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FUEL PRODUCED FROM CATALYTIC PYROLYSIS OF WASTE PLASTIC

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ملخص

يعتبر تحويل النفايات البلاستيكية إلى وقود من الحلول القيمة لتقليل كميات النفايات المتراكمة وقد تساهم في حل أزمة الوقود ، في هذه الدارسة تم جمع خليط من أنواع مختلفة للنفايات البلاستيكية من محافظة الفيوم - جمهورية مصر العربية تم غسلها والمعاملة بدرجات حرارة مختلفة مع استخدام عوامل حافزة لتقليل الوقود المستخدم لإسالة البلاستيك ، وأخيراً تم دراسة النسبة المئوية لكلاً من المادة السائلة ، الغازية ، الصلبة .

Abstract

Converting waste plastic into fuel is proposed as a Valuable solution for waste minization. Thus, crises of waste plastic and fuel shortage in Egypt are being solved. In this study, mixture of waste plastics (MP), Polypropylene (PP), Polystyrene (PS), Polyethylene (PE), Polyethylene Terephthalate (PET) and Polyvinyl Chloride (PVC) were collected from daily using of people in Fayoum city, Egypt. The collected MP washed pyrolyzed at different temperatures until maximum without catalyst and in presence of catalyst such as Aluminosilicate, mesostructured (Hexagonal) compared to natural zeolite. Finally, we studied the percentage of liquid, gas and solid fuel yield.

1. Introduction

Plastic is a polymer with high molecular weight which invented in 1962 by Alexander Parkes [1] and the term polymer means the unit of molecule repeated many times as PP. The number of repeating unit represented in brackets with a subscript [2]. One of the most commonly used materials in daily life is plastic, it has different classification according to chemical structure, density and synthesis. Society of Plastic Industry (SPI) divides plastics into seven groups based on the chemical structure and applications [3]. HDPE (High Density Polyethylene), LDPE (Low Density Polyethylene), PVC, PET, PP, PS and other. The production of plastic in the world has been rising up from 1.5 Mt in 1950 to 260 Mt in 2007 [4]. The major problem of plastic is the disposal of the waste plastic and another problem is that plastics are produced from non-sustainable oil or coal so it is a non-sustainable product [5,6]. The most important point of research nowadays is how waste plastics can be recycled and one of these methods is pyrolysis. This process is thermal cracking of large molecular weight polymers into small molecular weight one [7-10]. Some traditional treatments such as gasification and bioconversion are mainly used for organic materials and landfills or incineration although these methods are not safe completely [11]. Hydrocarbons are consisting of carbons and hydrogen. However, HDPE, LDPE, PP, PE and PS are similar to hydrocarbon fuels such as liquefied petroleum gas (LPG), petrol and diesel [12-14].The thermal cracking process is characterized by low costs and simple operation, but the high energy consumption and the low conversion efficiency and yield have seriously hampered its development. In order to improve the quality and yield of liquid fuel, great efforts have been made by many researchers by introducing suitable catalysts to improve the quality of pyrolysis products in many existing equipment [15-37]. That equipment with catalysts has some weakness Such as long material resistance time, undesired contact between plastics and catalysts, high heat transfer rate and cost of the catalysts

[38]. In this study, the pyrolysis of waste plastics collected from city in a developing country like Egypt was studied. The effect of natural zeolites was compared with a commercial catalyst.

2. Materials and Method

Plastics used in this research were waste plastic PET of Pepsi and Coca-cola bottles, PVC of oil bottles, LDPE of plastic bags and PE and PS of yogurt plastic cups. All of these plastics were collected from daily using of people in Fayoum city, Egypt. At the beginning, the bottles were dried and chopped into small pieces. For the pyrolysis process, amount of plastic pieces were then put into the reactor. so structured aluminosilicate was obtained from Sigma Aldrich. It has linear formula $(SiO2)x(Al2O3)y$ and aluminum composition is 3%, the unit cell size is 4.6-4.8 nm and the surface area in the powder form is 940-1000m2/g. The natural zeolite was heated up to 400 ºC for 5 hours to remove all volatile substances. The same experiment was carried out three times for the same amount of MP, one of them is thermally without any catalyst, the second was catalytically using Aluminosilicate and the third was catalytically using natural zeolite. In the first experiment, MP were fed into the reactor and heated up to 550ºC inside the gas heated reactor the MP had melted and their carbon chain cracked into fragments with lower molecular weights, at the end, the gas fractions were collected in air bag then analyzed and the liquid fractions were collected then analyzed. In the second and third experiment MP were mixed with the catalyst then that mixture was fed in the reactor and at the end, the catalyst was separated from bottom by filtration. The collected gases and liquids were analyzed by gas chromatography-mass spectrometry (GC-MS, QP2010S Shimadzu).

MP was cracked at different temperatures of 500ºC, 525ºC and 550ºC. For catalytic pyrolysis the catalysts used were Aluminosilicate, mesostructured (Hexagonal) and natural zeolite. The experiments were carried out using different MP to catalyst ratios of 1:1, 2:1, 3:1 and 4:1. All these ratios required different temperature conditions and different time ranges.

3. Results and discussions

Pyrolysis of MP without using any catalyst yielded good amount of liquid product, moderate amount of gas product and small amount of solid product (Fig.1).

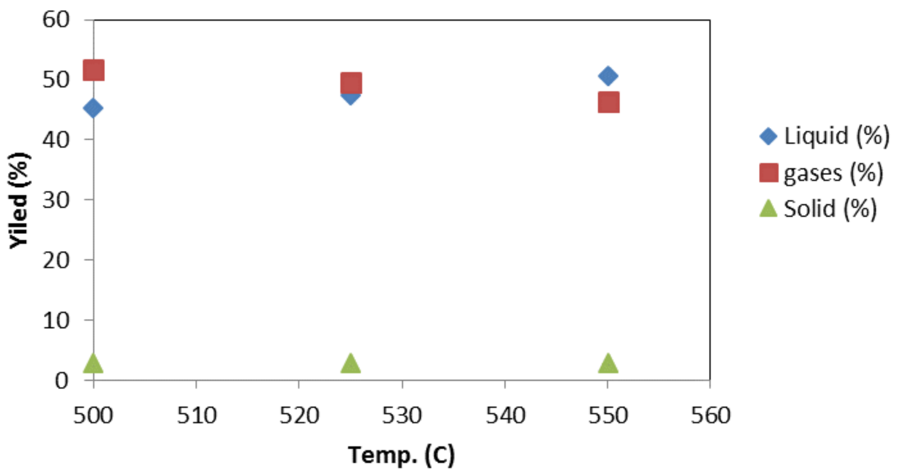

Fig. (4.1): Effect of pyrolysis temperatures on the produced fuel yields.

The operating parameters that were identified as being the most effective and relatively easy to control were the MP to catalyst ratio, temperature, time required for conversion. In the sequel, we present the main know-how obtained in operating the conversion reactor. The study was conducted over different operational conditions: total cycle time, MP to catalyst ratio and temperature. The primary objective of these cycles was to study the optimization conditions for adapting the reaction for enhanced conversion. The table of cyclic process applied is shown below:

Table 1:The reactor cycle definition indicating, MP to catalyst ratio, time, temperature and the yield percentage of products.

Cycle	Catalyst	MP (%)	Catalyst (%)	Ratio (R)	Time	Temp.	Liquid yield (%)	Gas yield (%)	Solid yield (%)
1	Alumino-silicate	80	20	4	10	550	55.3	41.6	3.1
2		75	25	3	15	525	80.4	16.8	2.8
3		66.6	33.3	2	20	500	65.1	31.9	3
4		50	50	1	30	450	56.4	40.2	3.4
5	Natural zeolite	80	20	4	10	550	55.3	41.6	3.1
6		75	25	3	15	525	58.6	38.2	3.2
7		66.6	33.3	2	20	500	61.4	35.3	3.3
8		50	50	1	30	450	82.5	14.3	3.2

A proper design of the time cycle is necessary, as shown in Table (1), pyrolysis of MP using catalyst yielded good amount of liquid product, moderate amount of gas product and small amount of solid product. The reaction products are resulted of changing conditions and consequently, they represent different mixtures of liquid, solid and gaseous products percentages. It is remarkable to note that high degree of conversion occurred in cycle 2 and 8, as react period increases, there is more time for the reaction, conversion is higher in the case that has more reaction time as in case of cycle 8. However, cycle 8 was the best liquid yield, while cycles 1 and 5 were the highest gas while the solid yield percentage was almost the same amount in all cycles. In case of using natural zeolite as a catalyst, the results showed that, at the highest temperature (550), the value of the gas produced was the highest percentage because cracking more plastic at this high temperature while the residue of solid and liquid left was low and moderate, respectively. Natural zeolite represent better results than aluminsilcate liquid product. The quality of product obtained was also better in case of catalytic pyrolysis.

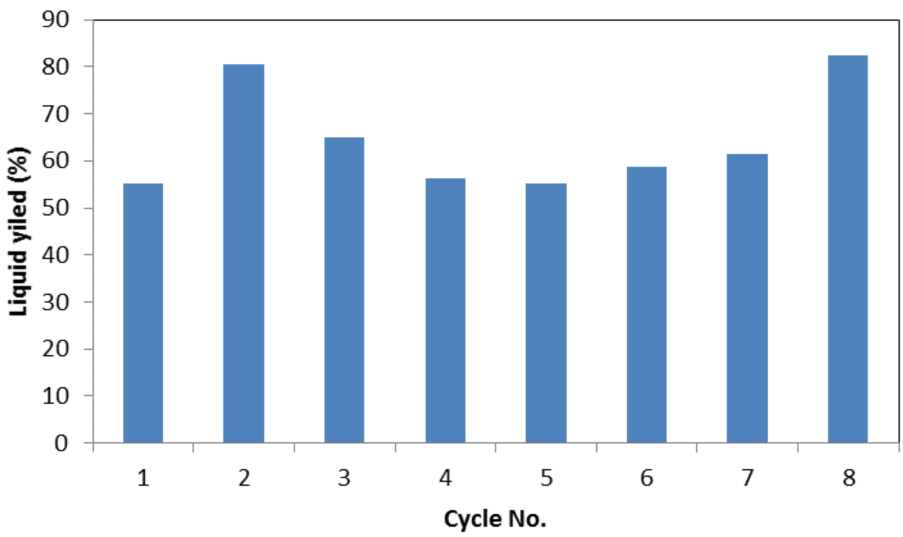

Fig. (2). Liquid yields at different cycles

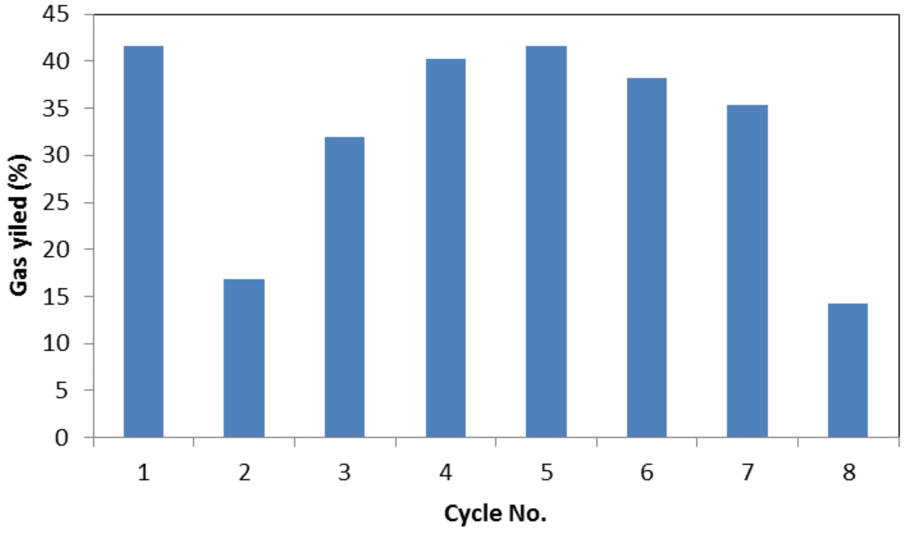

Fig. (3): Gas yields at different cycles.

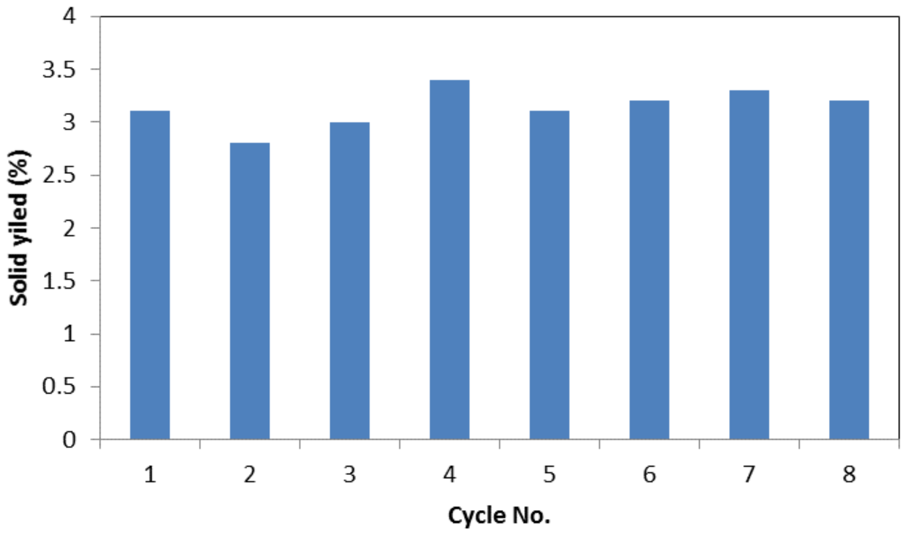

Fig. (4): Solid yields at different cycles.

4. Conclusion

Under the approach of recycling waste plastics by their Catalytic Pyrolysis, the conversion of allowed to determine a specific contribution in waste management. By converting plastics to fuel, we solve problems of fuel shortage and pollution. By taking into account that low-cost production process, it would be a great support to our economy. From the above results it can conclude that the fuel obtained from waste plastics present promise solution for both the environment and economy and more studies on this topic should be considered.

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