PYROLYSIS OF LOW DENSITY POLYETHENE (L.D.P.E) AND ANALYSIS OF ITS BY-PRODUCTS IN COMPARISON WITH JP-4 AVIATION FUEL

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Abstract: *non-biodegradable plastics are the major causes of pollution in the world today, this is a problem that has been frequently recurrent for a very long time.*
*Polyethene is the most common thermoplastic with wide range of application and an average of about 80 million tonnes produced per annum. Its primary use is in packaging (plastic bags, plastic films, geomembranes, containers including bottles) and in Africa it is widely used for packaging drinking water, usually referred to as "**sachet water**" [1].*
This research work focuses on Low Density Polyethene – a grade polymer, its effective management and usefulness when transformed into other products by pyrolysis. In this work, waste polyethene materials were gathered from dumpsites, sterilized and pyrolyzed at different temperatures using a home-made batch reactor and different products were formed at different temperature ranges: 140-190^{o}C, 200-300^{o}C, 300-470^{o}C during the process. The process entails the use of three different samples of polyethene of mass 300g, the sample was pyrolyzed and results were recorded and analyzed. The fuel oil produced from the pyrolysis of waste water sachets can therefore be used in place of JP–4, providing the aviation industry with a cheaper fuel oil from a cheaper source (waste LDPE) than crude oil.
Keywords: *polymer, polyethylene, pyrolysis, fuel, wax.*

ПИРОЛИЗ ПОЛИЭТИЛЕНА НИЗКОЙ ПЛОТНОСТИ (ПЭНП) И АНАЛИЗ ПОБОЧНЫХ ПРОДУКТОВ ПО СРАВНЕНИЮ С АВИАЦИОННЫМ ТОПЛИВОМ JP-4

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Аннотация: *бионеразлагаемые пластики являются основной причиной загрязнения в современном мире, и эта проблема часто повторяется в течение очень долгого времени.*
Полиэтилен является наиболее распространенным термопластом с широким спектром применения и производится в среднем в количестве около 80 миллионов тонн в год. Его основное использование - в качестве упаковки (полиэтиленовые пакеты, пластиковые пленки, геомембраны, контейнеры, включая бутылки). В Африке его широко используют для упаковки питьевой воды, обычно называемой «саше» [1].
Эта научно-исследовательская работа посвящена полиэтилену низкой плотности - качественному полимеру, его эффективному управлению и полезности при превращении в другие продукты путем пиролиза. В этой работе отработанные полиэтиленовые материалы были собраны на свалках, стерилизованы и подвергнуты пиролизу при различных температурах с использованием реактора периодического действия, в ходе процесса были получены различные продукты при различных температурных диапазонах: 140-190 °C, 200-300 °C, 300-470 °C. Процесс предусматривает использование трех разных образцов полиэфира массой 300 г, образец подвергался пиролизу, результаты регистрировались и анализировались. Таким образом, вместо JP-4 можно использовать мазут, полученный в результате пиролиза саше сточных вод, что обеспечивает авиационную промышленность более дешевым мазутом из более дешевого источника (отходы ПЭНП), чем сырая нефть.
Ключевые слова: *полимер, полиэтилен, пиролиз, мазут, воск.*

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INTRODUCTION

The use of polyethene for packaging of goods and products is a trend widely accepted in our world today and this trend bears no end in sight because the distributors of these goods and products find the use of polyethene packaging lighter and cost effective in the overall packaging and distribution of their various outputs. During polyethene packaging, lots of waste polyethene materials are realized and most producers tend to burn them, thereby resulting in the formation of dense fumes which in turn causes air pollution and ozone layer depletion, others retire to the process of burying them in large pits, but for the fact that this plastic is non-biodegradable, they remain underground for years, causing land pollution.

Life would almost be impossible without polyethene because as widely as polyethylene products are used, so also are their spent/used parts/components are found all over the places constituting serious environmental mishap and other related problems, they therefore pose serious environmental problems to inhabitants especially where solid wastes are deposited in towns (urban areas) and villages (rural areas). Urban waste disposal is the responsibility of various municipalities, local government and/or city co-operations [4].

Lots of studies have taken place in the past in order to solve the problem of these waste, The method to be discussed below allows for and easy, cost effective process of converting these waste into useful materials.

POLYETHENE

Polyethene is a polymer made up of the combination of many monomers of ethene (C_2H_4), so most polyethene have a general formula of $(C_2H_4)_n$, with “n” being the number of ethene monomer units contained in the overall polymer [2]. Polyethene is an addition polymer that is created by the polymerization of ethylene monomer units. Ethylene can be polymerized by a radical mechanism under very high pressures and temperatures with the addition of an organic peroxide radical initiator [3]. The process requires a highly purified ethylene feed and the operating pressure ranges from 1000 to 3000 atm and a temperature range of 120-3000C.Temperatures exceeding 3000^{o}C cause ethylene to decompose and are not recommended in practice [2]. Therefore, the development of mathematical models to predict the process behaviour is important to ensure a stable operation, associated with an improvement in the properties of the produced polymer.

MATERIALS NEEDED

- Low density polyethene films (gathered from dumpsites around the city)
- Heater
- Batch reactor
- Thermocouple
- Condenser
- Water at 298K for cooling
- Lagging material to prevent heat loss
- Measuring cylinder
- Weighing balance
- Steel spoon for stirring
- Nitrocellulose thinning

METHOD

1. Low density polyethene material waste was gathered from major dumpsites, these materials were screened washed, dried and cut into smaller sizes. Later, they were soaked in Nitrocellulose thinning in order to remove the labels and other ink related mater on them.
2. 300g of polyethene was weighed and passed into the reactor through the hopper, The hopper was then properly covered. Adequate precautions were put in place to make sure there is no leakage before start of experiment. The heater was then switched on and the pyrolysis continued, until the last drop of oil was noticed in the measuring cylinder. A glass condenser was connected tightly to the reactor to cool the condensing vapour from the reactor. Water at 25^{o}C, connected counter currently was used to cool the vapor. No catalyst was used.
3. The volume of fuel oil produced was observed with respect of time and temperature for the sample.
4. The two major products that were formed after the pyrolysis were: wax and fuel oil
5. The products produced during the pyrolysis were analyzed and some physical and chemical properties were obtained.

RESULTS

Table 1. Products obtained from pyrolysis of LDPE

Temperature (^{o}C)	Mass of waste polyethene (g)	Mass of fuel oil (g)	Mass of wax (g)	Mass of gaseous products (g)	Mass of carbon residue (g)
140-190	293.16	54.90	228.42	9.84	0.00
200-300	289.65	99.84	165.87	23.04	0.00
300-400^{o}C	300	259.5	0.00	5.79	34.68

It is to be noted that the wax was collected in liquid form and required about 20-30 minutes to solidify at room temperature.

Analysis of the fuel oil showed that it contained several polyaromatic molecules with Acenaphthylene being the most abundant. The fuel did contain water or ash and also had zero Sulphur content.

Further analysis of the fuel oil provided its physical properties as follows:

Table 2. Physical properties of fuel oil produced

properties	**quantity**
Density at 15°C	0.77 g/cm^3
specific gravity at 15°C	0.77
Saybolt viscosity at 15°C	>5.38 cSt
Flash point	<26 °C
Pour point	3 °C
Distillation range	45-360 °C
Heat of combustion	2.91 x10^7 KJ/mol
Hydrogen content	14.77 %
Carbon content	85.23 %

Properties of the fuel oil was compared with those of other fuels and it was confirmed that it had major similarities with the JP-4 fuel. JP-4 is a widecut (mixture of gasoline and kerosene) fuel oil that is used by the U.S Air force as aircraft fuels. It is also called jet fuel-4. JP-4 is a colorless to straw-colored liquid. It smells like gasoline and /or kerosene. JP-4 is flammable. Refining kerosene, a petroleum oil or shale oil can make JP-4. JP-4 is a blend of chemical made according to standards specified by the U.S. Air force for each fuel. JP-4 is liquids at room temperature, but can also change into vapor [5].

Table 3. Comparison of produced fuel oil produced with JP-4 aviation fuel

Properties	**Fuel oil**	**JP-4**
Hydrogen content	14.77 %	>13.5 %
Distillation range	45-360 °C	40-270 °C
Physical state	liquid	liquid
Flammability	Flammable at room temperature	Flammable at room temperature
colour	Light yellow	colorless
Density at 15°C	0.77 g/cm^3	0.751-0.802 g/cm^3
API	55	45-57

CONCLUSION:

The pyrolysis of waste low density polyethene waste to produce fuel oil increases with temperature. On the other hand, it was noticed that as temperature increased, the amount of wax produced decreased. The physical properties of the fuel oil produced compared favorably with that of Aviation fuel JP- 4, which shows that the fuel oil can be used in place of JP- 4, which is more expensive than Kerosene. Petroleum products like kerosene, gasoline, diesel oil etc could be obtained by pyrolyzing at lower temperature since the fuel oil produced contains C3 to C38. The effective management of the polythene waste through conversion into further usable products turns the littered surrounding to an environmentally friendly one by preventing outspread of disease and simultaneously creating employment for both skilled and unskilled labour.

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