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Effect of Maleic Anhydride Graft-Polyethylene (MAPE) on Mechanical Properties of Cow dung and Poultry dung Filled Low Density Polyethylene (LDPE) Composites

EZE, U. W[1]; ISHIDI, E. Y [1]; UCHE, C. A[2] and MADUFOR, I. C.[2]

[1] Department of Polymer Technology,
Nigerian Institute of Leather and Science Technology, Zaria, Nigeria
[2]Department of Polymer and Textile Engineering,
Federal University of Technology Owerri, Imo State, Nigeria
E-mail: wilstyrene@yahoo.ca, ogbosoedith@gmail.com / 07039194935, 08034518844.

ABSTRACT
Mechanical properties of Cow dung and Poultry dung filled Low Density Polyethylene (LDPE) Composites was investigated at filler loading of 0wt/%, 5wt/%, 10wt/%, 15wt/%, and 20wt/%. The fillers were sieved to particle size of 0.45mm. The effect of Silicone oil and Maleic anhydride graft-polyethylene (MAPE) were investigated. The LDPE composites with and without MAPE were prepared by injection moulding process, similarly samples with silicone oil were prepared in other to study its effect on the composites. Universal Testing Machine was used to evaluate their mechanical properties such as; tensile strength, elongation at break, elongation at yield, modulus of elasticity. The Hardness and impact strength were also determined. The tensile strengths, extension at break of the composites decreased as the filler loading increases, but the modulus of elasticity significantly improved as filler loading increases and thus with the addition of the compatibilizing agent. The notched charpy impact strength increased, this was attributed to the compatibilizing agent used. The results also showed that, addition of 4wt% of silicone oil at a fixed filler loading improves the elongation at break with slight increase in the tensile strength of the composite. However, the silicone oil caused the elastic modulus to decrease; this was attributed to the wetting effect of the oil. This study revealed that the incorporation of suitable compatibilizing agent could result to a stronger interfacial bonding between matrix and the filler thus leading to a significant increase in the hardness of the composite.
Keywords: Conpatibilizing agent, Mechanical properties, LDPE Composites.

INTRODUCTION

Over the last thirty years polymer composites are rapidly replacing other engineering materials. The volume and number of applications of polymeric composites have grown steadily, penetrating and conquering new markets relentlessly. Modern polymeric composites constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications [1]. While composites have already proven their worth as weight-saving engineering materials, the prevailing challenge is to make them cost effective [2-3]. The efforts to produce economically attractive composite components have resulted in numerous innovative manufacturing techniques currently being used in the composites industry [4].

Composites are now extensively being used for rehabilitation/strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity.

Unlike conventional materials (e.g., steel), the properties of composite material can be designed to suit a particular application [5]. The design of a structural component using composites involves both material and structural design. Composite properties such as stiffness, thermal expansion etc. can be varied continuously over a broad range of values under the control of the designer. Careful selection of reinforcement type enables finished product characteristics to be tailored to almost any specific engineering requirement. [6]

Whilst the use of composites will be a clear choice in many instances, material selection in others will depend on factors such as working lifetime requirements, number of items to be produced (run length), complexity of product shape, possible savings in assembly costs and on the experience and skills the designer in tapping the optimum potential of composites. In some instances, best results may be achieved through the use of composites in conjunction with traditional materials [7,8]

EXPERIMENTAL METHODS

Materials

Low Density Polyethylene (Matrix)

The thermoplastic polymer, low-density polyethylene (LDPE), WA11110-12- type virgin material, product of Exxon Mobile in the Kingdom of Saudi Arabia, was obtained from Ceeplas Industries, Aba, Abia State for the purpose of this research work.

Fillers

The Cow dung was collected from livestock market located at Obenze in Owerri west L.G.A of Imo State Nigeria, while the poultry dung was obtained from Agricultural farm of the Federal University of Technology Owerri, Imo State, Nigeria.

Anhydride graft-Polyethylene was from Exxon Mobile Ltd, Sigma ALDARICH chemical company USA, while the silicon oil is a product of Vickers Laboratory Limited, Burley-in-Warfedale West Yorks, England.

Sample Preparation

The animal dungs were sun dried for a period of four months after which they were crushed to smaller aggregates using hammer mill. This operation was done at the Scientific Equipment Development Institute Enugu. The aggregates were further reduced using a grinding machine before sieving to particle size of 450microns.

Composites of twelve different compositions were fabricated using cow dung (CD), silicon oil and MAPE; System A was a formulation with cow dung and compactibilizer with filler loading of 5wt%, 10wt% and 15wt% and 20wt%. System B was a formulation without the compatibilizer but with the same filler loading. The same process was followed to prepare the System C specimen using poultry manure (PD) as filler with same filler loading. System D samples were injection moulded.

The secondary processing was done at Ceeplas Industries Limited Aba, Abia State. Finally, specimens of suitable dimension were cut for different property tests according to experiment standard.

Table 1: Formulations for the filled low density polyethylene composites

S/NO.	Ingredients	Content
1.	Low Density Polyethylene (LDPE)	200g
2.	Filler (Cow or Poultry Dung)	0-20%
3.	MAPE	2%
4.	Silicon Oil	4%

Measurement of Tensile Properties

The tensile strength test was performed using Universal Testing Machine (UTM, Instron 1195 according to ASTM- D 638) and the following properties were investigated: tensile strength at yield, tensile strength at break, elongation at yield, elongation at break, modulus and energy at break of each sample.

Impact Resistance Measurement
The impact resistance of Polymeric material is a function of base resin plus the presence of impact modifiers that may be added during compounding. The impact test for the specimen was conducted according to ASTM D256. [9] Impact specimens of 60mm X 8mm X 5mm dimensions were notched at the middle to a depth of 3mm to create an area of stress concentration for initiating fracture.

Brinell Hardness Measurement
A Tensometer of type "W" by Monsanto was used to perform Brinell hardness test. The test samples were cut to rectangle shapes of 50mm by 30mm and placed in the machine. The result obtained represented the value average of the three samples.

RESULTS AND DISCUSSION

Tensile Strength

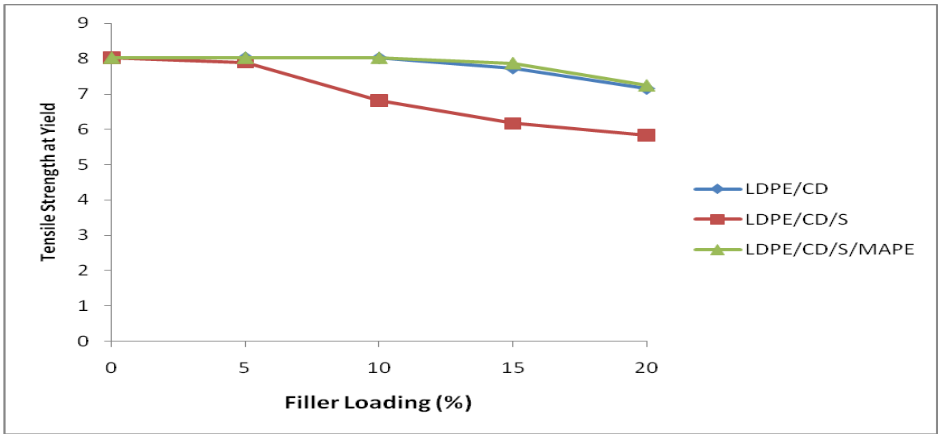

Fig 1: The plot of Tensile Strength at yield against Percentage filler loading (Cow dung)

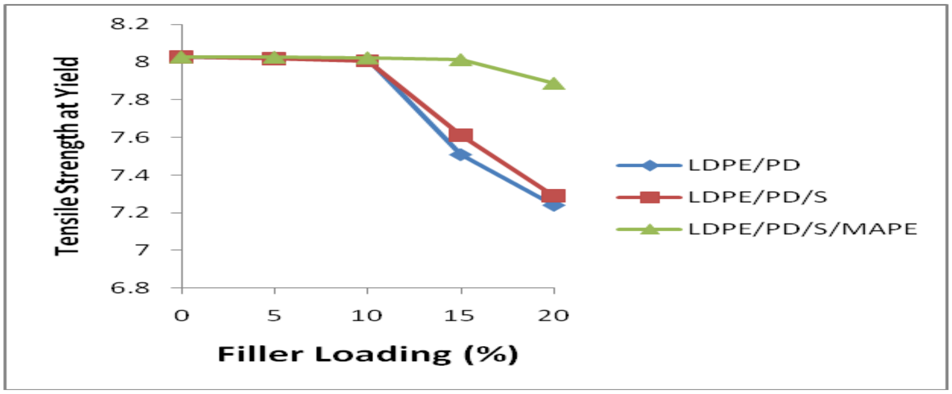

Fig 2: The plot of Tensile Strength at yield against Percentage filler loading (Poultry dung).

From Figure 1 and 2 the tensile strength at yield decreased with increasing filler loading for both Systems A and B, this could be attributed to poor interaction between the fillers and the matrix resulting to poor bonding However, the composites with MAPE showed slight improvement in tensile strength at yield compared to samples without MAPE. From the results obtained, addition of silicone oil led to a slight increase in the yield strength of the composite, although the unfilled sample still showed higher yield strength.

True Stress at Break

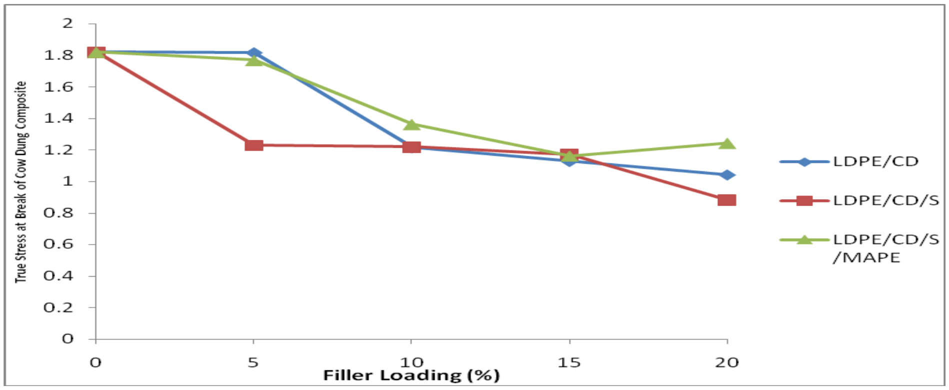

Fig 3: The plot of True Stress at break against percentage filler loading (Cow dung)

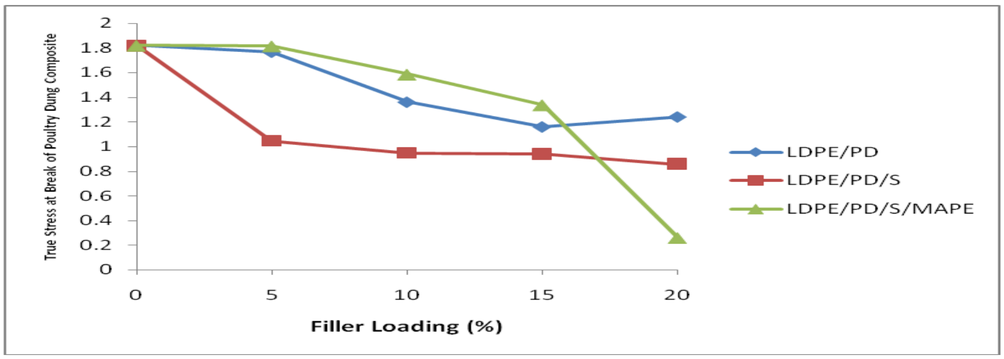

Fig 4: The plot of True Stress at break against percentage filler loading (Poultry dung)

True stress at break, sometimes regarded as the rupture strength of a material; were shown in Figures 3 and 4. The true stress at break decreases slightly with increase in filler loading for all the composite formulations. This could be as a result of increase in the brittleness of the composite. The incorporation of MAPE did not make a significant change in the true stress, however only a slight increase was observed in samples with low filler loading, it is expected that if the MAPE content is increased beyond 2% a better strength will be achieved.

Elongation

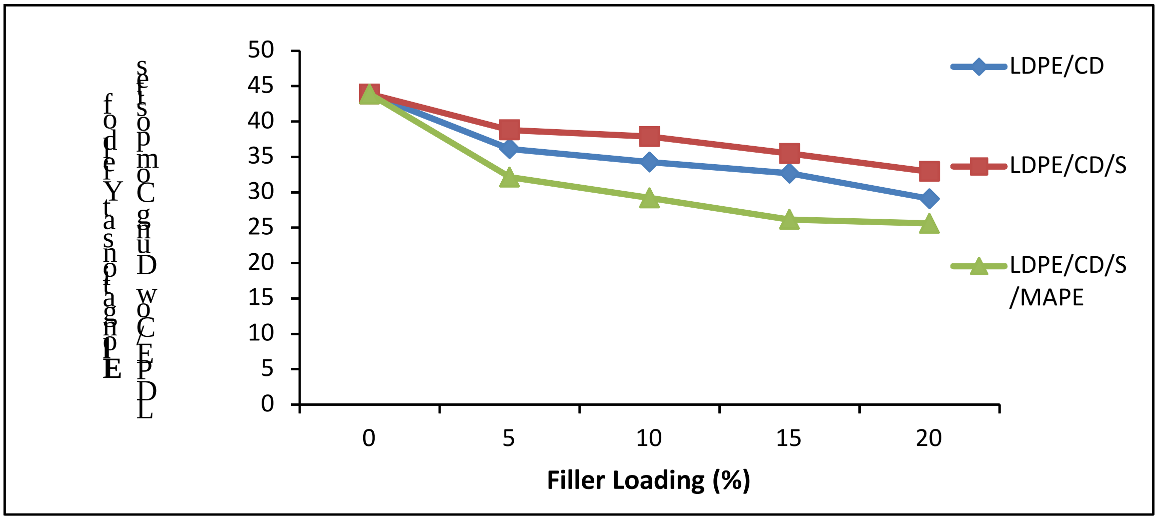

Fig 5: The plot of Elongation at yield against percentage filler loading (Cow dung)

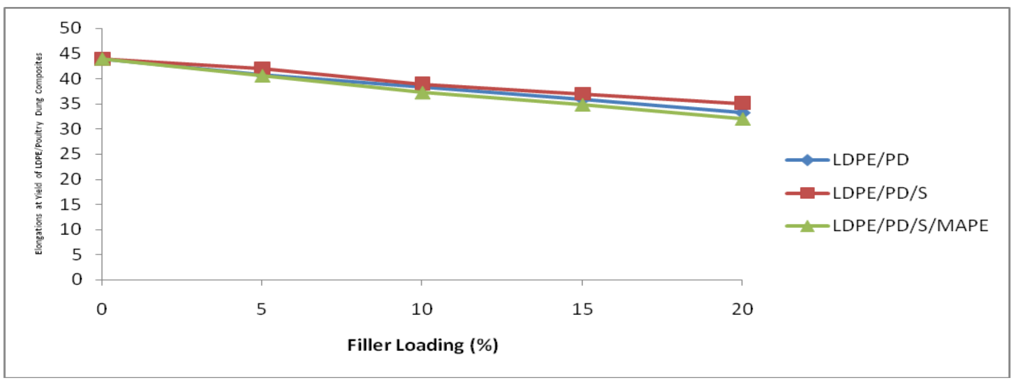

Fig 6: The plot of Elongation at yield against percentage filler loading (Poultry dung)

The values of the elongation at yield are shown in Figure 5 and Figure 6. The elongation at yield decreases with increasing fillers loading in all cases for both filler types. The incorporation of MAPE led to a decline in the elongation at yield. This could be attributed to mechanical restrain provided by the coupling effect of MAPE. However, the incorporation of 4% hydroxyl silicone oil led to slight improvement in the elongation at yield but not sufficient for most purposes since the unfilled sample still maintained a higher elongation at yield.

Modulus of Elasticity

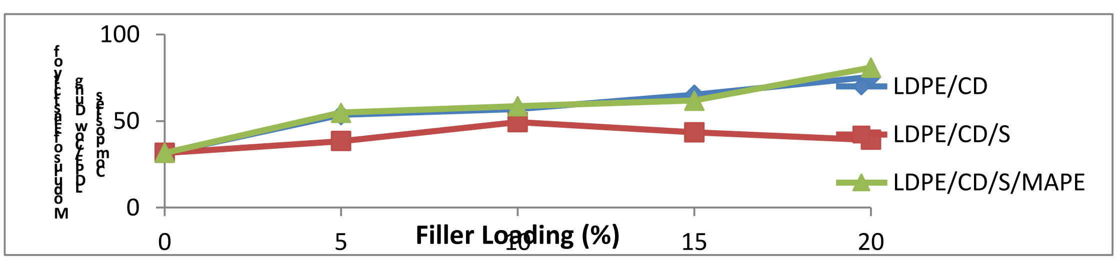

Fig 7: The plot of Modulus of Elasticity against percentage filler loading (Cow dung)

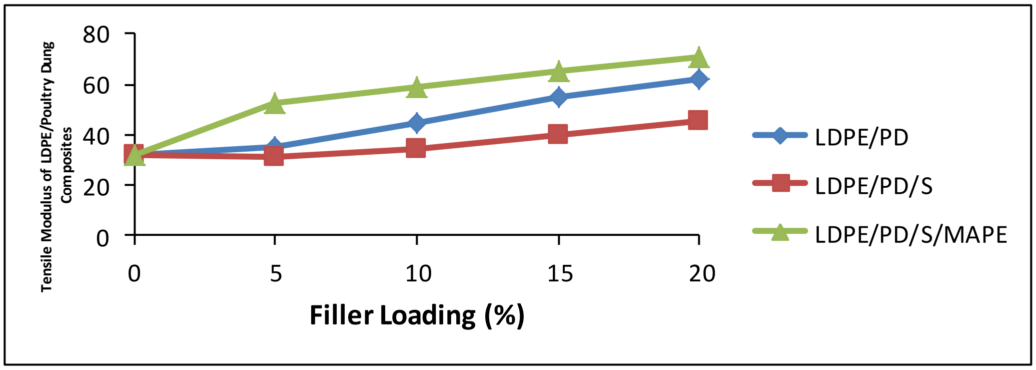

Fig 8: The plot of Modulus of Elasticity against percentage filler loading (Poultry dung)

Figure 7 and Figure 8 showed the modulus of elasticity (MOE) of LDPE/Cow dung and LDPE/Poultry dung composite respectively. The MOE increases with increasing level of filler loading in the sample. The incorporation of hydroxyl silicone oil led to significant decline in MOE when compared to samples without silicone oil; this could be as a result of the wetting effect of the oil on the filler particles. The addition of 2% MAPE increases MOE at all filler level for both filler type. Comparing the data in Figure 7 and Figure 8 Cow dung filled LDPE has a higher MOE as compared to Poultry dung filled LDPE, this could be as a result of reinforcement provided by straw which forms large percentage of the Cow dung.

Chapy Impact Strength Test

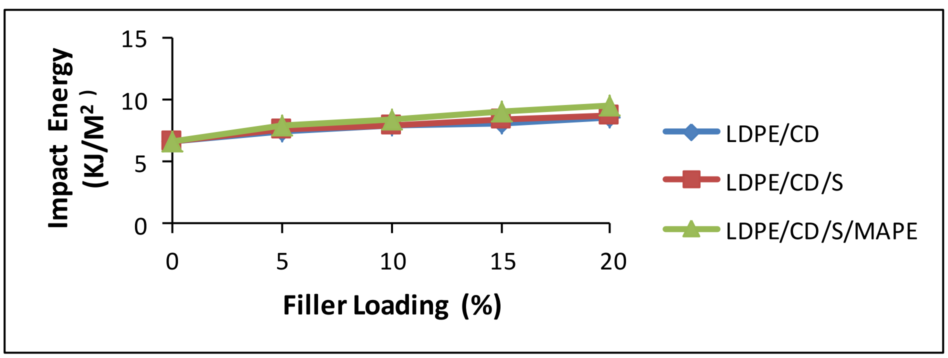

Fig 9: The plot of Impact Resistance against percentage filler loading (Cow dung)

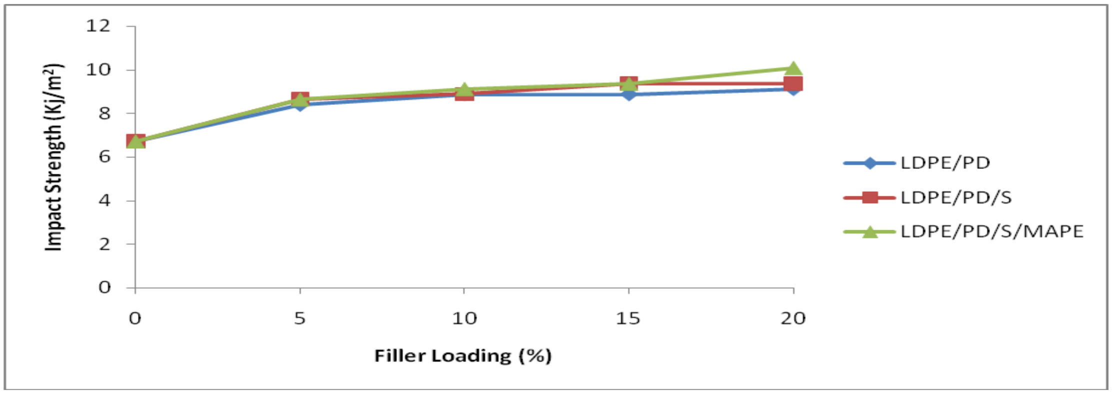

Fig 10: The plot of Impact Resistance against percentage filler loading (Poultry dung)

The addition of 2wt/% polyethylene-*graft*-maleic anhydride to various systems led to a higer impact resistance. This was due to improved interfacial bonding offered by the coupling agent, the addition of coupling agents helped to improve the inherently poor bonding between the hydrophilic animal dung's and the hydrophobic polymer matrix and helped to recover some of the impact strength. Interestingly 50% increase was recorded when compared with the unfilled sample. A comparative plot of LDPE/Poultry dung, LDPE/ Poultry dung/Silicone oil and LDPE/ Poultry dung/silicone oil/MAPE composites against percentage filler loading filler loading of Figure 9 and Figure10 showed a slight increase in the impact strength of the composite with the inclusion of 4wt % hydroxyl silicone oil. The inclusion of hydroxyl silicone oil led to higher impact resistance. Furthermore; an addition of 2% polyethylene-*graft*-maleic anhydride (MAPE) to various filler loading led to a higher impact resistance. At 20% filler loading, the composite with MAPE has an impact strength of 10.08 KJ/m^2 while the composite without MAPE has an impact strength of 9.12 KJ/m^2. This may largely be due to improved interfacial bonding offered by the coupling agent.

Brinell hardness Test

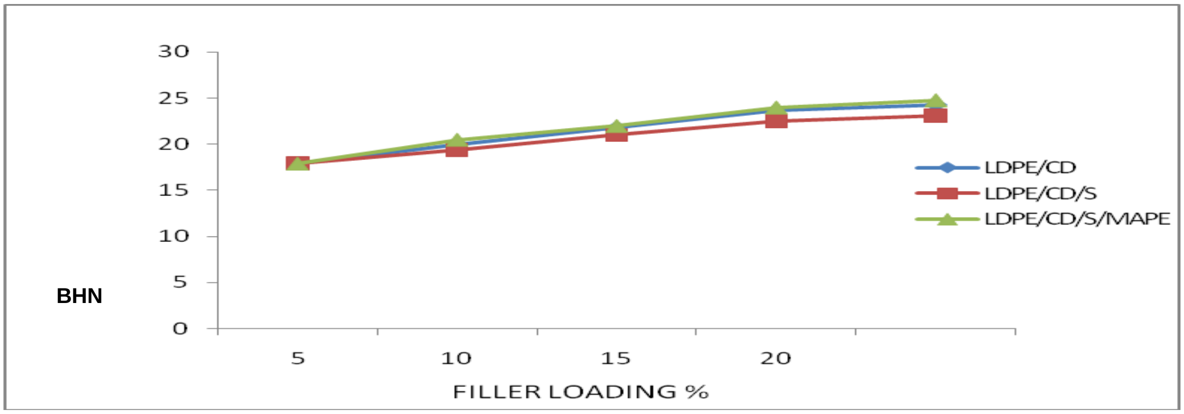

Fig 11: The plot of Hardness test against filler loading (Cow dung)

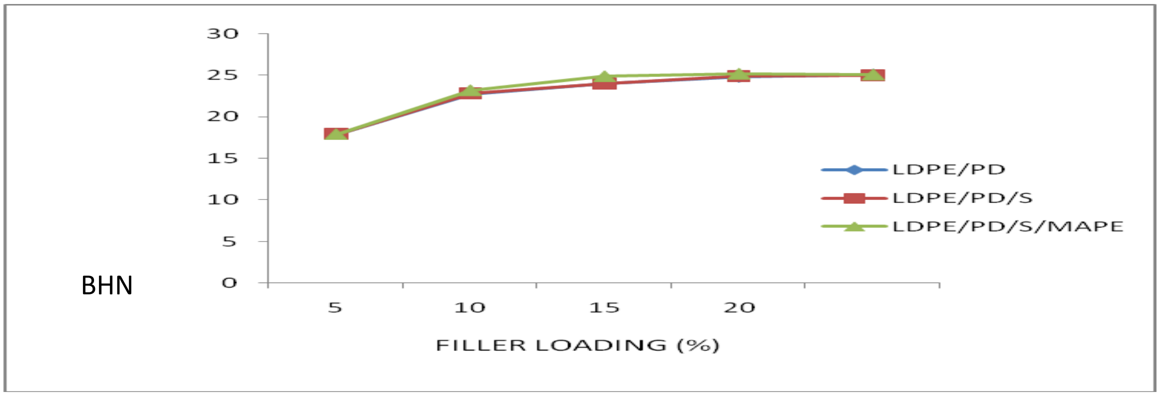

Fig 12: The plot of Hardness test against filler loading (Poultry dung)

It is seen that with the increase in fibre content in the composite, hardness value improved although the increment is marginal. A gradual increase in hardness with the weight fraction of fibre was observed. It clearly indicates that inclusion of cow dung/poultry dung fillers improves the load bearing capacity and the ability to withstand indentation on the composites. Similar report was recorded for other fibre reinforced thermoplastics composites [10]. The inclusion of MAPE led to a significant increase in the hardness of LDPE/poultry dung composite. However, there was no marked change in the hardness of these composite with the addition of hydroxyl silicone oil.

CONCLUSIONS

The result of this research shows that animal dung can be used as reinforcing fillers in thermoplastics. Specimens filled with both Cow and Poultry dungs are not as strong as unfilled LDPE, but strong enough for many applications. Increase in composition of cow dung in LDPE matrix caused the elongation at yield and elongation at break of the specimen to decrease. The elastic modulus of cow dung and poultry dung filled LDPE increased with increasing filler loading, MAPE was an effective coupling agent for LDPE composite since a 2% wt caused an increase in the MOE in both cow dung and poultry dung filled LDPE composite. Impact strength and hardness of cow dung and poultry dung filled LDPE increased with increasing filler loading.

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