A Promising Concept Of Waste Management Through Pyrolysis Of Low Density Polyethylene

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ABSTRACT: Waste management has been a topic of concern among researchers and this has led to the research into various methods of managing them. Pyrolysis otherwise known as thermal decomposition of waste polymeric materials is a renowned technology that is gaining popularity among researchers. This process helps to reduce the environmental menace caused by the conventional methods of waste disposal which include incineration and land filling. Waste low density polyethylene in the form of water sachets was collected from households over time, dried and shredded in preparation for pyrolysis. A measured weight of the waste Low Density Polyethylene (LDPE) was fed into the reactor for the pyrolysis to take place at temperatures above 350°C. The products of the pyrolysed waste LDPE which include the condensable gases and the non condensable gases were collected in their different collectors. The residue otherwise known as char was also collected. The liquid product also known as pyrolysis oil was analysed using analytical instruments such as GC-MS and FTIR. The analysis shows that the hydrocarbon components present in the oil are C_9 to C_{25} which are in forms of aliphatics, aromatics, esters and alkanoic acids.

Keywords: fuel grade products, low density polyethylene, pyrolysis, waste management.

1. INTRODUCTION:

Global population growth is eminent to inspire high energy demands and waste generation [1], [2]. Though researches are ongoing to scale up energy source to meet this demand, promising concepts dedicated to reducing specific waste implication of population growth are scarce. The available ones are rather not adequate to profile waste management for specific waste generated. On the account of Nigerian waste generation context, about 32 million tons of solid wastes are been generated annually [3], [4]. These include plastics, Municipal Solid Wastes, etc. [5]. Plastics which amount to 33.3% unlike other classifications have very stringent impact on environmental health; it can clog underground water pipe, suffocate useful organism, etc [1]. While allowing plastics to roam in the environment is not a good option, most research proliferations are still at their infancy stage. So, at this moment one cannot broadly say that waste management concept is fully implementable. Many approaches have been used for waste management process. This include anaerobic digestion, pyrolysis, etc [6], [7]. The former is concerned with a fermentation process [8] while the latter employs thermal decomposition techniques [9]. Effective waste management is a menace that affects virtually part of the globe. Varying techniques have been employed in different countries or communities to tackle the waste problem. More successes have been achieved in the developed nations than developing/third world countries [13]. Getting the exact figures relating to a lot of developing countries is difficult to come by. In a lot of cases the data obtained from literature are not consistent [10] for all classes of waste generated. Looking critically at plastic solid wastes (PSW) in particular, there has been a considerable increase in the rate of PSW generation since the 1940s. This was when industrial scale production of synthetic polymers began in earnest [11]. Whilst recycling has been shown to be an effective means of reducing PSW [16], an alternative route of thermochemical conversion of the plastics to valuable hydrocarbons has also been proposed. Pyrolysis is thought to be cost effective when compared to other processes [15]. Pyrolysis involves the thermal degradation of the plastic in the absence of air to produce oil and gas. Yield and composition of oil obtained depends on the type of plastic used for pyrolysis [14]. This is as a result of the varying compositions of the different plastics which can be determined via proximate analysis [12]. The oil obtained can be utilized as a liquid fuel or further refined to more important hydrocarbons. Zhang et al [20] successfully produced gasoline range hydrocarbons when low density polyethylene (LDPE) was pyrolysed other ZSM-5. In subsequent work they were able to also obtain high density Jet fuel via catalytic microwave pyrolysis of LDPE [19]. Zeaiter [18] studied pyrolysis of high density polyethylene (HDPE) over highly ultrastable zeolite Y and HBeta Zeolite having high amounts of C_1-C_5 gas being produced. Wong et al [17] also went on to study the conversion of LPDE into liquid fuels using ZSM-5 catalysts. In this paper, the pyrolysis of waste water sachets without the use of any catalyst and analysis of the liquid product otherwise known as pyrolysis oil in order to describe the oil components were considered.

2. MATERIALS AND METHOD:

2.1 MATERIALS:

Water sachets, glass wool, 1000ml three necked round bottom flasks (RB flask), rubber corks, condenser, chiller, nitrogen gas, 250ml three necked round bottom flask for liquid collection and gas bags for gas collection. The set up was arranged as shown in figure. Weighing balance, heating mantle, drying oven, sample bottles are required equipment. Analytical equipment required include the GC-MS and FTIR for the analysis of the products.

2.2 METHODOLOGY:

Waste LDPE in form of water sachets were collected from households, dried and shredded. 50g of the waste LDPE was measured using the Shimadzu UW2200H model weighing balance and fed into the 1000ml RB flask. The system was purged using nitrogen gas for about 1 minute to create inertness for the pyrolysis process. The LDPE was heated up as shown in the set up in figure at a heating rate of approximately $4^{o}C$ to a temperature of $450^{o}C$ being the limit of the heating mantle with respect to the feedstock. The temperature of the reaction was monitored using a K type thermocouple. The evolving gases which included the condensable and the non condensable gases were collected in a 250ml RB flask and gas bags

***Table 1:** Wavebands with corresponding peak assignments from the FTIR spectra.*

S/No	Wavebands (/cm)	Type of vibration	Associated functional group
1	910	C – H bending	Alkane
2	1033.88	C – H bending	Alkane
3	1458.23	C = C stretching	Aromatic fingerprint
4	1535.39	C = C stretching	Aromatic fingerprint
5	1643.41	C = C stretching	Aromatic ring
6	2854.74	C – H stretching	Alkyls, Aliphatics
7	2924.18	C – H stretching	Alkyls, Aliphatics
8	3610.86	O – H stretching	hydroxyl

3.0 RESULTS AND DISCUSSION:

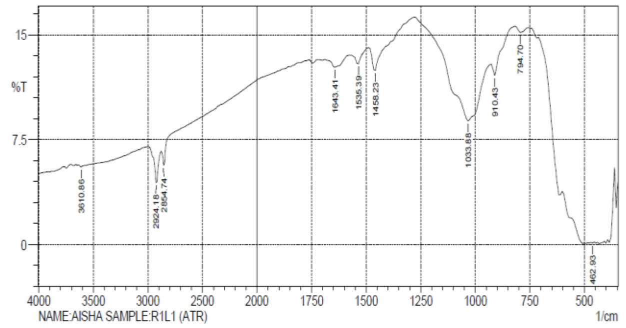
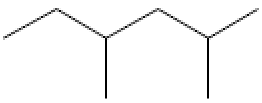
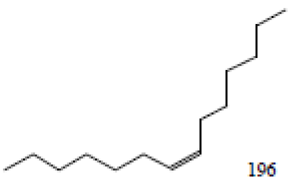
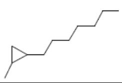


***Figure 1:** FTIR spectra of the pyrolysis oil sample.*

***Table 2:** GC – MS analysis of the pyrolysis oil.*

S/No.	Structural Formula	Molecular Formula	Nomenclature	Remark
1		C_9H_{20}	nonane	alkane
2		C_9H_{18}	nonylene	alkene
3		$C_{10}H_{20}$	octene	aromatic
4		$C_{10}H_{22}$	octane	aromatic
5		$C_{12}H_{24}$	dodecene	aromatic
7				aromatic
8		$C_{13}H_{26}$	Tridecene	aromatic
9		$C_{14}H_{24}$	tetradecene	aliphatic
10		$C_{11}H_{22}$	cyclopropane	aromatic

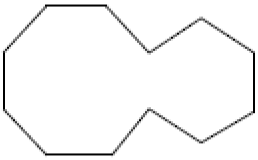
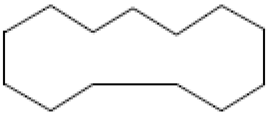
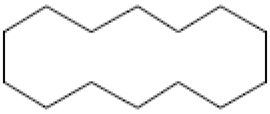
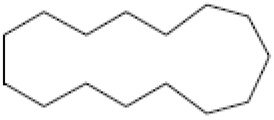
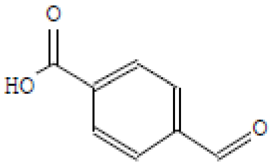
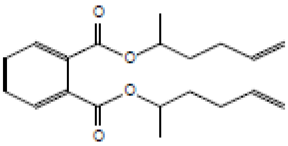
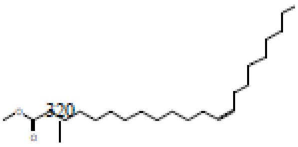
11		$C_{12}H_{24}$	cyclododecane	aromatic
12		$C_{13}H_{26}$	cyclotridecane	aromatic
13		$C_{14}H_{28}$	cyclotetradecane	aromatic
14		$C_{15}H_{30}$	cyclopentadecane	aromatic
15		$C_{17}H_{34}O_2$	Pentadecanoic acid	Alkanoic acid
16		$C_8H_{16}O_2$	P – formylbenzoic acid	Aromatic acid
17		$C_{20}H_{26}O_4$	Phthalic acid	Alkanoic acid
18		$C_{25}H_{48}O_2$	15-tetracosenoic acid, methyl ester	ester
19		$C_{23}H_{44}O_2$	13-docosenoic acid, methyl ester	ester
20		$C_{18}H_{36}O2$	9-octadecenoic acid, methyl esther	ester
21		$C_{12}H_{24}$	10-dodecenol	alkanol
22		$C_{22}H_{44}$	1-docosene	aliphatic

Table 2 shows the various components detected by the GC – MS analysis ranging from few aromatics [C_9 – C_{12}], aliphatics [C_{13} – C_{25}], esters and alkanoic acids . This is in conformity with the FTIR analysis described by table 2 and figure 1.

4.0 CONCLUSION:

In this study, the concept of waste management using pyrolysis of waste water sachets was investigated. 50grams of the waste water sachets was pyrolysed and approximately 43grams of the oil was produced which is 86%w/w yield. The pyrolysis oil was analysed and it was evident from the result that it consists of aliphatics, aromatics, esters and alkanoic acids. This oil can be further treated to produce usable fuel which can help in reducing the increasing energy demand by the growing population.

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