# PROCESSING OF WASTE POLYETHYLENE SACHETS FOR THREAD APPLICATIONS.

**Gideon Majiyebo Adogbo, Adelodun Olatunji Yusuf**

Department of Chemical Engineering, Ahmadu Bello University Zaria, Nigeria

Email:adogbogm@yahoo.com

## ABSTRACT

Disposal of waste polyethylene product is one of the most serious environmental problems confronting many developing countries thus; there is the need to explore new techniques in recycling them. In this work, Threads were made from waste polyethylene sachets, pure polyethylene materials and blends of ratio 1:1, 1:2, 1:3, 1:4 and 1:5 of pure to waste materials. The melting point ranged between 113-141°C for pure polyethylene threads, 109-132°C for waste polyethylene threads and 109-135°C for blended threads. The yield strength ranged between 21.7-47.2kN/m$^2$ for pure polyethylene threads, 8.8-31.4kN/m$^2$ for waste polyethylene threads and 7.2-32kN/m$^2$ for blended polyethylene threads. The modulus of elasticity ranged between 0.039-0.512MN/m$^2$ for pure polyethylene threads, 0.015-0.449Mn/m$^2$ for waste polyethylene threads and 0.012-0.50MN/m$^2$ for blended threads. However, the blended thread of ratio 1:1 gave melting point that ranged between 120-135°C which is comparable to 113-141°C of pure polyethylene threads, its yield strength and modulus of elasticity were comparable to that of pure polyethylene threads. Results gotten shows that waste polyethylene can be used to make thread.

**Key words:** Polyethylene waste, Threads, Extrusion.



## 1 INTRODUCTION

The amount of solid waste is ever increasing due to increase in population, developmental activities, changes in life style, and socio-economic conditions. Plastics waste is a significant portion of the total municipal solid waste [1],[2], consumption of plastic products has increased dramatically over the past few decades, they account for more than 70% of total plastics market [3]. This trend results in the generation of a vast waste stream that needs to be properly managed to avoid environmental damage [4]. Many countries around the world are continuously faced with the problem of generation and disposal of plastic wastes. Governments around the world have funded hundreds of research projects to find efficient waste treatment technology [5] .Water sachet polyethylene are the most widely used polyethylene in developing countries especially Nigeria. Sachet water making factories both licenced and unlicenced are found in virtually every street in cities, towns and villages of Nigeria. During the dry season about 70% Nigerian adults drink at least one sachet of pure water daily indicating that about 50-60 million used-water sachet are thrown into the streets of Nigeria on a daily basis [6]. The packaging of this sachet water is made of non-biodegradable synthetic polyethylene (polythene), which does not decay, decompose or corrode, and which when burnt, produces oxides of carbon, nitrogen and sulphur which can harm man and the environment [7], [8]. Waste recycling is often seen as an important aspect of an efficient and effective solid waste management system, plastic materials can be formed into shapes by different processes: extrusion, molding and casting or spinning. Mechanic properties particularly stiffness, strength and toughness of polymeric materials are decisive properties in industrial, technological and household applications [9]. Several studies have been carried out on the recycling of polyethylene:

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[10], [11], [12], [13]. Since these water sachets still possess some properties of polyethylene, they can be used in blend with pure polyethylene in making different polyethylene products like baskets, hats, ropes, bags, mats and for fabric sewing [14], [15]. Andrei [16] carried out a work on recycling of waste polyethylene into thread but was not blended with pure polyethylene and melt drawing was not carried out. This study is aimed at recycling polyethylene waste by converting waste water sachets into threads for different uses thereby combating the problem of waste management.

## 2 METHODS AND MATERIALS

A hollow container was designed with a pipe running through it; the container was filled with hot charcoal. 5g of pure polyethylene (PE) was charged into the pipe which was heated slightly above its melting point, a thermometer was fixed in the pipe to determine the temperature. During the heating process, as the molten material came out through the pipe end, it was made to fall on a spatula which was used to draw it downwards carefully and slowly to obtain threads. This process was repeated for 7.5g, 10g, 12.5g and 15g of pure PE to get different threads. The pipe was cleaned by allowing the residue to melt completely out of the pipe.

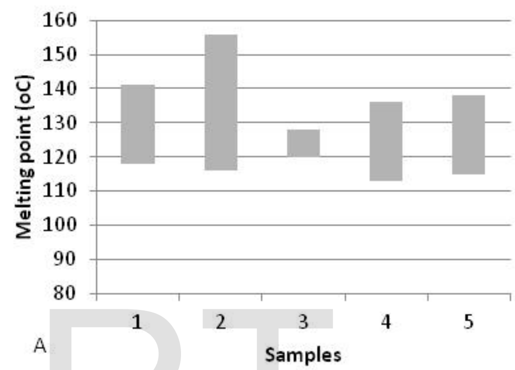
Collected waste PE samples were washed, dried and shredded after which they were charged into the heating container using the same procedure as above for sample weights of 5g, 7.5g, 10g, 12.5g and 15g to obtain threads.

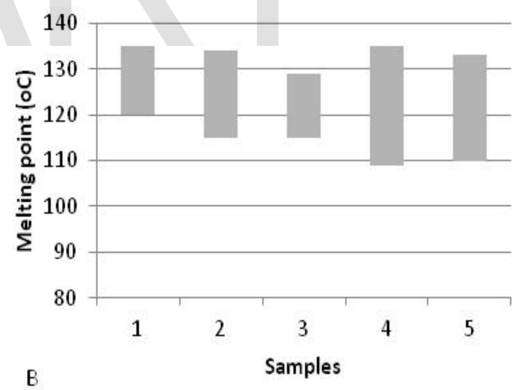
For the blended PE, blend ratios of 1:1, 1:2, 1:3, 1:4 and 1:5 of pure PE to waste PE were prepared giving weights of 5g, 7.5g, 10g, 12.5g and 15g. Each of the blended samples was subjected to heat in a stainless steel plate placed on an electric hot plate; it was properly stirred to achieve a homogeneous mixture. The mixture was allowed to solidify after which it was shredded and charged into the heating vessel for the thread making. The thicknesses of the threads made were determined using a micrometer screw gauge after which the tensile test was carried out.

## 3 RESULTS AND DISCUSSION

The physical properties of the threads obtained were observed to be two: colour and melting point. The colours obtained were: colourless, blue and green; the colourless threads obtained were mostly from the pure polyethylene samples while others were from the waste samples. The blue colour of some of the threads resulted from the blue ink on the waste polyethylene sachets. However, the green threads represent the waste and blended samples that were overheated.

The observed ranges of melting points for pure, waste and blended samples are presented below:



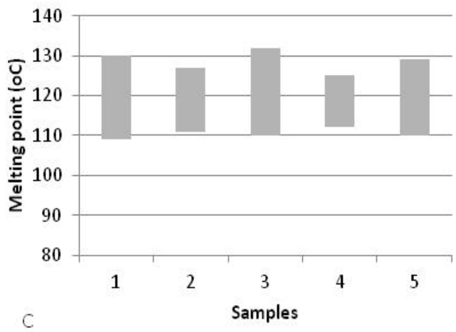



Fig. 1. Range of melting point for thread samples (A) Pure PE (B) Blended PE (C) Waste PE

The melting point for pure polyethylene threads was 113-141$^{o}$C which is comparable to 115-135$^{o}$C from literature [10]. That of waste polyethylene samples was found to be in the range of 109-132$^{o}$C which shows a reduction in the range. This is due to the fact that the waste samples are undergoing heating process for the second time and would definitely be weaker as a result of structural breakdown in its molecules. However, the blended samples gave comparable ranges of melting points to the pure and waste samples. The blended sample in the ratio 1:1 (sample B1) gave a melting range comparable to that of pure samples. That of ratio 1:2 (sample B2) was also found to be comparable to both pure and waste samples but more to the waste sample. Those of 1:3, 1:4 and 1:5 ($B_{3,}$ $B_4$ and $B_5$) were found to have melting points closer to that of waste samples, in general the blended sample had a range of 109-135$^{o}$C.

### 3.1 Mechanical Test.

The length (L) of each sample analyzed was kept at a constant value of 55mm. Initially, the load and extension values were zero.

The load values at yield and rupture for pure, blended and waste polyethylene threads are shown below:

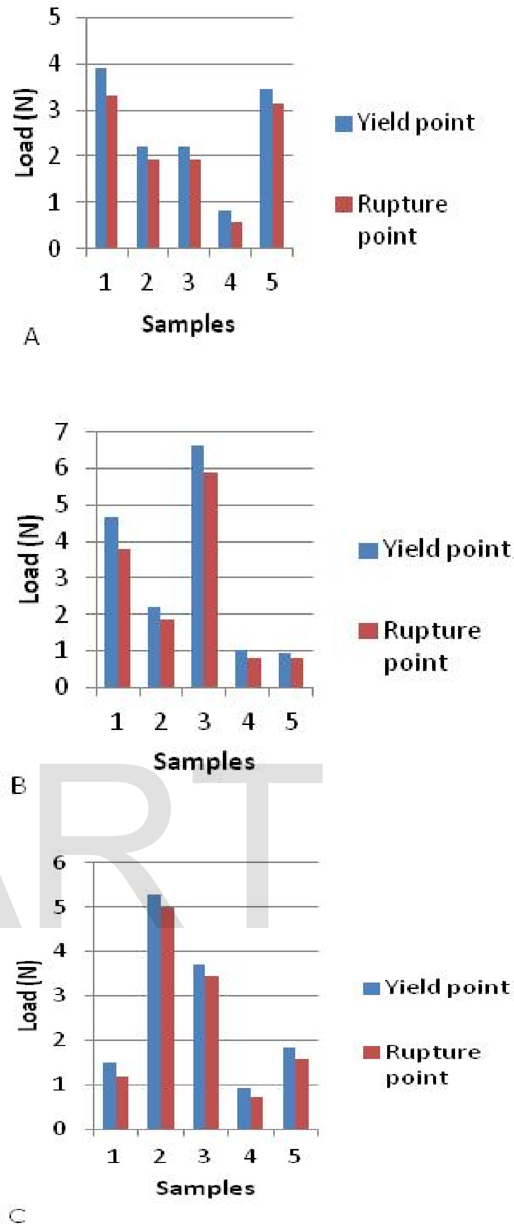



Fig. 2 Load values at yield and rupture point for (A) Pure PE (B) Blended PE (C) Waste PE

During the tensile test each thread was found to exhibit elasticity before rupture, within the range of elasticity, extension (mm) increased proportionally with load (N). After the yield point the load was found to drop while the extension increased further and the sample ruptured. The load at which rupture occurred was lower than that of the load which corresponds to the stress-strain curve.

The thickness of each thread was determined with a micrometer screw-gauge and it was used in determining the area (A) of the threads.

Formula used for the circular area:

$A = 2\pi rl$ …………………………………………… (1)

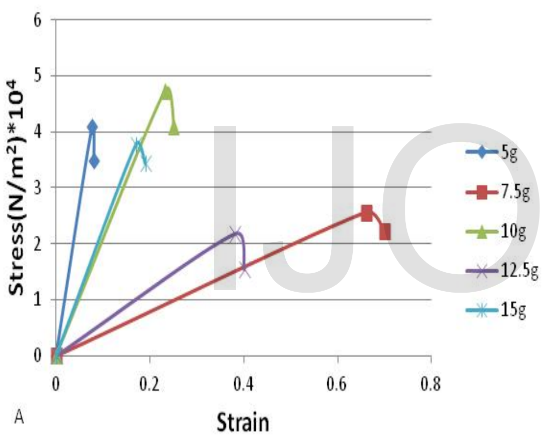
For rectangular and square shaped surface area of threads:

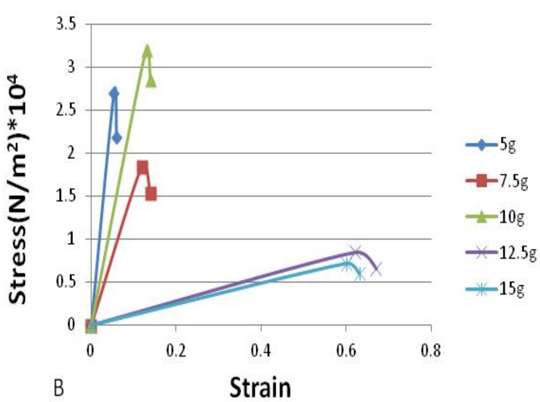
$A = perimeter\ (P) \times length\ (l)$ ………………… (2)

From the load, extension and area data, stress and strain values were determined using the formula:

$stress(N/m)^2 = (\frac{load(N)}{area(mm)^2}) \times 10^6$ ………. (3)

$Strain = extension(\Delta Lmm)/length(55mm)$ …... (4)



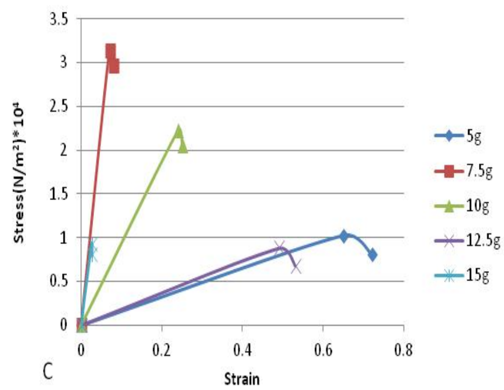




Fig. 3. Stress-Strain curves for (A) pure polyethylene (B) blended Polyethylene (c) waste polyethylene

The Fig. 3 shows the initial, yield and rupture points for the pure, blended and waste polyethylene used in making threads. The highest point in the curve is the yield point where the material begins to have permanent deformation and does not return to its normal shape and size after the release of the applied stress. The pure Polyethylene had higher yield points for all the samples compared to the blended and waste polyethylene which is due to the fact that the polyethylene had not been used and had not undergone any initial heating process like the blended and waste polyethylene thus its structural molecules had greater strength to withstand the applied stress. The blended polyethylene had yield strength greater than the used polyethylene except in the sample weights of 7.5g and 15g which could be due to poor drawing technique. The waste polyethylene cannot be used alone in making threads due to the low values of yield strength compared to the pure polyethylene.

In Fig. 3A, increase in the weight of the pure polyethylene did not lead to a corresponding increase in the yield point as expected which could be as a result of the drawing technique used or the temperature regulation. In figure 1B, as the quantity of the waste polyethylene was increased in the blend, the thread became more prone to creep, the waste polyethylene in figure 1C also showed a degree of elasticity when drawn although the yield point was lower compared to the pure and blended polyethylene. In the figure 1 above, it can also be seen that the rupture point was almost immediately after the yield point in all the analysis, this can be improved on by using more precise equipments and techniques. Due to the presence of entanglement of molecular chains, the polyethylene loses fluidity and shows rubber-like elasticity in the melt. In the course of melt drawing, the entanglement plays the role as transmitter of drawing force and the molecular chains supported by the entanglement orient in the stretching direction. This is why polyethylene can be stretched in the molten state. The blended polyethylene was drawn at the molten state hence waste polyethylene can be recycled into thread with improvement made on the drawing technique and heating process used.

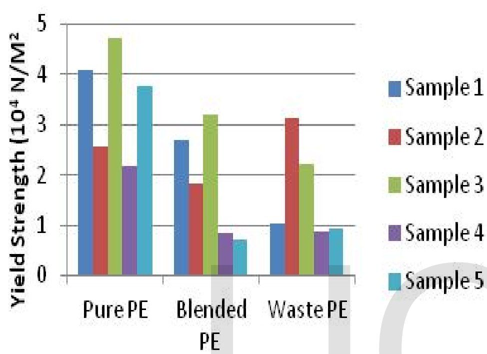



Fig. 4 Yield strength values of thread samples.

The yield strength obtained for the blended samples was in the range of 7.2-32 kN/m$^2$ for the blended sample. Although it was expected to decrease downwards, sample $B_3$ was greater than $B_2$; this was due to not achieving a perfect homogeneous blending of the pure and waste samples. However sample $B_1$ with blending ratio 1:1 gave yield strength of 27kN/m$^2$ which is comparable to those of pure polyethylene threads obtained. This shows an increase in strength as a result of blending; the ranges resulted from lack of similarities in the areas of the threads for the three samples. Although for the waste polyethylene, sample $C_2$ gave yield strength comparable to those of pure polyethylene samples. This was as a result of error in thickness determined and other errors during production. The strength of the threads obtained was generally in the range of 7.2-47.2 kN/m$^2$ which differed from literature (1-1.3GN/m$^2$), since the threads gave results within similar ranges, a well designed set up will give threads with properties similar to literature.

Within the elastic limit, modulus of elasticity was determined by using the relationship:

$$\in \ (N/m)^{\wedge}(2) = Stress/Strain \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

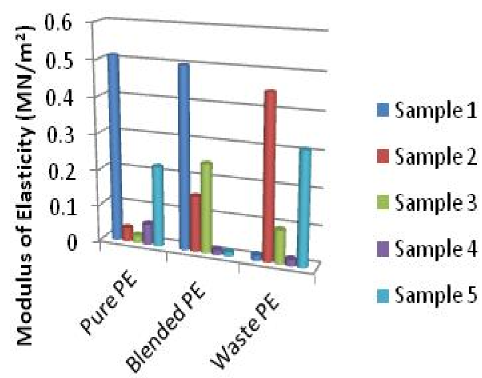



Fig. 5 Modulus of elasticity of thread samples.

One of the most important engineering parameter which reflects a material’s resistance against deformation, and should be measured before designing polymer is the modulus of elasticity. It is a measure of the stiffness or rigidity of materials depending upon strength of interatomic bonds and composition.

From the modulus of elasticity data obtained above, pure polyethylene threads gave a range of 0.039-0.512MN/m$^2$ indicating the stress which the threads can withstand under a particular strain. That of blended and waste threads ranged between 0.012-0.50MN/m$^2$ and 0.015-0.449Mn/m$^2$ respectively. Sample $C_2$ and $C_5$ of waste polyethylene threads gave modulus values of 0.449 and 0.311Mn/m$^2$ respectively which are comparable to that of pure polyethylene threads. It was also discovered that the thread with blending ratio 1:1 (sample $B_1$) gave a modulus of 0.5Mn/m$^2$ which is almost the same as 0.512MN/m$^2$ for sample $A_1$ of the pure polyethylene threads. However, as the blending ratio changes downwards, the modulus of elasticity approaches that of waste polyethylene threads. In general, poor temperature control and lack of properly maintained thread drawing speed greatly affected the result obtained

## 4 CONCLUSION.

Threads were made from pure, blended and waste polyethylene samples. From the analysis of the melting point, yield strength and modulus of elasticity of the threads, the blended polyethylene gave results close in range to that of the pure polyethylene. The yield strength of the threads obtained differed from literature which could be as a result of errors that occurred during the experiment. Hence a well designed set up with improvement in the drawing speed, temperature control and blending method would give threads of greater strength. The results obtained establishes the fact that waste polyethylene can be used for thread making and the strength of waste polyethylene threads can be increased by blending them with pure polyethylene, the blended polyethylene threads can be used for same applications as pure polyethylene threads thus combating the problem of waste management.

## REFERENCES.

[1] D.S Achilias, A.Antonakou, C.Roupakiasi, P.Megalokonomosi and A.Lappas, "Recycling Techniques of Polyolefins from Plastic Wastes" Global Nest Journal, Vol.10 No.1: pp.114-122, 2008.

[2] Alter, L. (2007), Africa wages war on scourge of plastic bags. http://www.treehugger.com/files/2007/08/africa_wages_wa.php#ch01

[3] Tamboli S.M, Mhaske S.T and Kale D.D, "Crosslinked Polymer" Indian Journal of Chemical Technology, Vol.11, pp. 853-864, 2004

[4] J.Aguado, D.P Serrano and G.S Miguel, "European Trends in the Feedstock Recycling of Plastic Wastes" Global Nest Journal, Vol.9 No.1: pp.12-19, 2007.

[5] Sarker M, Rashid M.M, and Rahman M.S, "Agricultural Waste Plastics Conversions into High Energy Liquid Hydrocarbon Fuel by Thermal Degredation Process" Journal of Petroleum Technology and Alternative fuels, Vol.2, No. 8, pp. 141-145, 2011.

[6] M.O Edoga, L.L Onyeji and O.O Oguntosin, "Achieving Vision 20-20 through Waste Management" Journal of Engineering and Applied Sciences Vol.3(8): pp. 642-646, 2008

[7] Jimenez A. and Zaikov G, "Recent Advances in Research Biodegradable Polymers and Sustainable composites, Nova, Hauppauge. NY..315, 2008.

[8] M.B Adetunji and B.M Ilias, "Externality Effects of Sachet Water Consumption and the Choice of Policy Instruments in Nigeria: Evidence from Kwara State" Journal of Economics, Vol.1 (2): pp.113-131, 2010.

[9] Hussein A.A, Sultan A.A and Matoq Q.A, "Mechanical Behaviour of Low Density Polyethylene/ Shrimp Shells Composite", Journal of Basrah Researches Sciences, Vol.37, No. 3A, 2011.

[10] O.O Olanrewaju and Ilemolbade, "Waste to Wealth: A Case Study of the Ondo State Integrated Wastes Recycling and Treatment Project, Nigeria" European Journal of Social Sciences , Vol. 8, No.1; pp.7-16, 2009

[11] N.Simon, O. Olayide and O. Chinyere, "Occurrence and Recalcitrance of Polyethylene Bag Waste in Nigerian Soils" African Journal of Biotechnology Vol. 9(37) pp.6096-6104, 2010.

[12] T.W Paul and S. Edward, "Analysis of Products from the Pyrolysis and Liquefaction of Single Plastics and Waste Plastic mixtures" Resources, Conservation and Recycling Vol.51 Issue 4: pp.754-769, 2006.

[13] D.S Achilias, A. Antonakou, C. Roupakiasi, P. Megalokonomosi and A. Lappas, "Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP)" Journal of Hazardous Materials Vol.149 Issue 3: pp. 536-542, 2007.

[14] Subbol W.K and Moindi N.M, "Recycling of Wastes as a Strategy for Environmental conservation in the Lake Victoria Basin: The case ofWomen Groups in Kisumu, Kenya, African Journal of Environmental Science and Technology, Vol.2, No. 10, pp.318-325, 2008.

[15] Plastic Bag Yarn.(2007), Gooseflesh. http://www.needlepointers.com/plasticbag

[16] A.Shylo, “Designing the most Appropriate Thread to be produced in Developing Countries by Recycling HDPE Bags”,http://www.scientiareview.org/pdfs/80.pdf.2009.