4.2. Scanning Electron Microscopy (SEM)**

Resolution of smaller objects can be provided from electron microscopy, allowing direct observation of thin specimens, like single polymer crystals, and the electron diffraction patterns. It is carried out in the conditions of temperature well below the room temperature and source of accelerated voltages (higher than the usual 50000 – 100000V) in order damage to single polymer crystals. In scanning electron microscopy (SEM), fine beam electrons are scanned across the surface of an opaque specimen. These photons are emitted when the beam hits to surface, then collected to provide a signal used to strengthen the intensity of the electron beam.

In this study, the tensile fracture surface morphology of the various blends comprising PE, CNF and gum Arabic in different ratio were microscopically viewed using a field emission scanning electron microscope.

**2.4.3. Thermogravimetric Analysis (TGA)**

Thermogravimetric analysis is a technique that measures the mass of a sample while it is heated, cooled or held isothermally in a defined atmosphere. It is mainly used for the quantitative analysis of products. The method allows us to study the decomposition of products and materials and to draw conclusions about their thermal properties. The TGA of the polymer blends was conducted using DTG-60AH thermometric analyzer to evaluate their thermal stability at different temperature. The temperature ranged from 30°C to 800°C, at a heating rate of 10°C min<sup>-1</sup> under nitrogen atmosphere.

**3. Results and Discussion**

**3.1. Results**

**3.1.1. Results on Proximate Analysis of Cashew Nut Flour and Gum Arabic**

The results of proximate analysis of Cashew nut flour and gum Arabic are shown in Tables 3 and 4 respectively.

*Table 3. Proximate composition of Cashew nut.*

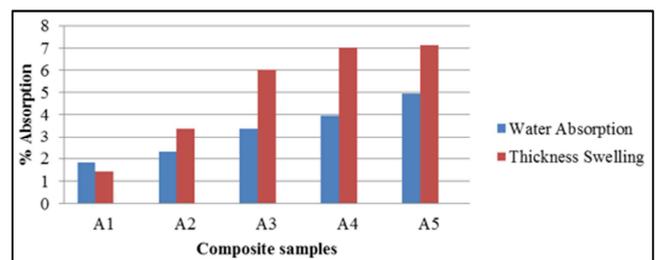
Parameter	Composition
Moisture content (%)	8.655 ± 0.035
Ash content (%)	2.565 ± 0.055
Crude fiber (%)	18.335 ± 0.085
Fat content (%)	31.625 ± 0.095
Protein content (%)	18.760 ± 0.150
Carbohydrate by difference (%)	20.010 ± 0.065
Energy value (Kcal) (%)	322.175± 0.535

*Table 4. Proximate composition of gum Arabic.*

Parameter	Composition
Moisture content (%)	1.515 ± 0.025
Ash content (%)	18.610 ± 0.03
Crude fiber (%)	46.345 ± 0.075
Fat content (%)	0.505 ± 0.015
Protein content (%)	1.645 ± 0.025
Carbohydrate by difference (%)	31.380 ± 0.11
Energy value (Kcal) (%)	136.645 ± 0.205

**3.1.2. Results on Water Absorption and Thickness Swelling of Polymer Blends**

The results on water absorption and thickness swelling of the polymer blends having no gum Arabic binder is presented in Figure 1.



**Figure 1.** Results on water absorption and thickness swelling of polymer blends.

### 3.1.3. Fourier Transform Infrared Spectroscopy of Polymer Blends

FTIR spectra of Gum Arabic, Cashew nut flour and polymer blends containing gum Arabic.

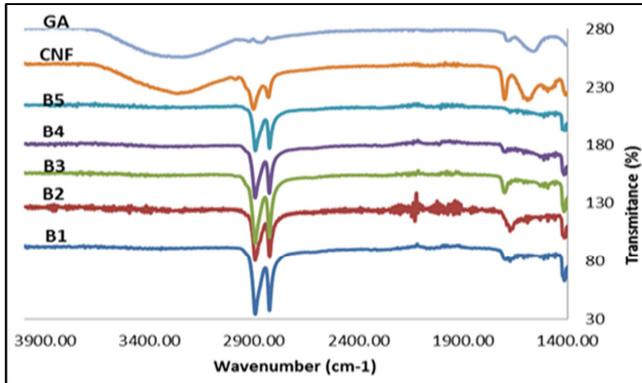


Figure 2. FTIR spectra of gum Arabic, Cashew nut flour and polymer blends containing gum Arabic.

### 3.1.4. Scanning Electron Microscopy

The SEM images of the various polymer blends containing different amount of gum Arabic binder is presented in Figure 3.

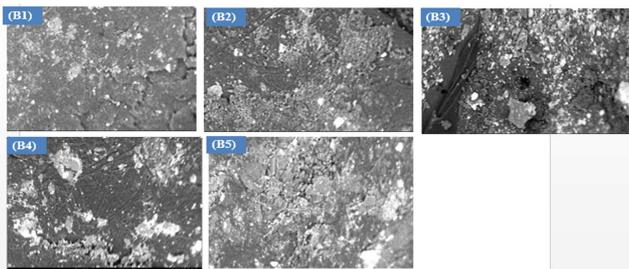


Figure 3. SEM micrographs of polymer blends containing gum Arabic.

### 3.1.5. Biodegradation by Composting Method

The results on biodegradation of the polymer blends via composting method is shown in Figure 4.

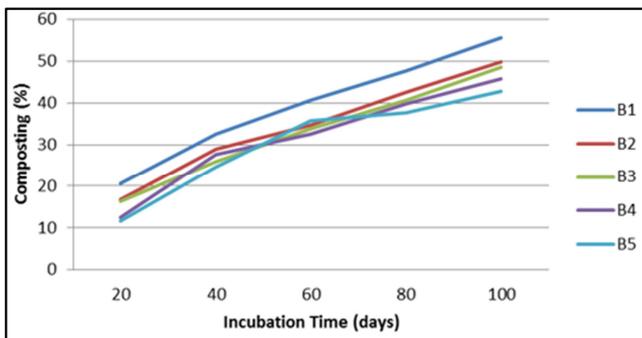


Figure 4. Results of Biodegradation by composting of polymer blends containing gum Arabic.

### 3.1.6. Biodegradation by Bench-Scale Simulation Method

The results on biodegradation of the polymer blends via Bench-scale simulation is shown in Figure 5.

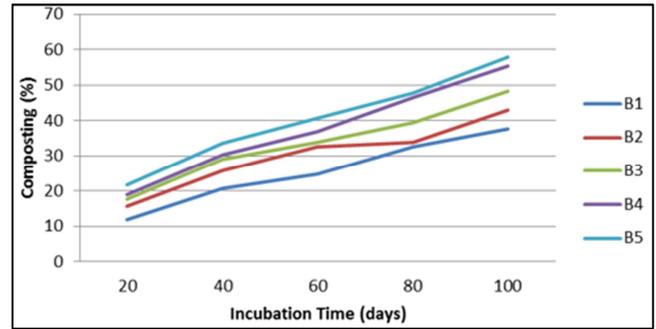


Figure 5. Results of Biodegradation by bench-scale simulation of polymer blends containing gum Arabic.

### 3.1.7. Thermogravimetric Analysis of Polymer Blends

The results of thermogravimetric analysis of the polymer blends containing gum Arabic binder is given in Figure 6.

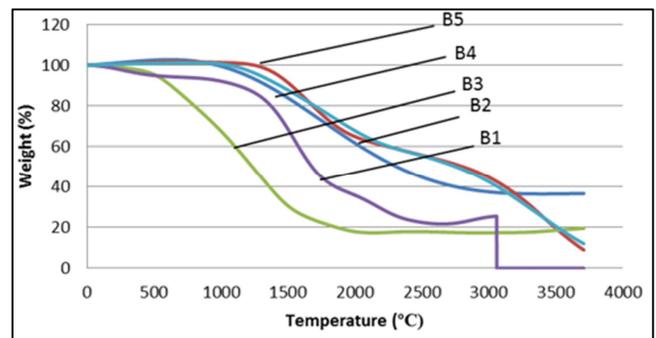


Figure 6. Results of Thermogravimetric Analysis of polymer blends containing gum Arabic.

## 3.2. Discussion

The results of proximate composition as presented in Table 3, revealed that the Cashew nut flour had moisture content ( $8.655 \pm 0.035$ ), ash content ( $2.565 \pm 0.055$ ), crude fiber ( $18.335 \pm 0.055$ ), fat content ( $31.625 \pm 0.095$ ), protein content ( $18.760 \pm 0.150$ ), carbohydrate by difference ( $20.010 \pm 0.065$ ) and energy value in Kcal of ( $322.177 \pm 0.535$ ), the result in some way agreed with finding reported by Badamasi H. and Ibrahim A. [9]. The results of proximate composition as presented in Table 4 indicated that, gum Arabic recorded moisture content ( $1.515 \pm 0.025$ ), ash content ( $18.610 \pm 0.03$ ), crude fiber ( $46.345 \pm 0.075$ ), fat content ( $0.505 \pm 0.015$ ), protein content ( $1.645 \pm 0.015$ ), carbohydrate by difference ( $31.380 \pm 0.11$ ) and energy value in Kcal of ( $136.645 \pm 0.205$ ). The moisture content determines the hardness of the gum and any excess of water in material encourages microbial growth [14-15].

The results of water absorption and thickness swelling tests of the blends as presented in Figure 1, comprising PE and CNF using the mixing ratio A1 (90% PE and 10% CNF), A2 (80% PE and 20% CNF), A3 (50% PE and 50% CNF), A4 (70% PE and 30% CNF) and A5 (90% PE and 10% CNF). In the water absorption and thickness swelling sample A1 has the highest percentage values as shown in the Figure 1, while A5 is the blends with least absorption and thickness swelling values. This could be due to higher content of the Cashew nut

flour in A1 which provided more hydrophilic hydroxide group capable of bonding with water molecules thereby increasing the water absorption and thickness swelling and vice versa. The sample formulation, A3 (70% PE and 30% CNF), based on its optimum performances in the water absorption and thickness swelling tests was chosen to fabricate the polymer blends using varying contents of Cashew nut flour and gum Arabic, while keeping the content of the PE constant at 70%.

The characterization of the polymer blends fabricated with gum Arabic as binder provided FTIR spectra as shown in Figure 2. These polymer blends contained sample formulation as B1 (70%PE + 25%CNF + 5% GA), B2 (70%PE + 20%CNF + 10% GA), B3 (70%PE + 15%CNF + 15% GA), B4 (70%PE + 10%CNF + 20% GA) and B5 (70%PE + 5%CNF + 25% GA) respectively. In the FTIR spectrum of CNF, the broad medium strong band absorption at  $3270\text{ cm}^{-1}$  initially, could be attributed to OH stretching vibration, however, it could also be assigned to N-H stretching, because most times an overlap of the two functional groups occurs in that region. The bands at  $2924\text{ cm}^{-1}$  and  $2857\text{ cm}^{-1}$  could be the C-H stretching similar to =CH bonding. While C=O stretch of fatty acids could be attributed to the absorption band at  $1640\text{ cm}^{-1}$  or even C=C stretching. The observations were similar to the previous research [10] with slight discrepancies.

In a similar way, the FTIR spectrum of gum Arabic shows strong broad band absorption at  $3287\text{ cm}^{-1}$  which could be OH group. Another noticeable absorption at  $2924\text{ cm}^{-1}$  could be C-H stretching, while an absorption band at exactly  $1600\text{ cm}^{-1}$  could be that of C=C. Also the Figure 2 shows spectra of blend samples (B1, B2, B3, B4 and B5), It was observed that the blends have almost similar spectra with peaks in the same regions. Sample B1 has strong and sharp absorption peaks around  $2916\text{ cm}^{-1}$  and  $2845\text{ cm}^{-1}$  which is a characteristic of C-H stretching, however, similar absorptions were observed in the other blends samples with slight drifts. For blend B2, the two peaks were observed at  $2920\text{ cm}^{-1}$  and  $2862\text{ cm}^{-1}$  while in samples B3 and B4 the two absorption peaks were observed at  $2914\text{ cm}^{-1}$ ,  $2849\text{ cm}^{-1}$  and  $2920\text{ cm}^{-1}$ ,  $2819\text{ cm}^{-1}$  respectively. Moreover, the B5 polymer blend sample has the peaks at  $2920\text{ cm}^{-1}$  and  $2844\text{ cm}^{-1}$ . The peaks around  $1742\text{ cm}^{-1}$ ,  $1727\text{ cm}^{-1}$  and  $1744\text{ cm}^{-1}$  are specific to B1, B2 and B3 samples and could be assign to C=O stretching. While  $2018\text{ cm}^{-1}$  and  $2085\text{ cm}^{-1}$  are specific to sample B4 and B5 respectively could be assigned to the conjugated C=C or carbon-carbon triple bonds. In the same way, the absorption bands observed at  $1459\text{ cm}^{-1}$ ,  $1468\text{ cm}^{-1}$ ,  $1463\text{ cm}^{-1}$ ,  $1563\text{ cm}^{-1}$  and  $1476\text{ cm}^{-1}$  for sample B1, B2, B3, B4 and B5 respectively. Those peaks could be assigned to  $\text{CH}_3$  bending. It could be observed that, both CNF and gum Arabic have OH characteristic absorption around  $3200\text{ cm}^{-1}$  and almost all the samples have absorptions around  $2900\text{ cm}^{-1}$  which could be C-H stretching similar to =CH bonding. Both CNF and GA have absorptions around  $1600\text{ cm}^{-1}$  which could be attributed to C=C.

The micrographs of the polymer blend samples are shown in Figure 3 above. From the results, the sample B1 to B5 micrographs showed some arrays of broken parts, presences of some cavities and agglomeration of the matrices, which

indicates the fact that, the distribution was not even. However, some authors have opined that some polymer blend materials are liable to micro-cutting, micro-ploughing and ultimately blend deformation as a result of poor interfacial bonding [9]. The strength of some blend materials is completely lost when the maximum strain energy is greatly exceeded. The image of sample B1 film depicts a smoother surface if compared to others that could be as a result of solvent evaporation and the ratio of the components. Sample B3 image reveal some large pores and nano-fibrous materials ranging from  $30\text{--}40\text{ }\mu\text{m}$  in diameter which could allow water penetration and absorptions. However, the B5 blend shows that the components are more evenly distributed and resulted in little agglomeration. Thus, the result showed that PE, CNF and gum Arabic are more compatible in sample B5.

The results of biodegradation from composting method is presented in Figure 4. It can be seen that, the blend sample B1 lost 9.89% of its original weight after the first 20 days of observation and then, the percentage of weight loss continued to increase over time until it reached 37.45% after 100 days period. The sample B2 also lost 12.67% of its original weight after the first 20 days of burial and then the weight lost continued to increase as analyzed at 20 days intervals up to 100 days and the final percentage weight lost after the last 20 days was 42.56%. In a similar trend, sample B3 has the initial weight loss of 15.34% for the first 20 days and the final weight loss after 100 days was recorded to be 48.67%. For the B4 and B5 samples, in the initial 20 days, weight losses were 13.67% and 20.41%, and for the final 20 days, the weight loss were 45.67% and 52.9% respectively.

The results of bench-scale stimulating method of the polymer blend samples is shown in Figure 5. The blend sample B1 lost 11.78% of its initial weight after the first 20 days and then the percentage of weight loss increases over time until it reached 37.78% after 100 days period. The sample B2 also lost its original weight by 15.59% after the first 20 days of burial in the soil and then the weight lost continued to increase as analyzed at a 20-day interval up to 100 days. Thereafter, the final percentage weight lost for the sample B2 after the last 20 days was 42.89%. Moreover, sample B3 has the initial weight loss of 17.67% for the first 20 days and the final weight loss after 100 days recorded was 48.23%. For the samples B4 and B5, the initial 20 days weight loss were 18.92% and 21.67% and for the final 20 day the weight loss were 55.34% and 57.89% respectively.

Base on the observation, by increasing the percentage of gum Arabic in the blend from 5% to 25% the biodegradation rate of the blends samples in terms of percentage weight loss increases in both the two methods of biodegradability tests adopted in this research. A study carried out to analyze the biodegradability of bio-composite prepared from petroleum-based polymer, poly (butylene adipate-co-terephthalate) (PBAT) and bioethanol found out that, the biocomposites were sensitive to hydrolytic biodegradation and the material showed 90% degradation in 120 days [11].

The thermogravimetric analysis results of the polymer

blends containing the varying contents of the gum Arabic binder are presented in Figure 6. Firstly, at the initial stage of the curves samples B4 and B5 show little decrease in mass due to water absorption from the system but for sample B3, a sudden loss of mass indicates rapid loss of moisture. Almost all the blend samples show mass change (decrease) at temperature between 250°C to 500°C except sample B3, which shows an earlier mass reduction around temperature of 300°C, the change could be associated to change in molecular structure and believed to reflect extent of depolymerization which may have occurred as previously reported in related literatures [12-13]. The TGA result obtained corroborated the qualitative chemical information generated by FTIR spectroscopy and that of the biodegradability tests.

## 4. Conclusion

It was revealed in this research that, both the CNF and GA have significant proximate compositions, with GA having the least moisture compositions of  $(1.515 \pm 0.025)$  compare to CNF which recorded  $8.655 \pm 0.035$ . Proximate compositions of samples especially moisture content, determine how fast it undergo microbial attack and degradation. It was also discovered that, incorporating Cashew nut flour and gum Arabic into polyethylene, proved to be potentially promising in influencing the biodegradation of the polyethylene. As the percentage of gum Arabic increase from 5% to 25% in the blends, their biodegradation also increases in the two methods of biodegradation adopted. This implies that, the gum Arabic plays key role in enhancing the biodegradation of the blends in addition to its binding properties. The characterization of the blend samples using FTIR, SEM and TGA was evident that, blend materials were formed with distinct characteristics from the individual components used in the blend formulation.

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