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Laboratory Conversion of Used Water Satchet as A Regenerative Resources for Candle Wax Production

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Abstract
In this study, used water sachet (polyethylene), non-biodegradable wastes are recycled into super wax used for the production of candle, a biodegradable product. This was achieved via the use of simplistic unifactor approach to eight different formulation of stearic acid (SA) and polyethylene (PE). The candles produced were analyzed using standard method .It was observed that as the ratio of (SA) to (PE) increased, better quality candles were produced The efficiency of the candle was enhanced by the dual function of the SA blend which acted as solvent dissolving the wax and additive promoting the hardness of the wax samples (A-J) showed loss of (7.7,7.3,6.0,5.2,4.2,5.2,4.9,2.9,4.2cm) in height and (8.10,7.50,7.22,6.10,5.19,4.13,5.9,5.28,3.28 g) in weight respectively when subjected to 15 min burning. The commercial candle lost 3 cm in height and 2.04g in weight within 15 min of burning. The various produced candle recorded solidification time of (30-40 min) at initial temperature ranges of (30-40^{0}C) and final temperature ranges of (150-200^{0}C), melting time of (PE) was (1-4 min) and SA (3-5 min). The variations in the studied parameters are akin to different formulations used for the production of candle wax.

Key words: Polyethylene; Candle; Super wax; Stearic acid.

1. Introduction

Polyethylene is the major material used in Nigeria for packaging of various types of eateries and treated water. After the consumption of the packaged water, the waste sachet constitutes the greatest threat to eco-system. It is non-biodegradable absolutely impossible to be consumed by micro-organism) [8], toxic and unhealthy to the environment and its inhabitant in developing countries like Nigeria. Waste is therefore any discarded material after primary use, and/or defective and of no use.[1] There are many waste types defined by modern system of waste management, notably; municipal wastes which include household waste, commercial waste and demolition waste. Hazardous waste includes; waste which are toxic to health. Biomedical wastes are clinical wastes. Special hazardous waste includes radioactive waste, explosive waste and electronic waste. Inappropriate manage waste can attract rodents and insects, which can harbor gastrointestinal parasite, yellow fever, worms and other conditions for human. Exposure to hazardous waste particularly can cause various other diseases including cancer. Toxic waste material can contaminate surface water, ground water, soil and air which can causes more problems for humans, other species and ecosystem. [3] Solid waste is ever increasing due to the increase in population, developmental activities and changes in life style.[4] Plastic waste constitute about 85% of the total solid waste because the consumption of plastic products are ever on the increase; ranging from plastic bottle water to common sachet water. Waste pollutes the environment if they are not properly disposed and managed. On the other hand, if properly disposed and managed will not constitute any environmental problem and as such, pollution will be eradicated.[5] This is because waste are just useful materials in the wrong place.[6] The economic cost of managing waste are high and are often paid by the municipal government.[7] Money can often be saved with more efficiently designed collection route, modifying vehicles and with public education, environmental policies such as pay as you throw can reduce waste quantities.[1] waste recovery(that is recycling or reuse),can curb economic cost because it avoids extraction of raw materials and often cuts the transportation cost. Water sachet polyethylene are most widely used polyethylene in Nigeria. [8] Pure water making factories both licensed and unlicensed are found in virtually every street in cities, towns and villages of Nigeria.[5] Sachet water began in 1994 when a dentist from the Brattleboro Vermont rotary club volunteered to go to a small Salvadoran village to provide medical service.[9] He was moved by the poor living condition and vowed to make a difference and do something. He decided to help the poor by providing rural villagers with portable water. [9]

Sachet water is the fastest growing business in Africa. Over ten million people survive through sachet water sale and supply in Africa. As they say water is life, sachet water quenches the taste of those who cannot afford bottle water. [9]

During the dry season about 70% of Nigerian adults drink at least two sachet water per-day, this means that 50-60 million used sachets are disposed to the waste bin in Nigeria on daily basis.[5] When burnt it produces carbon oxide, nitrogen and sulfur which are harmful to men and his environment. Recycling of waste sachet is therefore inevitable in saving the environment and its inhabitant.

This study therefore focuses on recycling of sachet polyethylene; a non-biodegradable waste into candle waxes, a biodegradable product, because candle burns off leaving nothing.

-To produce candle from polyethylene based wax:

1.1 Candle

Candle is an ignitable wick embedded in wax or another flammable solid substance such as tallow that provides light and in some cases, a fragrance. It can also be used to provide heat, or used as a method of keeping time. Candle was among the earliest invention of the ancient world as shown by the candlestick from Egypt. [19] A candle manufacturer is traditionally known as a chandler,[20] Various devices have been invented to hold candles, from simple tabletop candle holders to elaborate chandeliers. For a candle to burn, a heat source (commonly a naked flame) is used to light the candles wick, which melts and vaporizes a small amount of fuel (the wax). Once vaporized, the fuel combines with oxygen in the atmosphere to ignite and form a constant flame. This flame provides sufficient heat to keep the candle burning via a self-sustaining chain of events: the heat of the flame melts the top of the mass of solid fuel; the liquefied fuel then moves upward through the wick via capillary action; the liquefied fuel finally vaporizes to burn within the candle's flame. As the mass of solid fuel is melted and consumed, the candle becomes shorter. Portions of the wick that are not emitting vaporized fuel exposed length of the wick, thus maintaining a constant burning temperature and rate of fuel consumption.[21] If you look closely to a candle flame, you'll see blue area at the base of the flame, above that is a small dark orange-brown section, which support the large yellow region that we associate with candle flame.[22] The oxygen-rich blue zone is where the hydrocarbon molecule vaporize and start to break apart into hydrogen and carbon atoms. The hydrogen is first to separate and reacts with the oxygen to form water vapor. Some of the carbon burns here to form carbon dioxide. The dark or orange-brown region has relatively little oxygen, this is where the various forms of carbon continue to break down and small harden carbon particles start to form. As they rise, along with the water vapor and carbon dioxide created in the blue zone, they are heated to approximately 1000 degrees centigrade. [22] At the bottom of the yellow zone, the formation of the carbon (soot) particles increases. As they rise, they continue to heat until they ignite to incandescence and emit the full spectrum of visible light. Because the yellow portion of the spectrum is the most dominant when the carbon ignites, the human eyes perceives the flame as yellowish. When the soot particle oxidant near the top of the flame's yellow region, the temperature is approximately 1200 degrees centigrade. [22]

2. Materials and Method

2.1. Sample Collection

Used water sachets were gathered from various locations within Uke in Idemili Local Government Area of Anambra State, Nigeria.

2.2 Reagent

The two major reagents; Acetone and stearic acid used in the formulation of candle were purchased from May and Baker Nigeria Plc.

2.3 Sample preparations

The sachets were washed with detergent to remove all dirt, dried and later soaked in acetone prior to removal of the labels and other ink related matters on the used sachets. The cleaned samples were later re-dried and ground with crushing machine to increase the surface area, thus facilitating faster drying of the polythene.

2.4 Molds and wicks preparation

Eight molds were prepared from paw paw leaf base straw-ike stems. They were cut to the same length of 20 cm each. One end of the molds was covered with a small piece of footwear cut to size (diameter) of the paw-paw stem. The wick is passed through the center of the footwear using a needle and passed through the 2cm paw-paw stem with the help of a broom stick. The mold is held upright using a retort stand.

2.5 Production of candle wax from polyethyene (waste water satchet)

Different quantities (10-45g) of stearic acid were weighed and poured inside 500ml sets of beakers, placed on a hot plate and heated until a clear liquid was obtained. The ground WS was weighed and poured into the stearic acid, heated from 30^{o}c to 200^{o}c until clear liquid was obtained.

2.5.1 Molding of Candle

The finished products were properly mixed and poured into the improvised mold. The molds were slightly tapped by the sides so as to remove any trapped air bubbles during pouring. It took 30-40 minutes for complete solidifications of various grades of candles. Upon solidification more molten waxes were poured to ensure that the mold was properly filled. Opun complete solidification of the waxes, the finished candle was removed by cutting the mold open from the sides using knife. The excess wax was trimmed and the candles were properly dressed.

2.6 Characterisation of burning time

Eight samples (A-J) produced were weighed using electronic weighing balance while their lengths were measured with a ruler. Subsequently the candles were lighted and allowed to burn for 15minutes after which they are re-weighed and their length measured again.

3.0 Results and Discussion

Table 3(a) showed the formulations of waste polyethylene [water sachet] and stearic acid blend. The time taken for stearic acid and polyethylene to melt, the various temperature of different formulations and the solidification time of each candle produced.

Table 1. Stearic acid and wax composition of various samples

SAMPLES	Weight of STEARIC ACID (g)	Weight of P.E[g]	TIME OF MELTING OF STEARIC ACID (mins)	TIME TAKEN FOR P.E TO MELT (mins)	INITIAL MELTINGTEMP (^{o}C)	FINAL MELTING TEMP (^{o}C)	SOLIDIFICATION TIME (mins)
A	10g	1.5g	3mins	2mins	30^{0}c	150^{0}c	30mins
B	10g	0.15g	3mins	1mins	30^{0}c	160^{0}c	30mins
C	15g	0.25g	3mins	2mins	35^{0}c	160^{0}c	35mins
D	20g	0.1g	4mins	2mins	30^{0}c	170^{0}c	30mins
E	30g	3g	5mins	4mins	40^{0}c	200^{0}c	40mins
F	30g	0.3g	4mins	2mins	30^{0}c	200^{0}c	30mins
G	40g	0.7g	4mins	3mins	30^{0}c	200^{0}c	30mins
H	45	0.06	5mins	4mins	40^{0}c	200^{0}c	40mins

Table 2. Entails the length and weight of various candles produced. It is seen that as the quantity of stearic acid is increased and the quantity of wax reduced better quality candles are produced. Generally stearic acid melt when subjected to high temperature of about 30^0c, when the grinded waste polyethylene is added to the already molten stearic acid it takes average temperature of 200^0c to melt completely. The high temperature of 200^0c was necessary to ensure that the wax does not solidify or stick to the side of the mold during pouring.

Table 2. The sampes and the effect of burning them for 15minutes Before burning

SAMPLES	CANDLE HEIGHT[cm]	CANDLE WEIGHT[g]
Sample 1	16.4cm	17.30g
Sample 2	18.5cm	19.61g
Sample 3	17.3cm	20.41g
Sample 5	18.5cm	23.38g
Sample 7	18.2cm	20.30g
Sample 8	19.7cm	21.08g
Sample 9	18.3cm	20.21g
Sample 10	18.2cm	20.21g
Commercial candle	19.8cm	19.62g

Figure 2. Evaluation of various candles while burning for 15 minutes.

Table 3 shows the effect of burning the candles for 15minutes. It is observed that the higher the quantity of stearic acid the less fast a candle burns, this is because stearic acid serves both as a solvent in dissolving the wax and also as an additive to harden the wax and make it burn efficiently. This determines how long a candle last since hard candles are more likely to retain their shape while burning. The candles produced with stearic acid are more likely to drip less, sag less and burn faster. This effect was found to increase as the ratio of stearic acid to wax increases. Also increase in the amount of stearic acid produces a brighter burning flame with less soot.

The wick served as fuel while the wick was the absorbent. The wick absorbed the liquid wax and moves it upward while the candle burns. From table 3c it can be deduced that higher amount of wax was consumed when candle produced with lesser amount of stearic acid was burned for 15minutes, however with the addition of 30g, 40g and 45g of stearic acid better candles were produced with lesser consumption of wax.

Table 3. Samples After Burning

SAMPLES	CANDLE HEIGHT[CM]	CANDLE WEIGHT[g]	LOSS IN HEIGHT	L0SS IN WEIGHT
A	8.75cm	9.20g	7.7cm	8.10g
B	11.2cm	12.11g	7.3cm	7.50g
C	11.3cm	13.19g	6.0cm	7.22g
D	13.2cm	14.34g	5.2cm	6.10g
E	14.3cm	18.09g	4.2cm	5.19g
F	12.6cm	16.37g	5.2cm	4.13g
G	13.3cm	14.40	4.9cm	5.90g
H	16.8cm	15.80g	2.9cm	5.28g
I	14.2cm	18.83g	4cm	3.28g
J	16.2cm	17.83g	2cm	2.28g
Commercial candle	16.8cm	17.58g	3cm	2.04g

Figure 2. Various heights and sizes of the candles after burning

Conclusion

Used water sachet was successfully been recycled into useful biodegradable super wax via simplistic unifactor approach formulation of stearic acid and polyethylene. The creation of wealth and employment opportunity for skilled and unskilled laborers was inevitably, an added advantage to environmental cleanliness. All the candles produced from the various formulations in the studied parameters demonstrated excellent burning qualities.

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