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Review on Thermal Pyrolysis of Waste Plastic in to Liquid Fuel

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ABSTRACT

Recycling of waste plastics and other packaging materials is becoming more necessary since they represent a readily available source of fuels and/or chemicals and a growing disposal problem. One way of accomplishing such recycling is to convert these waste polymers into transportation fuels by thermal and/or catalytic processing. In recent work thermal processing was found to be easily accomplished. However, the products were not of sufficiently high quality to be used as transportation fuels without extensive upgrading. Waste materials from the U.S. (American Plastics Council) and Germany (Duals System Deutschland or DSD) were processed by hydro cracking, Commercial catalysts, KC-2001 and KC-2600 were used in hydro cracking experiments using 27 ml tubing reactors. Effects of reaction temperature, hydrogen pressure, and reaction time on product yields and quality were studied. The liquid products were subjected to detailed analysis by GC, GCiMS, and TGMS. Possible reaction mechanisms will be proposed based on the analytical data. Other bi-functional catalysts developed in our laboratory were also tested and results will be compared with those obtained using the mentioned commercial catalysts.

1. INTRODUCTION

Conversion of waste plastic to clean liquid fuels has been widely studied all over the world recently. Most bench scale and pilot plant studies employed two-stage processes, in the first stage, plastic is thermally degraded to crude oil-like liquid products, and the liquids are subjected to further catalytic cracking to produce gasoline-like products in the second stage. This process may be more costly than a single stage processing, is., direct conversion of waste plastic to gasoline-like products. The challenge of the latter is to utilize high efficiency catalysts. Pure polymers, such as high density polyethylene, polypropylene, polystyrene, etc., are different than compounds are believed to be poisonous to some catalysts which were effective in cracking pure polymers. Therefore, a catalyst with not only hydro cracking-hydrogenation ability, but also hydro de nitrogenation -hydro desulfurization function is needed for directly converting waste plastics to clean liquid fuels.

In Maharashtra from all 26 municipal corporations about 15000 to 18000 MT Municipal Solid Waste is generated per day. Out of which on an average 7-8% contribution is of plastic. Mumbai, Pune and Thane contribute more than 50% to total MSW. Though the percentage of Plastic MSW is less, it is so harmful due to its decomposition period of several million years. Indiscriminate littering of unskilled recycling/reprocessing and non-biodegradability of Plastic waste raises the following environmental issues:

- Indiscriminate dumping of plastic waste on land makes the land infertile due to its barrier properties.
- Lead and Cadmium pigments, commonly used in LDPE, HDPE and PP as additives are toxic and are known to leach out.
- During polymerization process fugitive emissions are released.
- During product manufacturing various types of gases are released.
- Non-recyclable plastic wastes such as multilayer, metalized pouches and other thermo set plastic poses disposal problems.
- Sub-standard plastic carry bags, packaging films (<40µ) etc. pose problem in collection and recycling.
- Burning of plastics generates toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1, 3-butadiene, CCl4, and Acetaldehyde.
- Littered plastics give anaesthetic look in the city, choke the drain and may cause flood during monsoon.
- Recycling industries operating in non-conforming areas are posing threat to environment to unsound recycling practices.

2. PYROLYSIS PLANT

Pyrolysis plant is an industry that converts waste plastic & tires into Pyrolysis Oil, Carbon Black & Hydrocarbon Gas. End products are used as industrial fuels for producing heat, steam or electricity. Pyrolysis plant is also known as: Pyrolysis unit, plastic to fuel industry, tire to fuel industry, plastic and tire recycling unit etc.

Pyrolysis plant falls under following categories of industrial projects:

- Waste to energy project
- Waste plastic and tire pollution control equipment
- Renewable energy project
- Petrochemical

We establish large scale Pyrolysis plants on turnkey basis (View photos). The total turnkey supply includes of machinery designing & simulation, equipment manufacturing, supply, installation, commissioning, technology transfer and operational training. We are one of the prominent leaders in establishing Pyrolysis plants on turnkey basis.

3. METHODOLOGY

3.1 Extraction of oil from waste plastic

Plastics are shredded and then heated in an oxygen free reactor 1 & 2 (known as Pyrolysis) to about 400°C. As the plastic boils, gas is separated out and often reused to fuel the machine itself. The fuel is then distilled and filtered, because the entire process takes place inside a vacuum and the plastic is melted not burned minimal to no resultant toxins are released in to the air as all the gases and or sludge aw reused to fuel the machine.

Impact of type of Plastics that can be used

- Burn pure hydrocarbons such as PP,PE will produce a fuel that burns fairly clean, & burn PVC and large amount of chlorine will corrode the reactors and pollute the environment.
- Burning PETE releases oxygen in to the oxygen deprived chamber there by slowing the processing and PETE recycles efficiently at recycling centers

It is best to recycle PETE traditionally. HDPE (jugs) and LDPE (bags and films) are basically PE, so usable as fuel as well, just slightly more polluting as thicker heavier fuel is created. But additional processing can turn even HDPE into clean fuel.

4. LITERATURE REVIEW

Hiroyuki Fujimura [2]: The US patent 6,902,711 B1 mentioned to provide a method and apparatus for treating wastes by gasification. This can recover and resources of the wastes open up a road to separation and reuse of the resources. This is also can produce synthesis gas having desired components for the use synthesis of ammonia (NH3) by partial combustion. Solving various problems caused by incineration or dumping of organic wastes, and obtain low cost hydrogen (H2) which is used for synthesis of MMONI. The apparatus contains of: (a) a fluidized bed reactor for partially combusting wastes at a temperature of from 450°C to 650°C;(b) a combustor that separated from fluidized bed reactor and operable at a temperature sufficient to melt an ash content of char, for receiving the gaseous material and the char from outlet of fluidized bed reactor and for gasifying the gaseous material and the char to form synthesis gas; (c) a cooler to cool the synthesis gas to form cooled synthesis gas;(d) a CO converter to receive the cooled H2 and CO2;(e) a separator to separate H2 from the CO2. In this patent, does not mention the amount of synthesis gas that can be produced.

Hans-Ulrich Dummersdorf, Helmut Waldmann [3]: According to US patent 5,369,947 the high energy content of mixed plastic waste of any composition could be efficiently converted into power in the form of electricity. At the same time, it would enable the plastic waste to be disposed of completely and safely without any formation pollutants. It would be saved a high percentage of fossil raw materials to preserve raw material resources and the environment. Thus problem has been solved by coupling a plasma Pyrolysis process with a combines gas or steam turbine processes, so that both processes together in their coupled form represent a

highly effective "plastic-driven power generator". The plastic waste is reacted in a plasma reactor under reducing conditions in plasma containing sub-stoichiometric oxygen at temperatures above 1200°C to form a plasma Pyrolysis gas consisting of low molecular weight carbon fragments which is then cooled to temperature below 1500°C. It is then delivered in compressed form as a fuel of high calorific value and high temperature to a gas turbine for generating power. The waste heat of this gas turbine is used to generate steam which is fed into a steam turbine for generating more power. The calorific value of this gas is 37,000 kJ/m3. The process of apparatus on this patent is too complex. It needs reacting the plastic waste in a plasma reactor (temperature of >1200°C), cooling it (temperature of <1500°C), compressing it (pressure of > 10 bar). It needs a steady state cycle. If the pressure is less than 10 bar, it would not be produces the heat and if it is more the max pressure standards (which is not mentioned in the patent), it will blow up the apparatus.

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