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CONVERSION OF WASTE HDPE AND LDPE INTO FEED STOCKS IN TUBE REACTOR

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The thermal degradation of waste polyethylenes (HDPE and LDPE) was investigated in a horizontal tube reactor at temperatures of 500, 525 and 550 °C. By thermal cracking, the HDPE and LDPE were converted into gas, liquid and wax-like hydrocarbon products with the yields of 3.1-6.0%, 5.9-22.4 and 70.6-91%, resp. The liquids were further separated with atmospheric and vacuum distillation into naphtha- and diesel-like products. These fuel-like products consisted of hydrocarbons of C_5-C_{10} and C_{11}-C_{27} in case of lighter and heavier products resp., which might be used as feed stock materials. Differences in the properties of volatile products could be observed with increasing temperature, but not significant differences were noticed between various waste polymers. Subsequent distillation of the products, fuel like liquids that had low sulphur and nitrogen content and high cetane index was carried out. The olefin content of the fractions and the distribution of the double bonds were determined by infrared spectroscopy and the distribution of carbon atoms by gas-chromatography. The gas and liquid products contained a significant amount of unsaturated hydrocarbons, mainly terminal olefins.

Keywords: tube reactor, chemical recycling, waste polyethylenes, cracking temperature, gas-chromatography, olefin content, carbon atom distribution

Introduction

The suitable treatment of plastic wastes got the focus of interest in modern society, because of increasing production of polymers, which generates enormous amounts of wastes from them. The question of recycling and reusing is important both from the environmental and energetic aspects. However, the global reserves of fossil fuels are limited; therefore there are efforts to convert wastes into valuable feed stocks. Some legal measures stimulate the higher rate of recycling e.g. in the member countries of the EU recycle of 20% of plastic wastes is aimed at in 2005, and 30% in 2010. The present amount of recycled waste plastics is less than 10% [1]. Thermal degradation of waste polymers is only one way of their utilization. In cracking reactions of plastic materials C-C bonds are cracked resulting in lighter and more valuable hydrocarbons. According to production data the main constituents of the plastic wastes are low-density polyethylene, high-density polyethylene and polypropylene, which represent about 20-20% of the wastes [2]. This is one of the reasons that their thermal or catalytic degradation was widely investigated. The reaction of decomposition resulted gases, liquids and heavier hydrocarbons. Further application of decomposed wastes can be as fuels or raw materials for the petrochemical industry. In fact, several researchers have investigated the route of thermal degradation of waste polymers to valuable products, and several methods have been suggested for solving of this problem. However, it is often complicated. The most investigated way of the degradation is the thermal and/or catalytic cracking in batch reactors.

The weight of the used materials is generally not more than 100-200g, although the preferred technique is thermal-gravimetry connected with an analysis e.g. TG-MS using 1-2g of polymers [3-9]. Cracking parameters are most important in respect of products properties [10-13]. Higher yields of gas and coke were observed at higher temperatures; moreover the liquid fraction had significant aromatic and cyclic hydrocarbon content. At lower temperatures the main product is liquid of high olefin content. The liquid can be further saturated with hydrogen, and perhaps isomerised by the use of catalysts and can be used as good quality synthetic diesel oil or lubricants. Cracking reactions are endothermic, and need lot of energy. Heat requirements can be reduced with catalysts, but the disposal and the activation loss or regeneration of the catalysts could cause some other problems. The cracking of LDPE and HDPE was studied also in fluidized bed reactor [14-16]. The pyrolysis of LDPE in an internally circulating fluidized-bed reactor [14, 15] using short residence time at 850°C resulted 90% of gas yields with 75% of olefins in the gases. Williams et al. [16] have evaluated the pyrolysis of LDPE in a fluidized bed reactor at temperatures of 500–700 °C. According to GC-MS analysis alkyldienes, alkenes and alkanes are found in the products. The carbon number range of the wax sample was C_{11}-C_{57}, whilst the oil sample was C_8-C_{44}. The wax-like product was very pure aliphatic material, with no aromatic content. It has the potential to be used in a conventional steam cracker or fluidised catalytic cracker in the petrochemical industry as substitutes for petroleum derived feed stocks. Ng et al. [17] have investigated the conversion of PE with VGO into fuels by catalytic cracking in a fixed bed reactor at 510 °C. Different ratios of PE/VGO were used, and the highest yield of gasoline was found when 10% waste PE was used.

In the present paper, we report the thermal cracking behaviour of a waste low-density polyethylene (LDPE) and high-density polyethylene (HDPE) in a horizontal tube reactor. The aim of this study is to investigate the effect of the cracking parameters (temperature and feed materials) on the properties of the products. The change of aliphatic species (n-olefin and n-paraffin) and their distribution were investigated in function of cracking parameters. Liquid fractions were separated into two fractions, and their application possibilities as fuel were studied.

Experimental

Raw Materials

Commercial high- and low-density polyethylenes (HDPE and LDPE) were used as raw materials. The HDPE waste was obtained from motor oil flasks, which were crashed to 5-7 mm pieces and used as raw material, and the LDPE waste was regranulated pellets of LDPE from the packaging industry. Their main properties are summarized in Table 1. Each polyethylene waste has Ca, Ti, Zn content from filler materials and pigments such as $CaCO_3$, TiO_2 and ZnO. The used raw materials had sulphur and nitrogen content from additives of polymer (e.g. anti oxidant, fire-retardant and antifuming additives).

Table 1 The properties of waste polymers

Properties	HDPE	LDPE
Grain size, mm	4-6	5-6
Density, g/cm^3	0.962	0.923
Melt-flow index, g/10min. $^{(1)}$	0.538	0.551
Ash content, %	1.14	1.03
Humidity, %	0.13	0.10
Metals, ppm		
Ca	55	89
Zn	21	44
Ti	545	417

$^{(1)}$ at 190 °C with 2160 N load

Cracking apparatus

The experiments were carried out in a horizontal tube reactor, which is schematically shown in Fig. 1. The cracking equipment consisted of four main parts: a feeding, a thermal degradation, a preliminary separation and a distillation part. Wastes with suitable grain size were fed in an extruder. In the extruder the raw material was preheated up to 250-280 °C. From the extruder the preheated polymer was directly driven in the reactor, where it was cracked at 500-550 °C into volatile products and wax-like residue. The reactor was connected to a separator and a distillation unit. In the separator, the hydrocarbons were separated into volatile products and residue. The volatile fraction was further separated in a condenser to gas and liquid. Cooling water at 20 °C was used for condensation. Non-condensable gases were passed through a flow meter and then flared. Gases and liquids were sampled and analysed by a gas-chromatograph. At room temperature solid residue was collected as a bottom product. The distillation took place under inert nitrogen atmosphere using atmospheric pressure and vacuum (15 Hgmm).

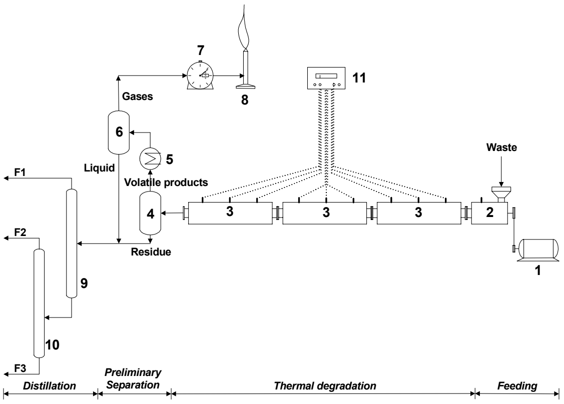

Fig. 1 Cracking apparatus for cracking of waste polymers *1. Motor, 2. Extruder, 3. Reactor, 4. Separator, 5. Condenser, 6. Separator, 7. Gas-flow meter, 8. Flare, 9. Atmospheric distillation, 10. Vacuum distillation, 11. Thermometer*

Analysis of products

In the present work the change of product properties was studied as function of cracking parameters. Gas and liquid products formed in cracking reactions were analyzed with the use of the following methods:

- liquid density measurement (MSZ EN ISO 12185),
- determination of the $–CH_2–/–CH_3$ ratio in liquid fractions with IR spectroscopy,
- determination of the olefin double bond distribution with SHIMADZU IR-470 type spectrometer,
- gas analysis using a Carlo Erba Vega Series GC 6000 gas-chromatograph (GC) provided with a 50 m × 0.32 mm fused silica column with Al_2O_3/KCl coating, at 40 °C,
- liquid analysis using a TRACE GC gas-chromatograph provided with a 30m x 0.32mm Rtx®-1 (Crossbond® 100% Dimethyl-polysiloxane) column. The temperature program of the analysis started at 40 °C (2 min.), then the temperature was raised to a rate of 15°C/min. to 330°C,
- determination of sulphur and nitrogen content of liquids (ASTM D 6428 99 and ASTM D 6366 99).

Results and discussion

Yields

The cracking behaviour of various waste polyethylenes was investigated in a horizontal tube reactor at 500, 525 and 550 °C temperature. The cracking reactions of wastes gave off three different products: gas, liquid and residue, which consisted of hydrocarbons of different lengths. The yields of products are shown in Table 2.

Table 2 The yields of products formed in thermal degradation of waste HDPE and LDPE (%)

Polymer	HDPE			LDPE		
Temperature, °C	500	525	550	500	525	550
Gas	3.1	3.9	4.7	4.0	5.5	6.0
Liquid	5.9	10.8	21.7	8.6	12.4	23.4
Residue	91.0	85.3	73.6	87.4	82.1	70.6

It was found that the yield of volatile products is increased with temperature in case of both polyethylenes. With increasing temperature the thermal stability of carbon chains decreases, therefore in case of higher temperature (550 °C) the possibility of cracking of C-C is greater than at lower temperature (500 °C). This results in a growing amount of the volatile products. From LDPE higher liquid yields were observed (8.6, 12.4, 23.4%) in contrast to HDPE (5.9, 10.8, 21.7%). This fact can be explained by the difference in the structure of polyethylenes. The LDPE polymer has lower density, because of its structure, which contains more branch chains than the HDPE. It means that LDPE has more tertiary carbon atoms, which have considerably lower resistance against thermal degradation. It was found that under the same circumstances (cracking temperature, residence time, etc.) the LDPE can be degraded a little easier than HDPE, therefore the cracking of LDPE could result in higher amount of liquids and gases.

Structure of products

Gases

The change of composition of gases with different cracking temperature is compared in Table 3. Significant differences are not observed between various gas compositions obtained at different temperatures, and the various densities of raw materials did not cause differences either. Gases formed in the degradation of both LDPE and HDPE contained high amounts of C_2 and C_4

hydrocarbons. This is consistent with results of previous papers [18, 19]. The concentration of olefins was higher than that of the paraffins of the same carbon number. It was earlier described that the possibility of β-scission reactions is greater than hydrogen transfer reactions in thermal degradation. It is well known that the thermal degradation of polymers takes place by radical mechanism and results mainly in monomers and oligomers. PE is built up from monomers of two carbon atoms $–(CH_2\text{-}CH_2)–$, which cracked into statistically determined fragments, e.g. ethane, ethane or butane, butane, etc. The possible scheme of the degradation is shown in Fig. 5.

Table 3 The composition of gases obtained in the cracking of HDPE and LDPE waste (%)

Polymer	HDPE			LDPE		
Temperature. °C	500	525	550	500	525	550
Methane	6.44	6.06	6.02	7.33	6.90	7.40
Ethene	28.29	27.27	27.78	25.84	26.55	27.28
Ethane	15.12	16.26	13.15	15.04	16.09	14.40
Propene	8.78	9.29	8.70	8.54	8.42	7.61
Propane	6.05	6.16	5.93	6.81	6.10	6.49
Butene	23.41	23.23	25.00	24.05	21.49	24.75
Butane	11.90	11.72	13.43	12.40	14.46	12.07

Initiation $R_1\text{-}\Psi\text{-}\Psi\text{-}R_2 \Rightarrow R_1\text{-}\Psi\cdot + \cdot\Psi\text{-}R_2$

Propagation $R_1\text{-}\Psi\cdot + R_1\text{-}\Psi\text{-}\Psi\text{-}R_2 \Rightarrow R_1\text{-}\Psi + R_1\text{-}\Psi\text{-}\Psi'\text{-}R_2$ (*intermolecular hydrogentrasfer)*

$R_3\text{-}(K)_m\text{-}\Psi\text{-}\Psi\text{-}\Psi\text{-}(\Psi)_n\text{-}\Psi\cdot \Rightarrow R_3\text{-}(\Psi)_m\text{-}\Psi\text{-}\Psi'\text{-}\Psi\text{-}(\Psi)_n\text{-}\Psi$ (*intramolecular hydrogentrasfer)*

$R_3\text{-}(\Psi)_m\text{-}\Psi\text{-}\Psi'\text{-}\Psi\text{-}(\Psi)_n\text{-}\Psi \Rightarrow \alpha\text{-olefin} + R_3\text{-}(\Psi)_m\text{-}\Psi\cdot$ (*β-scission)*

$R_3\text{-}(\Psi)_m\text{-}\Psi\text{-}\Psi'\text{-}\Psi\text{-}(\Psi)_n\text{-}\Psi \Rightarrow \alpha\text{-olefin} + R_3\text{-}(\Psi)_n\text{-}\Psi\cdot$ (*β-scission)*

Termination $R_5\text{-}\Psi\cdot + \cdot\Psi\text{-}R_4 \Rightarrow R_5\text{-}\Psi\text{-}\Psi\text{-}R_4$

Where $\Psi = –(CH_2\text{-}CH_2)–$
R_1, R_2, R_3, R_4, R_5 = alkyl group
$\Psi\cdot$ = radical from Ψ

Fig. 5 The scheme of cracking of polyolefin wastes

Liquid fractions

The liquid fractions and residues obtained in the cracking reactions were measured and analyzed also as fuel-like products. For the sake of investigation of this possibility, after thermal degradation the liquid products from the waste polymers and their residues were mixed and then separated with atmospheric and vacuum distillation into further fractions: white spirit like WSL, diesel like DL fractions and bottom products. Table 3 represents the main properties of each distillate fraction in case of HDPE and LDPE wastes.

Table 3 The properties of fractions after distillation

Polymer	HDPE						LDPE					
Temperature, °C	500		525		550		500		525		550	
Fraction	WSL	DL	WSL	DL	WSL	DL	WSL	DL	WSL	DL	WSL	DL
Yield (1)	8.00	13.70	15.74	28.93	13.98	34.09	10.85	16.28	19.30	31.99	21.46	37.22
Density. g/cm^3	0.738	0.795	0.747	0.801	0.741	0.802	0.733	0.789	0.752	0.801	0.748	0.796
- CH_2 - (2)	7.1	15.9	7.6	15.3	7.0	15.1	7.6	15.5	7.3	15.0	7.8	15.8
- CH_3 (2)	1.8	2.3	1.9	2.4	1.8	2.1	2.7	2.8	2.6	2.9	2.5	2.7
Olefin content												
Vinyl	52.3	37.4	49.6	39.1	49.1	35.6	45.1	32.8	44.3	31.4	44.6	31.5
Vinylidene	1.7	4.1	2.8	2.9	2.3	2.1	6.5	6.3	6.1	7.4	6.9	6.6
Internal	3.6	4.0	4.0	3.0	4.0	4.7	2.3	3.6	3.9	2.5	3.8	4.4
VK_{40}, mm^2/s	-	4.43	-	4.54	-	4.20	-	4.52	-	4.51	-	4.63
Corrosion test	-	Group1	-	Group1	-	Group1	-	Group1	-	Group1	-	Group1
Pour point, °C	-	8	-	10	-	8	-	5	-	5	-	3
Flash point, °C	-	105	-	101	-	98	-	96	-	99	-	95
Diesel index	-	71	-	72	-	72	-	69	-	70	-	70
S content, ppm	18	19	18	23	23	28	16	13	18	20	20	25
N content, ppm	10	14	9	12	10	11	9	9	13	11	12	8

(1) The yield applies to the weight of the raw material
(2) Groups in average molecule

Considerable differences could be noticed in liquid yields obtained only in thermal cracking and separation with distillations. The yield of WSL and DL fractions was 5.9-22.4% obtained in the cracking process (Table 3) depending on the temperature, in consequence of the decreasing thermal stability of the C-C bonds. Using further separations (atmospheric and vacuum distillation) the summarized yields of fuel like fractions WSL and DL were 21.7-49.68%. It means that further valuable liquids could be separated by distillation from residues obtained in thermal cracking. On the other hand some differences were observed between the characteristics of the two fractions (white spirit like WSL and diesel like DL), because WSL consists mainly of lighter hydrocarbons C_5-C_{10} and the DL C_{10+}.

The olefin concentration of liquids and the distribution of double bonds were determined by infrared spectra. The vinyl double bonds gave two intensive IR adsorption bands at 910 and 990cm^{-1} while vinylidene and internal double bonds have peaks at 890 and 956 cm^{-1}, resp. The analysis of liquid products obtained by thermal degradation gave an intensive adsorption band at 720cm^{-1}, which is proportional to the length of the carbon chain when the carbon number is higher than 6. Adsorption bands at 910 and 990cm^{-1} were more intensive in case of HDPE, and less notable in LDPE. However, the adsorption band at 890cm^{-1} was more intensive in case of LDPE than HDPE. This peak was observed from the deformation vibration of the vinylidene group in RR'C=CH_2 compounds. This phenomenon could be attributed to the various carbon chain structures of the raw materials. LDPE contained more branches therefore the formation of vinylidene type terminal olefins was stronger.

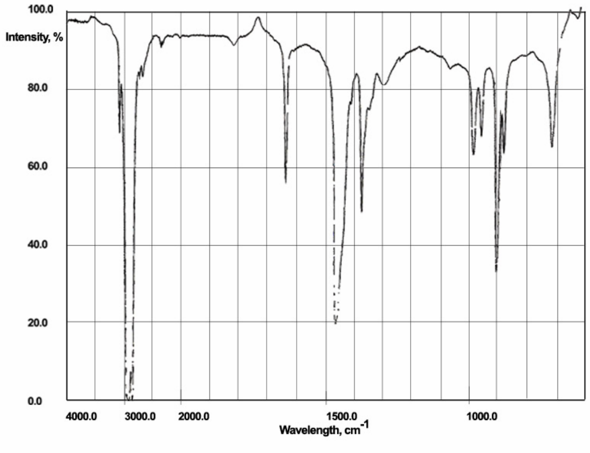

Fig. 6/a IR spectra of WSL fraction from LDPE (500°C)

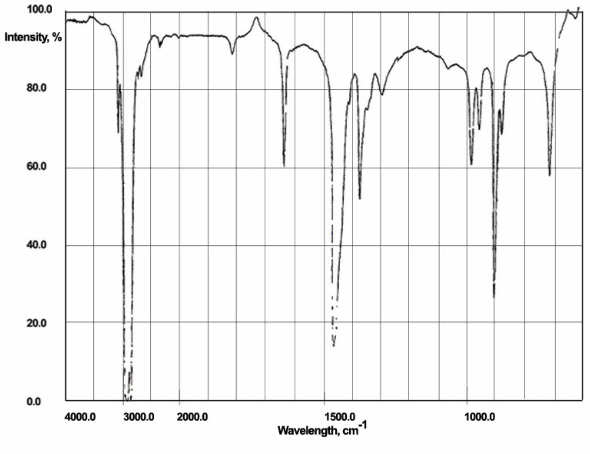

Fig. 6/b IR spectra of WSL fraction from HDPE (500°C)

The number of $–CH_2–$ and $–CH_3$ groups was also determined by IR technique in the range of 2800-3100cm^{-1}. The number of the $–CH_2–$ groups is proportional to the intensity of asymmetric stretching vibration band at 2927 cm^{-1} and the number of the $–CH_3$ groups to that of asymmetric stretching vibration band at 2958 cm^{-1}. It was found that LDPE waste degradation products have a little higher $–CH_3$ content, because of their chemical structure. From the other hand, the pour and flash point of DL from LDPE was lower than DL from HDPE, because of ramification.

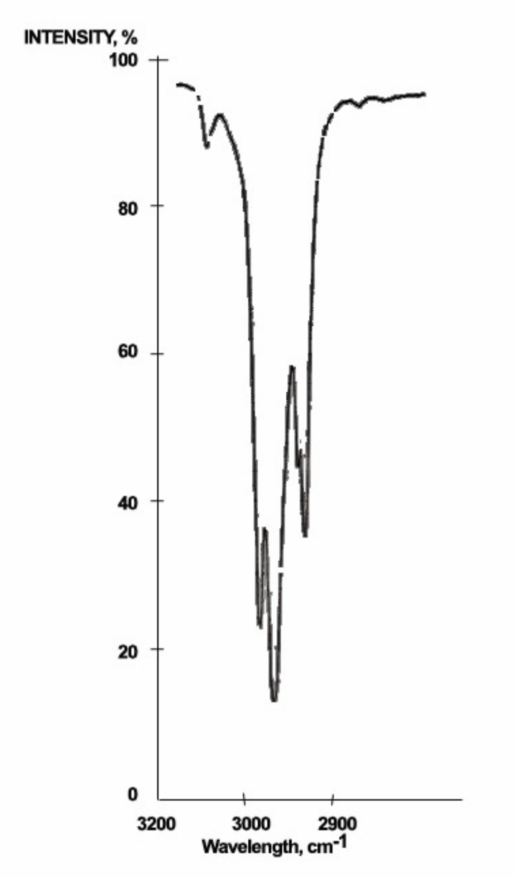

Fig. 7/a IR spectrum of WSL fraction wavelength range of 2800-3200 cm^{-1} from LDPE (500°C)

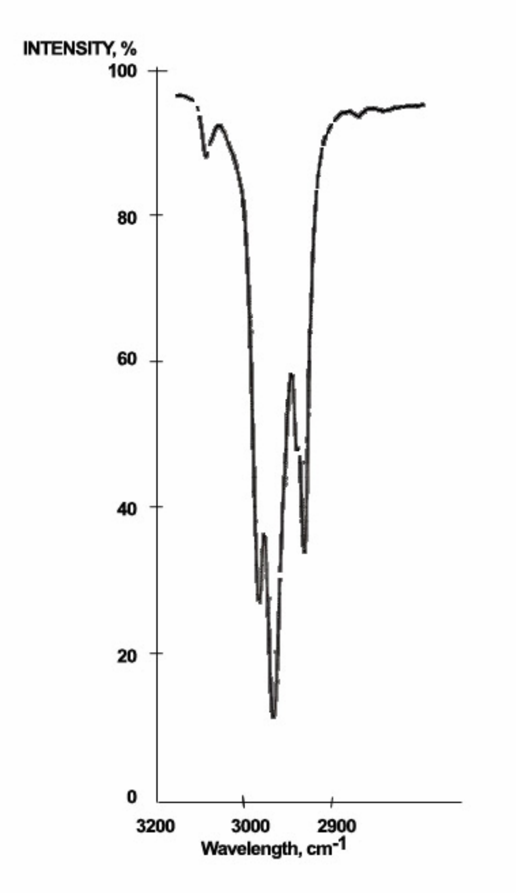

Fig. 7/b IR spectrum of WSL fraction wavelength range of 2800-3200 cm^{-1} from HDPE (500°C)

The heteroatom content is an other important parameter for further application of liquids. Therefore the concentration of sulphur and nitrogen was measured according to ASTM D 6429 99 and ASTM D 6366 99 standards. It was observed that the nitrogen content was lower than 15 ppm and the sulphur content was lower than 30 ppm. These properties are favourable for further fuel-like application of WSL and DL fractions.

Liquids obtained from thermal degradation of waste polyethylenes were analyzed by gas-chromatography. A 30m x 0.32mm column was used, coated with dimethyl-polysiloxane, which separated the hydrocarbons according to polarity under the applied circumstances. They have not distinguished those segments of the molecules parts, where the stability against the thermal degradation might be lower than in other parts of the carbon chain, therefore n-alkanes and n-alkenes were formed from C_5 to C_{10} in case of WSL fractions and from C_8 to C_{26} in case of DL fractions.

The composition of liquid fractions WSL and DL was demonstrated in Table 4/a and b. In these tables the summarized n-paraffin and n-olefin content and the calculated average molecular weight of each fraction were indicated. The average molecular weight of fractions was calculated from the composition.

Table 4/a. The composition of liquids obtained in the cracking of HDPE and LDPE waste (WSL) (%)

Polymer	HDPE			LDPE		
Temperature. °C	500	525	550	500	525	550
n-pentene	2.26	3.15	4.45	2.15	2.86	3.18
n-pentane	1.24	2.36	3.36	2.31	2.51	3.08
n-hexene	13.29	15.58	17.40	12.41	13.73	16.00
n-hexane	11.11	13.39	15.14	10.13	12.14	13.78
n-heptene	20.23	20.19	18.92	16.43	19.57	20.24
n-heptane	14.78	16.78	15.94	15.13	17.41	17.73
n-octene	13.61	12.43	9.99	15.03	113.88	12.49
n-octane	13.22	11.21	10.18	12.51	10.88	9.40
n-nonene	4.48	2.21	1.96	6.29	4.30	1.67
n-nonane	4.10	1.80	1.93	4.19	1.85	1.99
n-decene	1.26	0.81	0.54	1.84	0.77	0.16
n-decane	0.40	0.10	0.19	1.58	0.10	0.30
n-paraffin	44.87	45.63	46.74	43.84	44.89	46.27
n-olefin	55.13	54.37	53.26	56.16	55.11	53.73
M, g/mol	101.4	98.1	96.4	102.6	99.3	97.3

Table 4/b. The composition of liquids obtained in the cracking of HDPE and LDPE waste (DL) (%)

Polymer	HDPE			LDPE		
Temperature, °C	500	525	550	500	525	550
n-octene	0.00	0.74	1.08	0.00	0.72	0.88
n-octane	0.00	0.28	0.72	0.00	0.32	0.41
n-nonene	2.05	2.00	2.75	1.11	1.59	1.85
n-nonane	1.22	2.36	2.38	1.41	2.11	2.86
n-decene	3.69	3.47	3.52	2.88	3.56	3.07
n-decane	2.31	2.82	3.33	1.20	1.99	2.65
n-undecene	3.22	3.91	4.71	3.99	2.91	4.77
n-undecane	2.64	3.72	3.77	2.96	3.50	3.81
n-dodecene	3.24	4.03	4.77	3.69	4.07	4.31
n-dodecane	3.75	4.67	5.25	3.10	4.76	4.91
n-tridecene	4.57	4.54	5.04	4.42	4.45	5.11
n-tridecane	3.08	5.07	5.59	4.32	5.04	5.81
n-tetradecene	5.10	5.20	5.22	4.93	5.33	5.13
n-tetradecane	4.96	5.89	6.01	5.15	5.60	6.08
n-pentadecene	4.97	5.38	5.31	5.17	5.52	5.38
n-pentadecane	5.73	6.50	6.40	5.95	5.85	6.52
n-hexadecene	5.53	5.92	4.93	5.29	5.72	5.75
n-hexadecane	5.77	5.76	5.71	5.82	5.91	5.78
n-heptadecene	4.11	3.83	3.69	4.27	4.14	3.86
n-heptadecane	5.60	4.87	4.65	5.67	5.44	4.51
n-octadecene	3.75	3.05	2.71	4.01	3.77	3.10
n-octadecane	5.33	3.60	3.22	5.05	4.42	3.37
n-nonadecene	2.81	1.61	1.11	3.71	2.00	1.37
n-nonadecane	3.85	2.89	2.13	4.00	2.69	2.20
n-eicosene	2.03	1.39	0.36	1.97	1.43	0.36
n-eicosane	3.63	1.76	1.71	2.04	1.84	1.05
n-uneicosene	1.46	1.05	0.65	1.15	0.89	0.66
n-uneicosane	1.52	1.08	0.90	1.74	1.11	1.18
n-dodeicosene	1.04	0.53	0.36	0.87	0.54	0.49
n-dodeicosane	1.42	0.98	0.89	1.42	1.00	0.91
n-trieicosene	0.52	0.33	0.36	0.54	0.60	0.84
n-trieicosane	0.81	0.65	0.50	0.87	0.84	0.61
n-tetraeicosene	0.12	0.05	0.09	0.14	0.05	0.13
n-tetraeicosane	0.19	0.09	0.09	0.61	0.10	0.24
n-pentaeicosene	0.00	0.00	0.00	0.00	0.10	0.00
n-pentaeicosane	0.00	0.00	0.09	0.00	0.10	0.05
n-paraffin	51.79	52.97	53.33	51.88	52.60	52.94
n-olefin	48.21	47.03	46.67	48.12	47.40	47.06
M, g/mol	212.7	202.9	198.2	215.2	206.8	201.3

High olefin content was observed in liquids because of β-scission reactions. It was found that the content of olefins in case of F1 fraction obtained from both HDPE and LDPE was higher than the concentration of paraffins. The concentration of olefins decreased with increasing temperatures. It is consistent with earlier experimental results. J. Puente et al. published earlier that the yield of olefins decreased both with increasing cracking temperature and its reaction time in case of batch cracking [20]. This phenomenon could be attributed to the greater possibility of the intermolecular hydrogen transfer reactions and termination reactions with recombination at higher temperature.

Figs 8/a-b and Figs 9/a-b show total carbon atom distribution (n-paraffins and n-olefins) in fuel-like hydrocarbon fractions. It is well observable in these Figs that the concentration of lighter hydrocarbons increased with increasing cracking temperature in case of both white spirit like WSL and diesel like DL fractions. It is supposed to be the consequence of decreasing thermal stability of the C-C bonds. With increasing temperatures more and more C-C bonds are cracked resulting in lighter hydrocarbons. This phenomenon could be well followed with the average molecular weights.

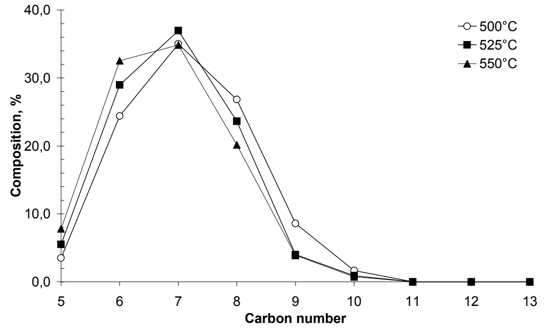

Fig. 8/a The carbon number distribution in liquids obtained by the cracking of HDPE waste (WSL)

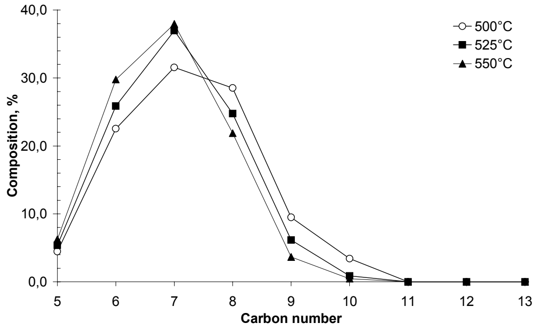

Fig. 8/b The carbon number distribution in liquids obtained by the cracking of LDPE waste (WSL)

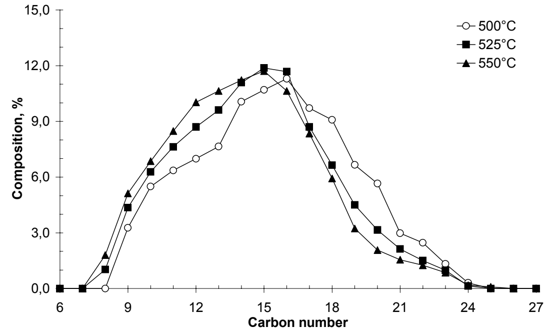

Fig. 9/a The carbon number distribution in liquids obtained by the cracking of HDPE waste (DL)

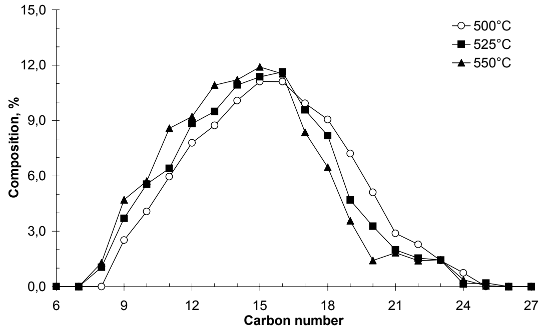

Fig. 9/b The carbon number distribution in liquids obtained by the cracking of LDPE waste (DL)

Conclusions

The degradation of different waste polyethylenes (HDPE and LDPE) in a horizontal tube reactor at 500-500 °C was studied. It was found that the cracking temperature had a significant effect both on the yields and structure of the products, because higher yields of volatile products were observed at higher temperature. The yields of valuable volatile fractions could be increased by vacuum distillation of the residue. Gas products of cracking consisted mainly of C_2 and C_4 hydrocarbons because of the chemical structure of the wastes. In liquid fractions basically aliphatic compounds (n-olefins and n-paraffins) were observed. The cracking temperature and composition of waste polymers (LDPE and HDPE) had a significant effect on the qualitative and quantitative properties of the products. The LDPE waste degradation products have a little higher branched hydrocarbon content, lower pour and flash point because of their chemical structure. It is important for the further application of the products. Other favourable properties for further fuel-like application were also found, such as nitrogen and sulphur content under 30ppm or high diesel index, etc.

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