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CHEMICAL RECOVERY FROM POLYSTYRENE AND LOW DENSITY POLYETHYLENE VIA CONVENTIONAL PYROLYSIS

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Keywords

Plastic waste management
LDPE
PS
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Green chemical production

Abstract

In Turkey, plastics have formed 5-14 % of total solid wastes. Plastic sources have been classified as thermoplastic and thermosets. Thermoplastics which covers Polyethylene (PE), Polystyrene (PS), Polypropylene (PP), Polyethylene terephthalate (PET) and Polyvinyl chloride (PVC) can be recycled by using mechanical recycling, energy recovery and chemical recovery routes. Pyrolysis as a chemical recovery technique is important to produce invaluable chemicals in high yields. In this study, it was aimed to obtain hydrocarbons from PS and Low density Polyethylene (LDPE) via pyrolysis. Product yields were calculated and liquid products were analyzed via GC-MS. In the light of the results, it was deduced that 520 ^{0}C and 570 ^{0}C were the suitable temperatures to obtain the liquid product with maximum yields for LDPE and PS respectively. That temperature was found for LDPE and PS co-pyrolysis as 570 ^{0}C. It was determined that Benzene-Toluene-Ethyl Benzene (BTE) fraction amount increased from 5 % to 6.4 % with LDPE adding in the feed for almost same liquid product yields of PS (88%) and LDPE/PS (84 %). In addition, it was obtained the pyrolytic liquid which comprised of wholly alkanes and alkenes for LDPE with 70 % product yield.

GELENEKSEL PİROLİZ İLE DÜŞÜK YOĞUNLUKLU POLİETİLEN VE POLİSTİRENDEN KİMYASAL GERİ KAZANIMI

Anahtar Kelimeler

Plastik atık yönetimi
AYPE
PS
Eş-piroliz
Yeşil kimyasal üretimi

Öz

Plastikler Türkiye'deki toplam katı atıkların %5-14'ünü oluşturmaktadır. Plastik kaynakları termoplastik ve termosetler olarak sınıflandırılmaktadırlar. Polietilen (PE), Polistiren (PS), Polipropilen (PP), Polietilen Tereftalat (PET) ve Polivinil Klorürü (PVC) kapsayan Termoplastikler, mekanik geri kazanım, enerji geri kazanımı ve kimyasal geri kazanımı yöntemleri kullanılarak geri kazanılabilirler. Bir kimyasal geri kazanımı tekniği olan piroliz, yüksek verimlerde değerli kimyasalları üretmek için önem taşımaktadır.Bu çalışmada, piroliz vasıtasıyla PS ve Alçak Yoğunluklu Polietilen (AYPE)'den hidrokarbonlar elde etmek amaçlanmıştır. Ürün verimleri hesaplanmış ve sıvı ürünler GC-MS aracılığıyla analizlenmiştir. Sonuçlar göz önüne alındığında, AYPE ve PS için sırasıyla 520 ^{0}C ve 570 ^{0}C'nin maksimum verimlerle sıvı ürün eldesi için uygun sıcaklıklar olduğu çıkarımı yapılmıştır. Bu sıcaklık, AYPE ve PS eş-pirolizi için 570 ^{0}C olarak bulunmuştur. Benzen-Toluen-Etil Benzen (BTE) fraksiyon miktarının beslemeye AYPE eklenmesiyle, PS (%88) ve AYPE/PS (%84) için neredeyse aynı sıvı ürün verimlerinde, %5'ten %6.4'e arttığı belirlenmiştir. Ek olarak, AYPE için tamamen alkan ve alkenlerden oluşan %70 verimle pirolitik sıvı ürün elde edilmiştir.

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1. Introduction

Solid wastes have caused air, water and soil pollution (Chae and An, 2018; Verma, Vinoda, Papireddy and Gowda, 2016). Besides that, their amount and composition have increased day by day because of population growth and technological progress in urban areas (Karak, Bhagat and Bhattacharyya, 2012).

Turkey imported plastic products which costed nearly

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12 million dolars in 2019 (Trade Map - List of supplying markets for a product imported by Turkey, n.d.-a). Saudi Arabia, Germany, Republic of Korea, China and Belgium were presider countries in that importation (Figure 1). In the same year, Turkey exported plastic products which costed nearly 6 million dolars (Trade Map - List of importing markets for a product exported by Turkey, n.d.). Iraq, Germany, United Kingdom, Israel and Romania were presider countries in that exportation (Figure 2). Turkey has imported plastic waste also (Trade Map - List of supplying markets for a product imported by Turkey, n.d.-b). In Figure 3, it was shown that plastic waste importation amount of Turkey with respect to the countries in 2019. In Turkey, plastics have formed 5-14 % of total solid wastes. In addition to that, disposal methods of plastics have mainly based on collecting in landfills (What a Waste : A Global Review of Solid Waste Management, n.d.).

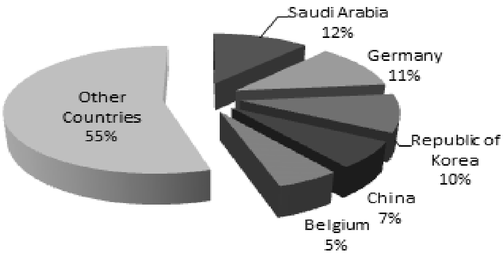

Figure 1. Investment of Turkey on Plastic Importation in 2019 (Trade Map - List of supplying markets for a product imported by Turkey, n.d.-a)

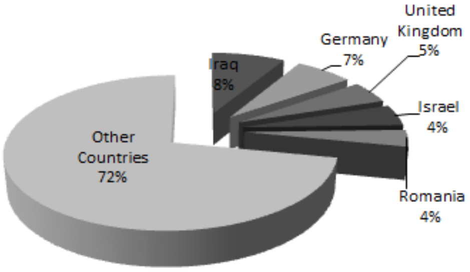

Figure 2. Income of Turkey from Plastic Exportation in 2019 (Trade Map - List of importing markets for a product exported by Turkey, n.d.)

Plastics have been classified as thermoplastic and thermosets. Because, thermosets can not take a form of fluid when they are heated, their degradation has been hard (Pascault, Verdu and Williams, 2002; Xu et al., 2020). PET, LDPE, High Density Polyethylene (HDPE), PVC, PS and PP form thermoplastic resources (Francis, 2016). Water bottles, detergent bottles, food packaging materials, window profiles, coffee cups, microwave food trays are the well-known products of PET, HDPE, LDPE, PVC, PS and PP respectively (Doddamani, 2020; Ko, Kwon, Lee and Jeon, 2020; Lambert and Wagner, 2016; Shankar, Bang and Rhim, 2019; Vallabhy, Arun Kumar, Bharath, Dhakshina Moorthy and Jain, 2019; Zhao, Hu and Luo, 2020). In Europe, PP is the most consumed plastic type (10 Million Tons) in 2017. LDPE consumption follows it (9 Million Tons). PS consumption quantity is about 2 Million Tons (Plastics-the Facts 2018 An analysis of European plastics production, demand and waste data, n.d.).

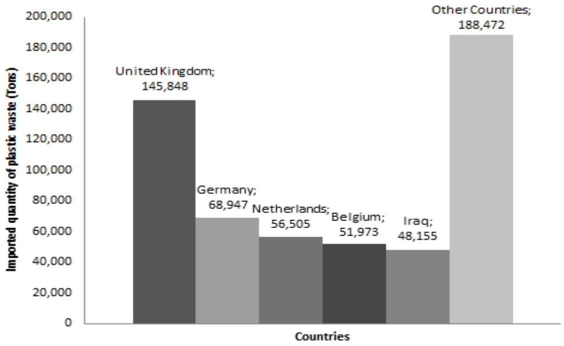

Figure 3. Plastic Waste Importation of Turkey in 2019 (Trade Map - List of supplying markets for a product imported by Turkey, n.d.-b)

Difference between LDPE and HDPE arises from branching. LDPE has high branching, so its molecular forces are poor. LDPE has high ductility, i.e. Thanks to that structural property, LDPE takes shape easily. Besides that, it has water-resistance property. It is used in garbage bags, stretch film and grocery bags (Anuar Sharuddin, Abnisa, Wan Daud and Aroua, 2016).

PS has obtained from polymerization of styrene monomers. Chemical structure of polystyrene is a long hydrocarbon chain which composes of phenyl groups. It has resistance to heat and mechanical impacts. Its application areas are food packaging, electronic, medical and toy sectors. Therefore it has high ratio in municipal solid wastes (Anuar Sharuddin et al., 2016).

There have been three routes to recover thermoplastics. They are mechanical recycling, energy recovery and chemical recovery. In mechanical recycling expensive mechanic devices is used. One type polymer, not the mixture, can be recycled in that route. The process covers the steps which are milling the polymer feedstock, washing it with water and caustic soda. After, additives and pigments are added to it. After that, pelletizing is applied to it. Finally, last product is obtained from it. Energy recovery is the last choice for recycling plastics. In that route, the solid is burned. Calorific value of thermoplastics is the same as petroleum (about 43 MJ/kg). Like petroleum, carbon dioxide (CO_2) and steam appears. It is necessary to use several cleaning methods for flue gas like active carbon utilizing, ammonia adding. In chemical recovery, plastic wastes are recycled for producing chemicals with depolymerization under controlled temperatures. Pyrolysis is a type of chemical recovery techniques (Al-Salem, Lettieri and Baeyens, 2009). With pyrolysis, it has been possible to obtain invaluable hydrocarbons in high yields (Akubo, Nahil and Williams, 2019). Singh, Ruj, Sadhukhan and Gupta (2020) carried out polystyrene pyrolysis in a stainless steel reactor system with 20 ^{0}C/min heating rate and 500 ^{0}C. They obtained 78 % liquid product yield. They observed that the product involved C_{14}-C_{24} hydrocarbons in the ratio of 50 %. They found styrene peak area as 8 %. Miandad et al. (2016) worked on PS pyrolysis with 1 kg feedstock at different temperatures between 400 and 500 ^{0}C with 10 ^{0}C/min heating rate. They obtained maximum liquid product yield as a 81 % at 450 ^{0}C. They found that liquid product included styrene in the ratio of 50 %. Mukherjee, Ruj, Gupta and Sadhukhan (2020) studied on LDPE pyrolysis at 20 ^{0}C/min heating rate with different temperatures (450-600 ^{0}C). They found that maximum liquid product yield was 84 % at 550 ^{0}C. They observed that the liquid involved C_1-C_6 hydrocarbons in the ratio of 50 %.

In this study, it was aimed to obtain hydrocarbons from PS and LDPE via pyrolysis. Effect of temperature and feedstock ratio on the product yields investigated. Besides that, chemical compositions of pyrolytic liquids were determined via GC-MS.

2. Materials and Methods

2.1. Materials

PS foam was provided from a hospital as a form of blood collection tube tray. It was sliced to small fragments. Then, its air was removed in furnace at 125 ^{0}C during 4 hours. LDPE whose type of F2-12 was provided from Petkim Petrokimya Holding A.Ş.

2.2. Pyrolysis of Plastics

Pyrolysis experiments were carried out in a semi-batch setup. Temperature was varied as 470, 520, 570 and 620 ^{0}C at 10 ^{0}C/min heating rate. After it was reached the desired temperature, experiments were continued during 60 min. Temperature in ceramic furnace was controlled via Paratherm brand PID controller, while temperature in glass reactor was controlled via Elimko 2000 M brand digital controller. Before the experiments, the tubular glass reactor including feed, which had 4 cm diameter and 33 cm length, was put into the ceramic furnace. Then, glass equipments which were connectors, condenser and liquid connection vessel with jacket were linked to each other. After then, due to prevent heat loss during the experiments, the reactor was covered with an insulator material. During the experiments, product which was come from the reactor was cooled in condenser in which ethylene glycol circulated. Then, the liquid product collected in the vessel and gas product was released to the atmosphere from the top hole of the vessel. System was held inert atmosphere by using nitrogen (N_2) gas at 25 ml/min flowrate. Feedstock ratio (wt./wt.) was choosen as 1/1, 1/2, 2/1 for co-pyrolysis experiments. 15 g of feedstock in total was used for each experiment. Pyrolysis setup was shown in Figure 4. After the experiments, the glass equipments were seperated to each other and liquid product was taken. Besides that, the reactor was taken out from the furnace and it was waiting for its cooling. Product yields were computed by utilizing Equation (1)-(4) in the form of mass percentage. Error percentage of the experiment was assumed to be in gas yield.

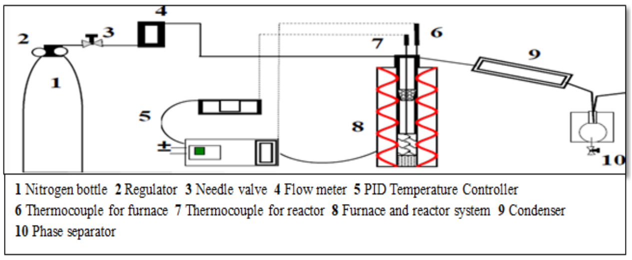

Figure 4. Experimental Setup (Çelikgöğüs and Karaduman, 2015)

Solid residue yield=

$$\frac{\text{reactor after the experiment,g}-\text{empty reactor,g}}{\text{feed in the reactor,g}}*100 \qquad (1)$$

Liquid yield=

$$\frac{\text{liquid in collection vessel after the experiment,g}}{\text{feed in the reactor,g}}*100 \qquad (2)$$

$$\text{Gas yield}=100-\text{Liquid yield}-\text{Solid residue yield} \qquad (3)$$

$$\text{Total conversion}=\text{Liquid yield}+\text{Gas yield} \qquad (4)$$

2.3. GC-MS Analysis of Pyrolytic Liquid

Liquid products were analyzed by utilizing Thermo Finnigan brand DSQ 250 model GC-MS equipment. Capillary column which was inside the equipment was Zebron Brand. The column had 0.25 mm inner diameter and 60 m length. Temperature of the column was adjusted before automatic injection of the sample. Initially, the sample was held at 45 ^{0}C for 4 min. Then, temperature was increased to 280 ^{0}C with 3 ^{0}C/min heating rate. After that, temperature was preserved at that temperature for 20 min. Total analyzing time was specified as nearly 100 min. The equipment which was used was shown in Figure 5.

Figure 5. Photograph of the Analytical Instrument

In this study, research and publication ethics were followed.

3. Results

3.1. Effect of Temperature on LDPE Pyrolysis

In Figure 6, it was shown that change of LDPE product yields with temperature. It was observed that the liquid product yield was around 70 % at all temperatures. But, maximum yield was recorded as 71.6 % at 520 ^{0}C. And then, the liquid yield decreased a little bit at 570 and 620 ^{0}C. That data was suitable with literature. Marcilla, Beltrán and Navarro, (2009) found maximum liquid yield at 469-520 ^{0}C for LDPE. It was found that gas product yield was around 30 % at all temperatures. That data was also suitable with literature. Çit et al., (2009) worked in the same temperature area of our study and they found that the gas yield of LDPE changed between 20% and 40%. But, maximum yield was recorded as 32.1 % at 620 ^{0}C. That temperature was also the point which the liquid yield was minimum. It was observed that solid residue yield had tendency to decrease regularly with increasing temperature. It was 1.8 % at 470 ^{0}C and 0.3 % at 620 ^{0}C. Besides that, total conversion which means that the sum of gas and liquid product yield was found as 99.7 % at 620 ^{0}C.

In Table 1, it was shown that composition of LDPE pyrolytic liquid which was detected via GC-MS. It composed of totally hydrocarbons which were alkanes and alkenes. Onwudili, Insura, and Williams, (2009) were also reported that liquid product of LDPE pyrolysis comprised of cycloalkanes, n-alkanes and n-alkenes.

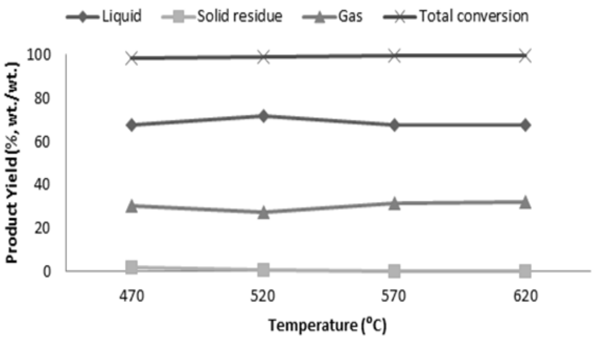

Figure 6. Effect of Temperature on Product Yields of LDPE

3.2. Effect of Temperature on PS Pyrolysis

In Figure 7, it was shown that alteration of PS product yields with temperature. Maximum yield was recorded as 88.3 % at 570 ^{0}C. And then, the liquid yield decreased to 87.2 % at 620 ^{0}C. That data was suitable with literature. Liu, Qian and Wang, (2000) found maximum liquid yield at around 600 ^{0}C for PS. It was found that gas product yield decreased from 20 % to 10 % when the temperature was increased from 520 ^{0}C to 570 ^{0}C. Gas yield of PS was found also low amount by other researchers. For example, Miandad et al., (2017) determined gas yield of PS as 13% at 450 ^{0}C. In other research, Zhou et al., (2015) found that PS had 6% gas yield at 800 ^{0}C. It was observed that solid residue yield had tendency to decrease regularly with increasing temperature. It was 5.9 % at 470 ^{0}C and 2.2 % at 620 ^{0}C. Besides that, total conversion was found as 97.8 % at 620 ^{0}C.

In Table 2, it was shown that composition of PS pyrolytic liquid which was detected via GC-MS. It composed of totally hydrocarbons which were aromatics. The amount of BTE fraction was obtained in the ratio of 4.94 % at 570 ^{0}C. In addition to that, it was found that Styrene was the main component of liquid product of PS.

Nisar et al., (2019) were also detected that liquid product of PS pyrolysis composed of methyl benzene, styrene and alpha-methylstyrene mainly

Table 1

Chemicals in LDPE Pyrolytic Liquid at 520 ^{0}C

Retention time, min	Component	Formula	Peak Area, %	Retention time, min	Component	Formula	Peak Area, %
4.19	1-butene	C_4H_8	0.13	31.84	1-tetradecene	$C_{14}H_{28}$	2.59
4.59	Cyclobutane, methyl-	C_5H_{10}	0.82	36.55	1-pentadecene	$C_{15}H_{30}$	2.61
5.61	1-hexene	C_6H_{12}	1.66	37.04	pentadecane	$C_{15}H_{32}$	1.59
7.78	1-heptene	C_7H_{14}	1.92	41	3-tetradecene, (E)-	$C_{14}H_{28}$	3.07
8.12	Hexane, 3-methyl-	C_7H_{16}	1.5	41.44	nonadecane	$C_{19}H_{40}$	1.66
8.8	Cyclohexane, methyl-	C_7H_{14}	0.58	45.17	1-octadecene	$C_{18}H_{36}$	2.82
9.28	Cyclohexene, 1-methyl-	C_7H_{12}	0.36	45.58	octadecane	$C_{18}H_{38}$	1.74
10.46	Cyclohexene, 4-methyl-	C_7H_{12}	0.37	49.13	1-docosene	$C_{22}H_{44}$	2.59
11.48	1-octene	C_8H_{16}	2.23	52.38	1-hexadecyne	$C_{16}H_{30}$	0.46
12	octane	C_8H_{18}	1.48	52.87	1-heptadecene	$C_{17}H_{34}$	2.55
12.81	cyclooctene	C_8H_{14}	0.36	53.23	eicosane	$C_{20}H_{42}$	1.83
13.97	1-octyne	C_8H_{14}	13.97	56.41	hexadecene	$C_{16}H_{32}$	2.54
15.69	Cyclodecene (E)-	$C_{10}H_{18}$	0.25	56.75	hexadecane	$C_{16}H_{34}$	1.84
16.37	1-nonene	C_9H_{18}	2.35	59.8	3-eicosene, (E)-	$C_{20}H_{40}$	2.28
16.96	nonane	C_9H_{20}	1.36	60.1	heneicosane	$C_{21}H_{44}$	1.75
20.62	1-hexene, 2-methyl-	C_7H_{14}	0.28	63	9-nonadecene	$C_{19}H_{38}$	1.99
21.3	1-decene	$C_{10}H_{20}$	0.3	66.08	1-hexadecene	$C_{16}H_{32}$	1.73
22.25	decane	$C_{10}H_{22}$	1.38	66.35	hexatriacontane	$C_{36}H_{74}$	1.7
25.22	Octadecane, 6-methyl-	$C_{19}H_{40}$	0.1	69.02	Cyclodocosane, ethyl-	$C_{24}H_{48}$	1.45
25.68	1-octene, 2-methyl-	C_9H_{18}	0.1	69.27	pentacosane	$C_{25}H_{52}$	1.57
25.88	1-undesine	$C_{11}H_{20}$	0.13	74.5	1-tricosene	$C_{23}H_{46}$	0.85
26.88	1-dodecene	$C_{12}H_{24}$	2.69	74.75	octacosane	$C_{28}H_{58}$	1.03

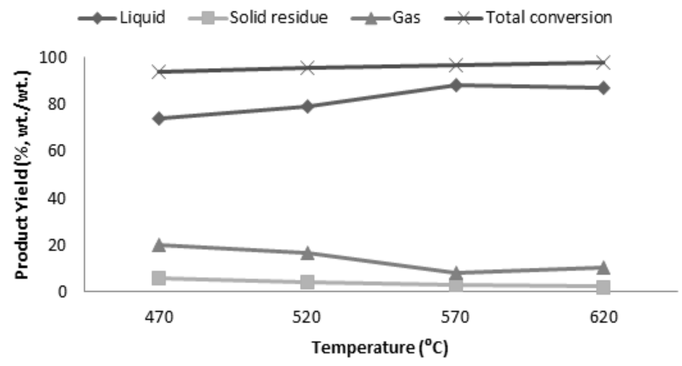

Figure 7. Effect of Temperature on Product Yields of PS

3.3. Effect of Temperature on Co-Pyrolysis of PS and LDPE

After individual pyrolysis of PS and LDPE, it was recorded that the maximum liquid yield was observed as 520 ^{0}C for LDPE and 570 ^{0}C for PS. In that time, it was investigated on co-pyrolysis of PS and LDPE. To find the temperature for maximum liquid yield, co-pyrolysis experiments were done with equal amount of LDPE and PS in the feed at 470, 520, 570 and 620 ^{0}C.

In Figure 8, it was shown that alteration of product yields of plastic mixtures with temperature. It was observed that the liquid product yield was around 80 % at all temperatures. However, maximum yield was recorded as 83.5 % at 570 ^{0}C. And then, the liquid yield decreased a little bit at 570 and 620 ^{0}C. Koo, Kim and

Seo, (1991) recorded also that maximum liquid yield observed at 600 ˚C for equal amount of PS and LDPE pyrolysis. It was found that gas product yield was determined as about 20 % for all temperatures. It was observed that solid residue yield had tendency to 3.9 % decrease regularly with increasing temperature. It was at 470 ^{0}C and 0.3 % at 620 ^{0}C. In addition, total conversion was found as 99.7 % at 620 ^{0}C.

In Table 3, it was shown that composition of PS and LDPE co-pyrolytic liquid. It was detected that nearly 30 % of the peak area was belong to BTE fraction.

Table 2

Chemicals in PS Pyrolytic Liquid at 570 ^{0}C

Retention time, min	Component	Formula	Peak area, %
6.81	Benzene	C_6H_6	0.1
10.12	Benzene, methyl-	C_7H_8	3.96
14.29	Ethylbenzene	C_8H_{10}	0.88
16.43	Styrene	C_8H_8	72.12
17.63	Benzene, (1-methylethyl)-	C_9H_{12}	0.04
18.56	Benzene,1-ethenyl-4-methyl-	C_9H_{10}	0.14
20.51	Alpha-methylstyrene	C_9H_{10}	2.45
22.66	Benzene, 2-propenyl-	C_9H_{10}	0.11
29.48	Naphtalane,1,2,3,4-tetrahydro-	$C_{10}H_{12}$	0.03
45.29	bibenzyl	$C_{14}H_{14}$	0.45
53.35	Styrene, dimer	$C_{16}H_{18}$	11.71
61.16	Naphtalane, 1-phenyl	$C_{16}H_{12}$	0.2

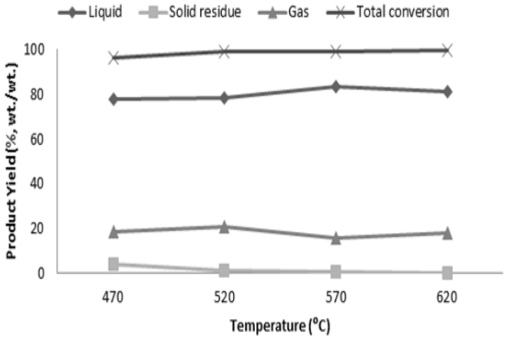

Figure 8. Effect of Temperature on Product Yields of PS and LDPE (1/1)

Table 3

Chemicals in PS and LDPE co-pyrolytic liquid at 570 ^{0}C

Retention time, min	Component	Formula	Peak area, %
4.18	1-butene	C_4H_8	0.3
4.59	Cyclobutane, methyl-	C_5H_{10}	0.78
5.16	cyclopentene	C_5H_8	0.1
5.61	1-hexene	C_6H_{12}	0.94
7.06	benzene	C_6H_6	0.12
7.4	Cyclohexene	C_6H_{10}	0.14
7.78	1-heptene	C_7H_{14}	0.89
8.12	hexane, 3-methyl-	C_7H_{16}	0.51
8.8	Cyclohexane, methyl-	C_7H_{14}	0.14
9.3	Cyclohexene, 1-methyl-	C_7H_{12}	0.23
10.16	Benzene, methyl-	C_7H_8	5.21
10.48	Cyclohexene, 4-methyl-	C_7H_{12}	0.21
11.5	1-octene	C_8H_{16}	1.04
12	octane	C_8H_{18}	0.51
12.83	cyclooctene	C_8H_{14}	0.21
13.4	Cyclohexane, 2-propenyl-	C_9H_{16}	0.1
13.99	1-octyne	C_8H_{14}	0.1
14.29	ethylbenzene	C_8H_{10}	1.02
14.76	Cyclohexane, ethylidene	C_8H_{14}	0.2
16.16	styrene	C_8H_8	28.12
16.5	1-nonene	C_9H_{18}	0.71
17.02	nonane	C_9H_{20}	0.27
17.55	Benzene, (1methylethyl)-	C_9H_{12}	0.1
20.44	Alpha-methylstyrene	C_9H_{10}	2.25
21.31	1-decene	$C_{10}H_{20}$	0.11
22.25	decane	$C_{10}H_{22}$	0.45
24.97	dodecane	$C_{12}H_{26}$	0.1
37	pentadecane	$C_{16}H_{34}$	0.39
56.68	hexadecane	$C_{19}H_{40}$	1.66
59.76	3-Eicosene, (E)-	$C_{20}H_{40}$	1.01
60.05	Heneicosane	$C_{21}H_{44}$	0.4
61.13	Naphtalene, 1-phenyl-	$C_{16}H_{12}$	0.59
72.02	tricosane	$C_{23}H_{48}$	0.39
74.49	1-tricosene	$C_{23}H_{46}$	0.47
77.31	pentatriacontane	$C_{35}H_{72}$	0.29
79.84	nonacosane	$C_{29}H_{60}$	0.15

3.4. Effect of Feedstock Ratio on Co-Pyrolysis of PS and LDPE

After co-pyrolysis of equal amount of LDPE and PS in the feed, it was recorded that the maximum liquid yield was observed as 570 ^{0}C. In that time, it was investigated effect of feedstock ratio on co-pyrolysis of PS and LDPE at 570 ^{0}C. In Figure 9, it was shown that comparision of product yields of plastic mixtures which had 1/1, 2/1 and 1/2 LDPE/PS ratio in the feed with temperature. It was observed that the solid residue yield was around 1 % at all feedstock ratios. However, minimum yield was recorded as 0.8 % at 570 ^{0}C and 2/1 LDPE/PS ratio. Total conversion was determined as about 99 % for all feedstock ratios. But maximum conversion value was obtained as 99.2 with 2/1 LDPE/PS ratio. Maximum liquid product yield was found as 83.5 % with equal amount of LDPE and PS in the feed. At that feedstock ratio gas product yield was determined as 15.6. As a result, PS adding to the feed increased liquid yield from 70 % to 80 %, while it decreased gas yield from 30 % to 20 %.

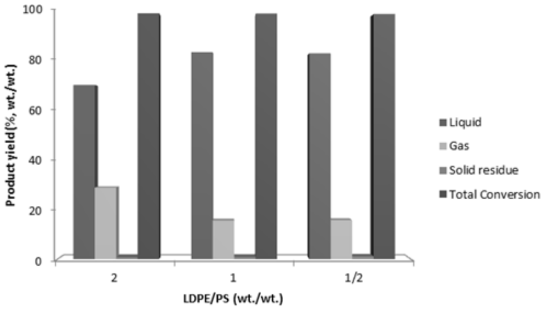

Figure 9. Effect of Feedstock Ratio on Product Yields of PS and LDPE

4. Conclusion

It was carried out pyrolysis of LDPE and PS in a semi-batch reactor at 470, 520, 570 and 620 ^{0}C with 1/1, 1/2 and 2/1 LDPE/PS ratios. Product yields were calculated and liquid products were analyzed via GC-MS. Maximum liquid product yields were determined as 71.6 % at 520 ^{0}C, 88.3 % at 570 ^{0}C and 83.5 % at 570 ^{0}C for LDPE, PS and LDPE/PS (1/1) pyrolysis respectively. Regarding that result, it was concluded that because of synergic effect liquid yield of LDPE increased. In addition, maximum value of total conversion values were found as 99.7 % at 620 ^{0}C, 97.8 % at 620 ^{0}C and 99.2 % at 570 ^{0}C for LDPE, PS and LDPE/PS (2/1). BTE fraction was not found in LDPE pyrolytic liquid. However, it was found at the ratio of 5 % in PS pyrolytic liquid and at the ratio of 6.4 % in the co-pyrolytic liquid of LDPE and PS (1/1) at 570 ^{0}C with nearly same liquid product yield. With that study, it become possible to increase hydrocarbon content of pyrolytic liquid. More clearly, alkane-alkenes from LDPE and aromatics from PS combined together in the pyrolytic liquid. Thanks to co-pyrolysis of PS and LDPE, it was thought to obtain hydrocarbon rich liquid which will be a fuel.

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Contribution of Researchers

In that study; Gamze Ozcakir as the project researcher contributed to do pyrolysis study, analyze the products, discuss the results and write the paper. Ali Karaduman as the project supervisor proposed the idea, developed the methodology and contributed to do pyrolysis study, analyze the products, discuss the results and write the paper.

Conflict of Interest

No conflict of interest was declared by the authors.

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