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Mini Review

Conversion of Agricultural waste plastics into high energy liquid hydrocarbon fuel by thermal degradation

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For worldwide cultivation purposes farmers use numerous plastics. To cultivate watermelon, grapes, pumpkin, cucumber, potatoes, etc. they use polyethylene poly bags or polyethylene sheets. Polyethylene poly bags parts and polyethylene sheets are used to protect Crops from adverse situation such as natural disaster, muddy water and some external parasites insects. After that, the used plastics become a waste and they are non-biodegradable. Most common way to deal with those agricultural waste plastics is landfill/incineration. However this method is not a sustainable solution in the long run, because it will create ecological problems. So the problems of waste agriculture plastics cannot be solved by landfilling/incineration. Because safe depots are expensive and incineration stimulates the growing emission of harmful green house gases for example, NOx, SOx, COx etc.; Natural State Research, Inc. (NSR) can resolve the problems of agricultural waste plastics by converting it into high energy liquid hydrocarbon fuel. Produced fuel can be use alternative of Gasoline, Diesel, Heating oil, and Aviation fuel. To mitigate the present market demand we can substitute the method as a potential source of energy.

Key words: Cultivation, non-biodegradable, parasites, atmosphere, incineration, contamination, conversion, fuel, thermal degradation, agriculture plastic.

INTRODUCTION

The American Environmental Protection Agency (EPA) has struggled to resolve the problems posed by massive amount of waste material produced by feedlots, slaughterhouses, agricultural, food processing factories, etc. Organic waste is generated by the agricultural and food production industries at the rate of billions of tons each year and that's just in the USA. Problems with the disposal of waste sludge from these facilities are receiving a tremendous amount of attention (www.pmcbiotec.com/downloads/agriocultural.pdf). Each year about 550,000 of non-natural wastes are generated on farms in England, of which it is estimated that about 85,000 are waste plastics (http://www.agriculturewasteplastics.org.uk/agri/about.ht ml). Over 90% of holding produce plastic waste, with packaging waste estimated to be about 21000 tons each year and non-packaging plastics waste estimated at about 65,000 tons per year. (http://www.agriculturewasteplastics.org.uk/agri/about.ht ml). Governments around the world have funded hundreds of research projects to find an efficient waste treatment technology to handle this astonishing amount of material. As waste plastic treatment NSR is able to convert those wastes into liquid hydrocarbon fuel and this will be profitable. An agricultural waste plastics is a polymer of High Density Polyethylene (HDPE-2), Low Density Polyethylene (LDPE-4) and imitative of other, consisting of a chain of organic units joined by $-CH_2-$ links. Numerous $-CH_2-$ monomer units are linked together to form long chain hydrocarbon by Polymerization Reaction. Polyethylene including other plastics has enormous use in farmer's field, such Polyethylene's are: watermelon and bread bags, frozen food bags, grocery bags and etc. The Synthesis of Polyethylene can be derived from Ethylene.

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Abbreviations: NSR, Natural state research; **EPA,** environmental protection agency; **HDPE-2,** high density polyethylene; **LDPE-4,** low density polyethylene; **DSC,** differential scanning calorimeter; **EA,** elemental analyzer; **FTIR,** fourier transforms infra-red spectroscopy.

Table 1. Experiment yield percentage calculation.

Production yield (Fuel)(%)	Residue yield (%)	Gas yield (%)
60.46	32.56	6.98

Calculations of table-1 shows that the total experiment yield is 100% (Liquid fuel is 60.46, solid residue is 32.56 and light gas (C_1-C_4) is 6.98.

Polymerization of Ethane into Polyethylene reaction is given below.

Polymerization reaction

$$(CH_2{=}CH_2)\ n\ \ \Delta, \xrightarrow{\text{Polymerization}} \text{-}CH_2\text{-}CH_2\text{-}]\ n$$

(Ethylene) (Polyethylene)

Both high and low density polyethylene has many types of uses in our daily life including various agricultural aspects. Polyethylene is made by polymerization of ethylene. To save fertility of land and restrain environmental balance in the atmosphere waste agricultural plastics need to be cleaned up from the land, otherwise remaining waste plastics in the land is non-rotten able. It makes unsaturated mixture in the soil and turns it into worst and complex blend that inhibit the crops growth which leads to terrible impact in total cultivation process. When the seeds are cultivated in the land with such unsaturated blend, some seeds are seeding on remaining waste polyethylene surface, as a result of this after blooming, the plants soft root fails to go through the soil to complete photosynthesis mechanism due to polyethylene layer and ultimately plants dies due to the lack of glucose. Many of researchers and experts have done lots of research and worked on agricultural waste plastics: thermal degradation process (Aguado et al., 2007; Marcilla et al., 2007), pyrolysis (Cozzani et al., 1997; Marcilla et al., 2008), and the catalytic conversion (Manos et al., 2000).

EXPERIMENTAL

Sample preparation

Agricultural waste plastics samples (watermelon bag, grapes bag, wheat Bag, etc.) NSR used is collected from California, USA. Prior to the experiment each unclean waste agricultural plastics samples were washed, dried and torn manually by scissors.

Sample loading and set- up

NSR carried out the experiment in laboratory scale and inside of labconco protector laboratory fume hood in glass reactor (Chemglass Round Bottom Boiling Flask one neck, KIMAX Brand Liebig Condenser, Heat Mantle and Variac Glascol and Chemglass Round Bottom Boiling Flask 2 neck). To perform the experiment NSR took the volume of the boiling flask which is 1000 ml. Due to experimental purpose we poured 86 g of waste agricultural sample in the boiling flask without any catalyst. Then the boiling flask filled with sample is placed on the heat mantle and then we connected the variac meter with the heat mantle. During experiment also, attached distillation adapter, clump joint, condenser and collection flask with high temperature apiezon grease. Subsequently, to measure electricity consumption electricity logger was connected.

Condensation process

When the experiment started the variac percent was 70 (315ºC) for quick melting, after the sample melted the variac percent is decreased to 50 (225ºC) due to smoke formation. The average (optimum) used variac percent in this experiment is 70 (315ºC). Gradually, temperature contour was maintained by variac meter, with proper monitoring. Produced vapor travel through the condenser, due to cooling water, the vapor turns into liquid fuel and confirmed that the condensation process has been completed properly. The process performed without used any vacuum, chemical or catalysts.

Fuel calculation and residue collection

The complete process took about 2 h and 36 min and the electricity used is about 0.346 kWh. Based on our laboratory scale, 1gallon of fuel production purposed electricity used 13.3 kWh and 1 Metric Ton of agricultural waste plastics total electricity would be 4030.30 kWh. The obtained fuel is 52 g that is 69 ml and derived density is 0.76 g/ml that is compared to gasoline fuel and it has burning properties. At the end of the state we cooled down the experiment and collected the ash type carbon residue 28 g from the boiling flask for further analysis. This residue will be less when NSR will go for commercialization plant.

If NSR proceed further fractional distillation process of the produced fuel, the probable product would be Aviation, Naphtha, Diesel and Fuel oil. Ultimately, without having any problem, NSR technology can convert all of agriculture sample into liquid hydrocarbon fuel. The materials of liquid Hydrocarbon fuel are concluded by hydrocarbon functional group analysis by FT-IR data. Fuel Production, Residue and Gas Yield Percentages are given below in Table 1. NSR laboratory scale one gallon production cost is $1.46; While NSR will go commercialization plant cost will be less than dollar (Table 2).

RESULTS AND DISCUSSION

Fuel characterization by fourier transforms infra-red spectroscopy (FTIR analysis)

Agricultural watermelon plastics fuel was analyzed by FTIR Spectrum - 100 (Fourier Transform Infra- Red

Table 2. Comparison data with agriculture waste plastic to fuel and other fuel production cost.

Feedstock	Fuel name	Commercial cost /gallon ($)	NSR Lab scale/ gallon ($)
Mineral	Diesel	2.45	-
Sugar cane	Bio-fuel	1.9	-
Agriculture plastic	Liquid fuel	-	1.46

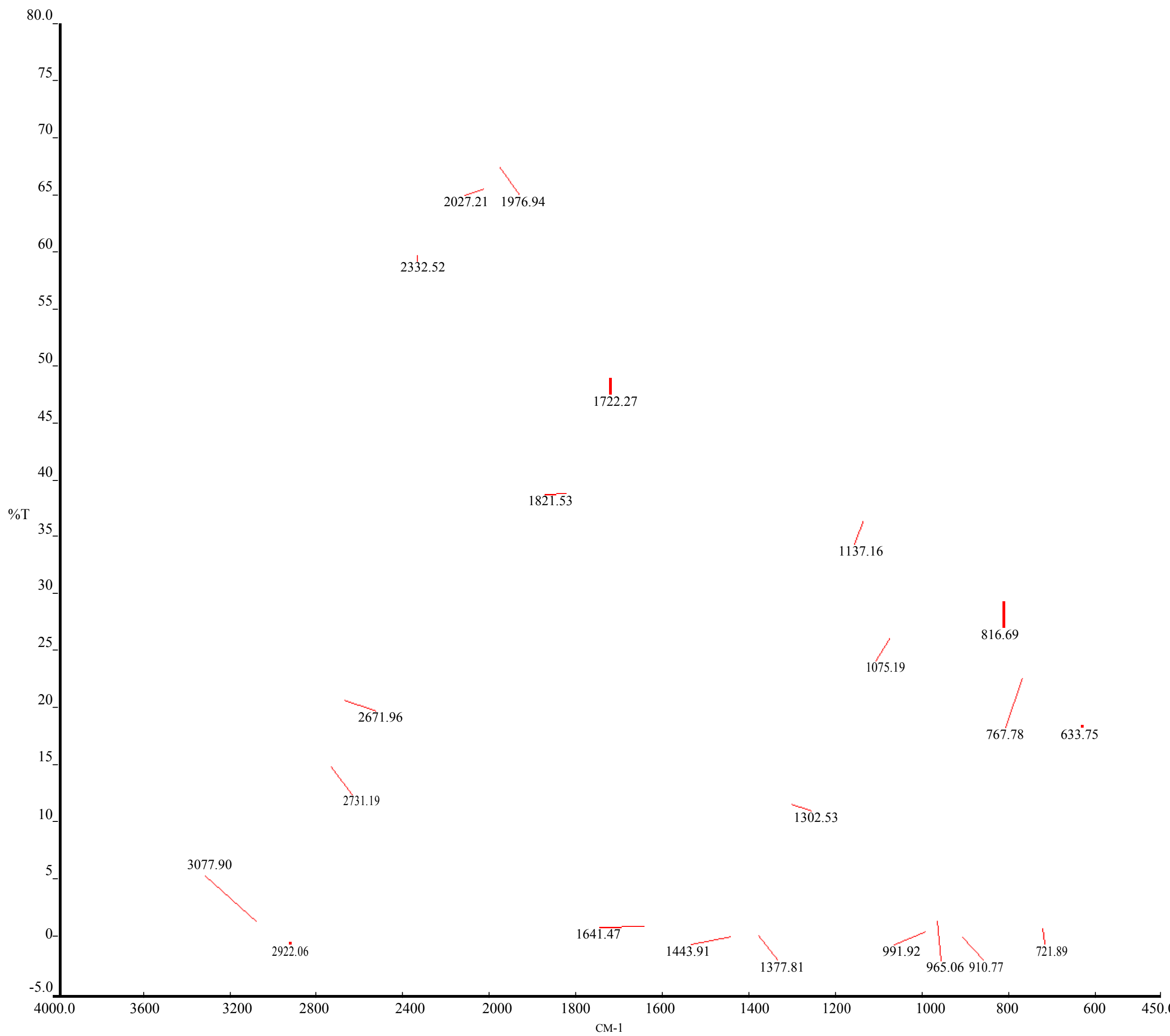

Figure 1. FT-IR spectrum of agricultural watermelon plastic fuel.

Spectroscopy). FTIR analysis indicated the following types of functional groups are present into liquid fuel; such groups are: H bonded NH, CH_2, C-CH_3, Non-conjugated, CH_3,-CH=CH_2, -CH=CH- (trans) and -CH=CH- (cis) etc. (Figure 1). By FTIR analysis we calculated energy of each spectrum band functional group. In the functional group H bonded NH the energy is 6.11×10^{-20} J; functional group C-CH_3, the energy is 5.80×10^{-20} J and in Non-conjugated the energy is 3.6×10^{-20} joule. Also in functional group CH_3, the energy is 2.87×10^{-20} J and the functional group -CH=CH_2, the energy is 1.97×10^{-20} Joule. In the functional group -CH=CH- (trans) the energy is 1.93×10^{-20} J and in functional group -CH=CH- (cis) the energy is 1.91×10^{-20} J. In FTIR library search found out that the following compounds are present in Agricultural watermelon waste plastics fuel. 0.394 F06640 4-Amino - Acetaphenone, 0.393 F37460 2, 5-Dihydroxy Acetaphenone, 0.302 F00508 Ethyl

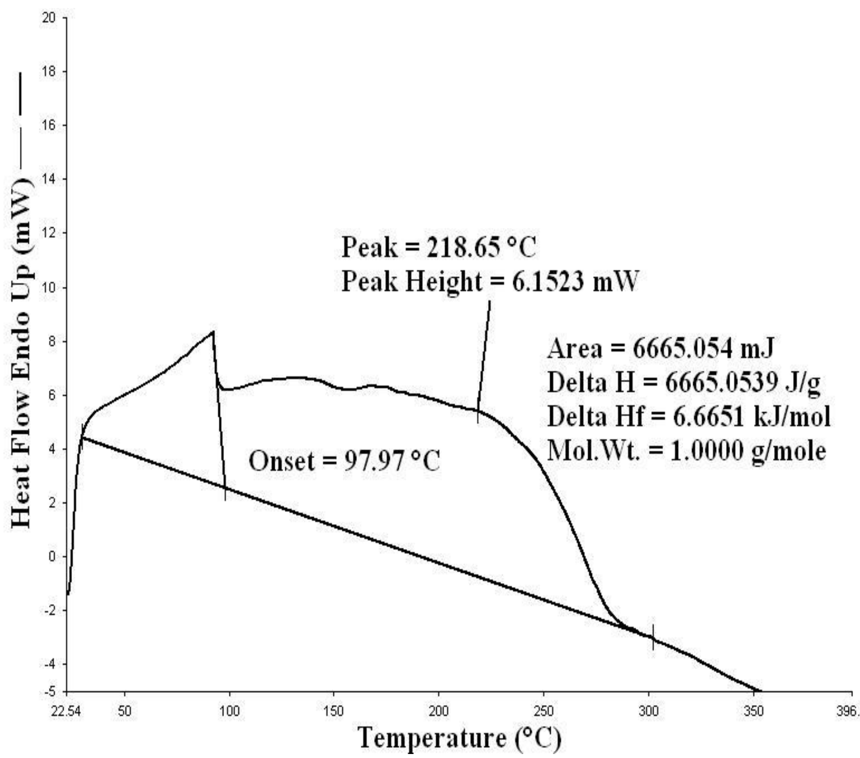

Figure 2. DSC graph of agriculture watermelon plastic fuel.

Table 3. Elemental analyzer data for residue analysis.

Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulfur (%)
48.26	6.85	0.04	1.11

Acetohydroxamate, 0.272 F54150 2-Hydroxy Acetaphenone, 0.260 F65470 3-Methyl Acetophenone, 0.249 F22850 4- Chloro Acetophenone 0.245 F91080 Trichloro Acetonitrile, 0.236 F65155 2- Methoxy Phenyl Acetonitrile, 0.220 F80072 BIS (3, 5, 5-Trimethyl Hexyl) Phthalate, 0.214 F35038 1, 1-Dichloro Acetone.

Fuel characterization by differential scanning calorimeter (DSC analysis)

Agricultural watermelon waste plastics fuel ran by Differential Scanning Calorimeter (DSC). From DSC analysis we found onset temperature is 97.97°C (Figure 2). Onset temperature represents boiling point of the fuel and at this point derived compound is Heptane (C_7H_{16}) with Molecular Weigh of 100.21 g/mole, and the density is 0.683 g/mole with flash point -4°C. (Reference**:** Hydrocarbon Standard Data Table).

DSC Graph postulates the following items (Figure 2): Peak = 218.65°C, Peak Height = 6.1523 Mw, Area = 6665.0539 mJ, Delta H = 6.6651 kJ/mol, Mol.Wt. = 1.000 g/mol

Residue characterization by elemental analyzer (EA-2400)

California Waste Watermelon plastics sample solid residue ran by Elemental Analyzer (EA-2400). From EA-2400 result found the following composition of Carbon and Hydrogen ratio as well as Sulfur and Nitrogen availability as a trace quantity that can be ignorable.

EA-2400 data table (residue)

From EA-2400 (CHNS Mode) residue analysis data shown (Table 3), we noticed that Carbon and Hydrogen percentages are only 48.26 and 6.85%, respectively and other impurities under consideration. During fuel production period 6.98% light gas produced and NSR did not analyzed yet is under consideration.

Conclusion

The conversion of agricultural waste plastics to liquid hydrocarbon fuel was carried out in thermal degradation process and in absence of a catalyst. NSR executed the experiment by washing out agricultural waste plastics. Experiment procedures are followed by NSR's own process. By utilizing NSR's technology can solve all agricultural waste plastics problems by saving environment, landfill cost, etc. The produced fuel from agricultural waste plastics can be used as feedstock of refinery because it has high content of energy value or can be produce electricity.

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