Thermal and Catalytic Cracking of Plastic Wastes into Hydrocarbon Fuels

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Abstract: The objective of this work is to convert plastic wastes to hydrocarbon fuel using thermal and catalytic cracking. The performance of Nano-catalysts from Bentonite has been compared to bulk catalysts. Plastic wastes are a big environmental problem because these materials are not biodegradable. This study offers solutions to the environmental problem. Plastic wastes will be converted into a source of energy. Different types of plastic wastes, for instance polyethylene, polypropylene and a mixture of them, have been studied and the results are evaluated. This study shows that the catalytic cracking of a mixture of polyethylene (PE) and polypropylene (PP) in the presence of a Nano catalyst (Bentonite) yielded a higher percentage of gasoline range is 83.5 %.

Keywords: Catalytic cracking, plastic wastes, Nano catalyst.

1. INTRODUCTION

Plastic wastes keep increasing around the world. This represents a threat to the environment due to their enormous quantity. However, plastic wastes are non-biodegradable, such as organic wastes hence the most widely methods for the disposal of municipal solid wastes is landfilling. An alternative method for the disposal of plastic wastes is incineration where wastes burnt to extract the chemical heat energy [1].

Other disposal methods have been suggested by different researchers, one of them are the conversion of plastic wastes to fuels by the pyrolysis process [2-14], where other illustrated the possibility of converting municipal solid waste (MSW) to liquid hydrocarbon products by catalytic cracking [15-23], there was likewise a novel method for updating the hydrocarbon fluid to enhance the quality [24-25]. Other methods produce liquid fuel oils from Catalytic coprocessing of plastic wastes and petroleum residue [26]. Others performed synthetic diesel fuel from polyethylene thermolysis [27], and another showed the impact utilizing a different Zeolite catalyst in Catalytic cracking of High-Density Polyethylene [28-30].

The aim of this work is studied recycling of plastic wastes to useful hydrocarbon liquid fuel in a batch reactor using Nano materials as catalyst. And identify the role of the external catalytic surface on overall cracking reactions to obtain high gasoline range.

2. MATERIALS AND METHODS

A. Materials:

Plastic wastes have been used in this work are plastic bags and plastic bottles. Which were collected from the garbage of houses and shops.

These materials are collected, sorted and crushed. Further, the materials were washed and dried. Bentonite Nano materials have been used as a catalyst.

B. Procedures:

Plastic wastes are collected and prepared by cutting the plastic into small pieces to facilitate the process of cracking during heating. Then are fed to batch reactor in appropriate loadings, Nano materials is added to reaction medium, the reactor is closed tightly to prevent the emission of any fumes. Heating plastic is continued till the last drop of fuel oil collected in the collection beaker. The vapor out from reactor passing through the condenser and after cooling the vapor it condensed to liquid fuel oil.

C. Analytical Method:

Gas chromatography/mass spectrometry (GC/MS) apparatus was used for analysis of the composition of fuel hydrocarbon products.

These hydrocarbons are similar to that exist in the gasoline range. Such as:
Table 1: List of components which in gasoline range

<table>
<thead>
<tr>
<th>List of components which in gasoline range:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclopentane, ethylidene-</td>
</tr>
<tr>
<td>1-Octene</td>
</tr>
<tr>
<td>Cyclohexene, 1,2-dimethyl-</td>
</tr>
<tr>
<td>Cyclopentene, 1-(1-methyllethyl)-</td>
</tr>
<tr>
<td>1-Nonene</td>
</tr>
<tr>
<td>Cyclohexane, cyclopropyl-</td>
</tr>
<tr>
<td>cis-2-Nonene</td>
</tr>
<tr>
<td>Cyclohexane, propyl-</td>
</tr>
<tr>
<td>1,9-Decadiene</td>
</tr>
<tr>
<td>1-Decene</td>
</tr>
<tr>
<td>Cyclopentane, 1,2-dimethyl-3-(1-methyllethyl)-</td>
</tr>
<tr>
<td>1,11-Dodecadiene</td>
</tr>
<tr>
<td>1-Undecene</td>
</tr>
<tr>
<td>Cyclohexane, penty1-</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

Experiments were performed with different types of wastes (plastic bags, plastic bottles) with different techniques thermal and catalytic cracking. In the present and absence of catalyst. As shown in the following figures:

A. Cracking of plastic bags in the presence of a bulk catalyst (Bentonite):

- As shown in this Fig. The peak appears 1.0% catalyst/feed at which gasoline yield is 71.46%, followed by decreasing down to 1.5% catalyst/feed at gasoline yield is 44.8%. Then increases gradually up to 61.74% gasoline at 3% catalyst/feed.
- It is well known increasing the catalyst (Bentonite) loading lead to increasing the breaking down of the molecular chains because of at high temperature the carbon-carbon bond breaks down under the effect of temperature and catalyst.

![Fig.1](image)

- However, at higher catalyst (Bentonite) content Specifically, at 1.7% the yield of gasoline decreases, which can be explained due to the formation of larger molecules of coke on the surface of the catalyst. Contradically at higher loading of Bentonite, again the recovery gasoline increases at 3% catalyst/feed because the compensation of extra Bentonite which leads to breaking more c-c bonds within the range of gasoline.
- The best result of the percentage of gasoline is 71.46% at the 1% catalyst/feed.

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B. Cracking of plastic bags in the presence of Nano catalyst (Bentonite):

- In Fig. 2 the percentage of gasoline range is plotted versus catalyst/feed % loadings. As shown in this figure. The peak appears at 1.5% catalyst/feed at which gasoline yield is 34.72%, followed by increasing to 60.25% gasoline at 2% catalyst/feed. Then decreasing down to 47.25% gasoline at 3% catalyst/feed.

![Fig. 2](image)

- The effect of Nano catalyst starts from 1.5% catalyst/feed, The peak reach to the maximum at 2% catalyst/feed. High surface area of catalyst leads to breaking down of C-C bonds from which we combined more gasoline with a gasoline range, higher than 2% catalyst/feed the gasoline percentage decreased because higher loading of Nano catalyst, some of catalyst statistically accumulated that we can find the effect decreases at 3%.

- The best result of the gasoline percentage is 60.25% of Nano 2% catalyst/feed.

C. Cracking of a mixture of (plastic bags, plastic bottles) in the absence of a catalyst:

- In Figure 3 the percentage of gasoline range is plotted versus mass of bottles loadings. As shown in this fig. The peak appears at 5 g at which gasoline yield is 33.84%, followed by increasing to 65.51% gasoline at 10 g. Then decreasing down to 18.88% gasoline at 15 g then almost constant at 20 g. Increasing the mass of bottles the gasoline % increases up to limit until the mass of bottles is 10 g then decreasing sharply with increasing the mass of bottles.

![Fig. 3](image)

- The best results of the gasoline percentage are 65.51% of the mass of bottles plastic is 10 g.

D. Cracking of mixture of (bags, plastic bottles) in the presence of Nano catalyst (Bentonite) by [Chemical method (sol-gel)]:

- As shown in this figure the peak appears at 1% catalyst/feed at which gasoline yield is 17.47%, followed by sharply increasing to 64.2% gasoline at 2.5% catalyst/feed.
Nano catalyst (by the sol-gel method) does as very good inspirational which increasing the surface area of catalyst this lead to increasing the gasoline range.

**E. Cracking of a mixture of (plastic bags, plastic bottles) In the presence of Nano catalyst(Bentonite) by [ultra sonic method]:**

- In Fig.5 the percentage of gasoline range is plotted versus catalyst/feed % loadings.
- As shown in this figure the peak appears at 0.5% catalyst/feed at which gasoline yield is 83.5 %, followed sharply decreasing to 41.3 % gasoline at 2% catalyst/feed.

4. **Conclusions**

The results reported in this work show that used bulk catalyst (Bentonite) for Cracking of plastic bags yielded 71.46% gasoline comparing to using Nono catalyst(Bentonite) which yielded 60.25% gasoline. We have been prepared Nano catalyst (Bentonite) from local raw material by different two methods sol-gel and ultrasonic methods, the study has been investigated that the catalytic cracking of a mixture of bags and plastic bottles in the presence of Nano catalyst by ultra-sonic method yielded higher percentages of gasoline range than which used by the sol-gel method.

**REFERENCES**


