Supporting Information

Synthesis of Acidic-Basic Y Zeolite from Kaolin: Catalytic and Mechanism Study in the Cracking of Polyethylene

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1- Experimental

1-1- Materials

Sodium hydroxide pellets (Na(OH); 99%, Merck), commercial solid silica (SiO_2; 99%, Merck), ammonium nitrate (NH_4NO_3; 99%, Merck), and sodium aluminum oxide ($NaAlO_2$; 99%, Merck) were purchased. Linear low density polyethylene (LLDPE) was donated from Jam Petrochemical Company, Iran. Commercial NaY zeolite with physical properties of the surface area (S_{BET}): 840 m^2/g, external surface area (S_{ext}): 9.4 m^2/g, SAR: 10.72, total pore volume (V_t): 0.36 cm^3/g, and micropore volume (V_{micro}): 0.32 cm^3/g was purchased from a Chinese company. A kaolin was donated from an Iranian company which its composition is given below (**Table S1**).

1-2- Preparation of the seed and extracted silica for the synthesis of NaY Zeolites

The kaolin initially was converted into metakaolin by its calcination at 800 °C for 6 h. The obtained metakaolin and kaolin were characterized by TGA, dTGA, and powder XRD techniques as they have been given in **Figure S1**. The metakaolin was then used to extract its silica by treatment in Na(OH) solution 2M at 180°C for 6 h. The chemical composition of the extracted silica, filter cake, and kaolin were analyzed by the XRF technique (**Table S1**). The extracted silica solution was used for the synthesis of FAU-type zeolite in this study. The seed used in the synthesis was ball-milled as it further accelerates crystallization rate and induces its properties in the resultant zeolites.[1]

Ball-milled seed was obtained from milling 80 grams of commercial zeolite with 34 balls (2 mm) at a speed of 200 rpm for 4 hours and then used for the synthesis of the FAU-type zeolite. The ball-milled seed was characterized by the powder XRD, FTIR, FE-SEM imaging, XRF, and N_2 sorption techniques (**Figure S2**). The XRD pattern of the ball-milled seed presented all the related diffraction peaks of the FAU-type structure but the relative crystallinity (RC) was decreased to 59.9% (**Figure S2A**). The N_2 adsorption isotherms of the seed presented typical isotherms for microporous materials but with smaller physical properties of total surface area (S_{BET}: 670 vs 840 m^2/g), total pore volume (pore volume: 0.30 vs 0.36 cm^3/g), and enhanced external surface area of Sext: 13.72 vs 9.35 m^2/g (**Figure S2B**). The FTIR spectra of the ball-milled seed showed characteristic absorption bands related to the FAU-type structure (**Figure S2C**). Despite preserved micro-structure, the morphology of the ball-milled seed turned into aggregates of smaller rounded irregular particles (**Figure S2E** *vs* **S2D**).

1-3- Synthesis of FAU-type zeolite from kaolin

Extracted silica (100 ml) was placed in an ice bath and after the temperature of the solution reached 4°C, an aluminum solution containing 6.23 g of sodium aluminate and 27 mL of water was added dropwise. Then, from 0.6 grams of the ball-milled seed was added to the resulting gel. Molar composition of the resulting gel was equal to **1 SiO_2: 0.167 Al_2O_3: 1.85 Na_2O: 0.0131 K_2O: 0.008 CaO: 84.50 H_2O.** The resultant gel was aged under vigorous stirring at room temperature for 24 h. Crystallization was done at 50°C in 24 h. After filtration and washing until pH=7, the sample was dried overnight at 80°C. The obtained sample was named NaY-BS.

Ion exchange of the sample, NaY was conducted with 1 M ammonium nitrate solution at 80°C for 4 hours (15 mL of ammonium nitrate solution per 1 gram of zeolite). This process was repeated three times and then calcined at 500°C for 6 h. The ionized exchange sample was named HY-BS.

2- Characterization

Powder X-ray diffraction (PXRD) was performed on the samples for phase identification and purity analysis of crystalline materials on an X-ray diffractometer, Bruker AXS-DB advance by Cu K_α radiation (λ = 1.5418 Å). The relative crystallinity (RC) of the samples was obtained by calculating the total area of the XRD peaks in the 2θ of 15.7, 18.7, 20.4, 23.7, 27.1, 30.8, 31.5 and 34.2° compared to the same peaks of the reference zeolite Y.[2] Morphology and size of the zeolites were investigated using a field emission scanning electron microscopy (FE-SEM) model

MIRA III TESCAN, Czech Republic. Fourier transformation infra-red spectrometry (FT-IR) of the samples was conducted on a Perkin Elmer–Spectrum 65 by the KBr technique. The physical properties of the NaY zeolites and the corresponding HY form were measured by N_2 sorption The N_2 sorption isotherms measurements of the zeolite samples were carried out on a Bellsorp Mini II, Bell, analyzer at 77 K after degassing the samples at 300 ˚C for 5 h under N_2 flow unless mentioned. The surface area was determined by the Brunauer–Emmett–Teller (BET) method. The external surface area and micropore volume were determined from the slope and the intercept of the *t*-plot, respectively. The pore size distribution (PSD) was obtained from both adsorption isotherm by Barrett-Joyner-Halenda (BJH) method [3] Thermal gravimetric analysis (TGA) of the samples were conducted on a Netzsch-TGA 209 F1 in different temperatures ramp (°C/min) and under flow of N_2 or air. The chemical composition of the solid samples was measured on X-ray fluorescence spectrometry (XRF), Model PHILIPS, PW1410. Transmission electron microscopy (TEM), high-resolution TEM (HRTEM) and EDX elemental maps were acquired using an FEI Tecnai G2 F20 at 200 kV. The Bronsted acidity and basicity of the samples were measured by NH_3-TPD and CO_2-TPD technique, respectively. The NH_3 temperature programmed desorption (NH_3-TPD) was conducted on a Quantachrome ChemBET 3000 to measure the Bronsted acidity of the samples. For this, degassing was initially conducted at 300 °C for 1 h, NH_3 adsorption was done at 110 °C by gas flow 5% NH_3/He, and then NH_3 desorption was conducted in the range from room temperature to 800 ºC. In case of CO_2-TPD, degassing was conducted under flow of N_2 10 ml/min for 1 h and then CO_2 adsorption was conducted at 50 °C for 30 min, and CO_2 desorption was conducted under flow of He (10 ml/min) at the temperature ramp of 10 °C/min from the room temperature to 900 °C.

The pyridine infrared spectroscopy (Py-IR) measurements were conducted on Fourier infrared spectrometer, Bruker Company with 32 scanning times and a resolution of 4 cm^{-1}. For that, each sample was pressed into a 13 mm self-supporting sheet and placed in the in-situ pool of the infrared spectrometer. The sample was vacuumed to 10^{-3}Pa at 400℃ for 1 h, so that air on the sample surface were desorbed, and then the sample was cooled to room temperature. After equilibrating with pyridine for 30 min, the temperature was raised to 200 ℃, vacuumed again to 10^{-3} Pa, kept for 30 min, cooled to room temperature, and scanned in the range of 1400 ~ 1700 cm^{-1} wave number. The infrared spectra of pyridine adsorption then were recorded at 200 ℃ and 350 ℃, and the corresponding spectrum were collected for analysis. The 1540 and 1450 cm^{-1} bands were selected for calculation of Bronsted acidity and Lewis acidity content.

3- Catalytic test to determine product selectivity

The zeolite synthesized from extracted silica (**HY-BS**) and a commercial reference Y zeolite (HY zeolite) were used in LLDPE cracking. For the purpose of the higher intimacy of polymer and catalysts, the LLDPE pellets were crushed into a fine powder using a hammer mill under liquid N_2 at 77 K and the test samples were prepared by grinding the LLDPE powder and zeolite in a weight ratio of 60:40 in a hand mortar and pestle for 5 min. The LLDPE cracking by the zeolites was conducted in a glass reactor using one gram of the test samples at 550 °C for 30 min reaching full conversion and then gas, liquid, and solid containing coke were collected (**Figure S3**). The obtained fractions, gas, liquid, and solid residue were analyzed by the related technique. The light olefins ($C_2^=$-$C_4^=$), light alkanes (C_1-C_4) as well as C_5 of the collected gas were analyzed by injecting the gas samples in a gas chromatograph (GC) Varian, Model CP-3800 with FID detector equipped with a Bruker column, Model CP7576, length 25m, O.D 0.25 mm coated by Al_2O_3/KCl using helium as carrier gas. The peak position of each component already was determined by injecting its pure and their mixture into the GC-Mass. The yield of each component was obtained from its peak intensity from the GC spectra. The light olefins (LO)/light alkanes (LA) was calculated to determine quality of the gas fraction. The hydrogen transfer coefficient (HTC) was measured as reported previously by HTC = (n-C_4 + i-C_4)/$C_4^=$.[5] The liquid composition was determined by injecting oil samples in a GC-2010 using a VF-1MS capillary column (15 m length and 0.25 mm film thickness) and by a GC-Mass. The yield of each component of the liquid oil was obtained from its peak intensity. The deposited coke, total coke on the zeolites was measured by the TGA technique under air flow (10 ml/min) at the heating ramp of 10 °C/min from 30-900 °C and the hard coke (coke) was determined from weight decrease of the samples in the temperature range of 200-900 °C.

The gas, liquid oil, and coke yields were calculated as follows:

gas yield (%) = $(m_{LLDPE} - (m_{liquid\ oil} + m_{total\ coke}))/m_{LLDPE}) \times 100$;

liquid oil yield (%) = $(m_{liquid\ oil}/m_{LLDPE}) \times 100$;

and (hard)coke (%) = ($m_{(hard)coke}/m_{LLDPE}$) × 100, where m stands for the mass of the component. Yield of the component of the gas fraction was defined as Yield (%) = yield of gas fraction (%) × yield of the component from GC by intensity.

4- Thermogravimetric analysis (TGA) of LLDPE and LLDPE in the presence of Zeolite for Kinetic study

The TGA of the sole LLDPE and that with zeolites was conducted on a Netzsch-TGA 209 F1 at varying temperature rates of 5, 10, and 20 °C/min from 30-600 °C under N_2 flow at a rate of 10 ml/min. For each test reaction, 10 mg of the test sample (LLDPE: zeolite: 60:40) was used. Using TGA analysis, the activation energy value was calculated at different conversion percentages by kinetic analysis. The maximum temperature for 50% decrease in the weight of LLDPE, index T50, was used as catalytic activity descriptor.[4]

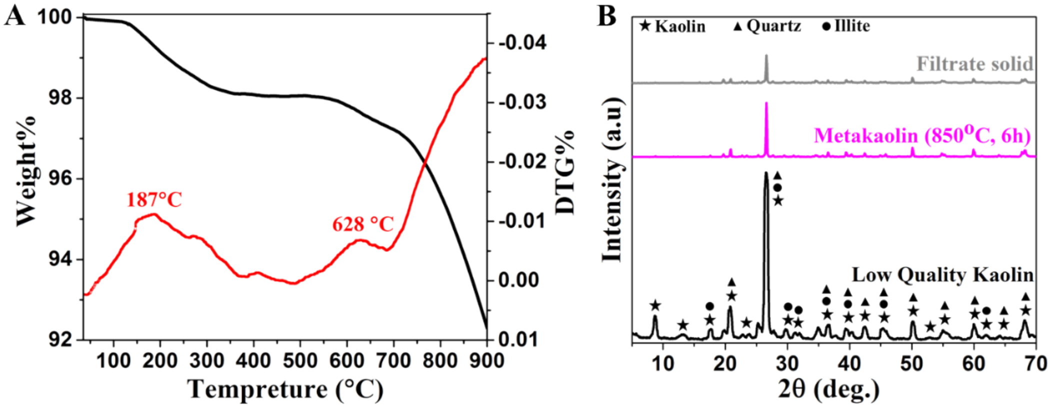

Figure S1. (A) TGA and dTGA of kaolin and (B) XRD pattern of kaolin, metakaolin and filtrate solid.

Table S1. The XRF analysis of kaolin, Filtrate cake, Spray-dried of extracted silica, reference NaY zeolite, and NaY-BS

Material	Components (wt.%)										
	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	MgO	TiO_2	SAR[a]	P_2O_5	LOI
Kaolin	75.90	15.02	0.068	0.547	0.333	4.72	0.269	0.187	17.2	0.04	2.16
Filtrate cake	62.02	28.0	0.599	0.420	1.504	6.45	0.214	0.243	3.76	0.043	0.13
Spray-dried of extracted silica	21.3	0.21	N	1.005	32.57	0.107	N	0.024	172	0.025	44
zeolite NaY	61.09	19.72	0.16	0.15	12.06	0.03	N	0.06	10.72	N	6.25
NaY-BS	32.76	24.61	0.01	0.37	15.62	0.08	N	0.021	4.33	N	24.77

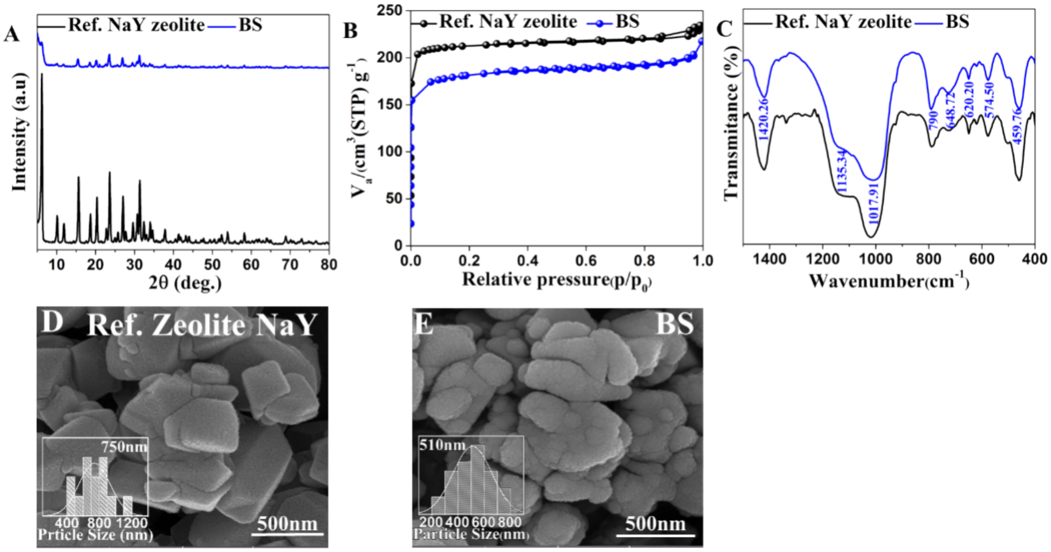

Figure S2.A) XRD pattern, B) N_2 sorption isotherms, C) FTIR spectra, D) and E) SEM image of the reference NaY zeolite and ball-milled seed.

Table S2. Physical and chemical properties of the reference HY zeolite, seed, and the HY-BS

Sample	S_{BET} (m^2/g)	S_{micro} (m^2/g)	S_{ext} (m^2/g)	V_t (cm^3/g)	V_{micro} (cm^3/g)	V_{meso} (cm^3/g)	SAR_{xrd}	SAR_{xrf}	RC (%)	Particle size (nm)	NH_3-TPD	CO_2-TPD
Ref. zeolite HY	840.18	-	9.35	0.36	-	-	10.72	10	100	750	2931	735
HY-BS	326.82	238.99	87.83	0.25	0.15	0.1	4.22	4.33	42.7	435	1100	957.2

Table S3. NH_3-TPD and CO_2-TPD of the reference HY zeolite and the HY-BS zeolite.

Sample	Temp. range (ºC)	NH_3 desorption (µmole/g-catalyst)	Maximum desoption temperatures (°C)	Temp. range (ºC)	CO_2 desorption (µmole/g-catalyst)	Maximum desoption temperatures (°C)
Ref. zeolite HY	104-255	876.13	201	46-220	13.1	125
	255-350	979.6	288	220-700	722.59	435
	350-600	1139.2	394	46-700	735.69	125, 435
	104-600	2994.9	201, 288, 394	-	-	-
HY-BS	107-335	362.5	175,214,273	45.3-220	10.8	107
	335-500	390.4	452	220-700	946.4	318, 455, 578
	500-700	347.7	568	45.3-700	957.2	107, 318, 455, 578
	104-700	1100.6	175, 214, 273, 452, 568	-	-	-

Table S4. Pyridine-IR spectroscopy of the reference HY and HY-BS zeolites at room temperature, 200, and 350 °C.

Catalyst	**Tem (℃)**	**BAS content (µmole/g)**	**LAS content (µmole/g)**	**Total acidity content (µmole/g)**	**LAS/ BAS**	**BAS density (µmole/m^2)**	**LAS density (µmole/m^2)**	**Total acidity (µmole/m^2)**
Ref. HY zeolite	r.t	777.4	166.9	944.3	0.2	0.93	0.20	1.12
	200	611.3	95.1	706.3	0.16	0.73	0.11	0.84
	350	361.3	37.8	399.0	0.10	0.43	0.04	0.48
HY-BS	r.t	428.6	348.7	777.3	1.1	1.31	1.1	2.40
	200	246.6	193.7	440.3	1.0	0.75	0.59	1.34
	350	137.3	98.7	236.1	0.96	0.42	0.30	0.73

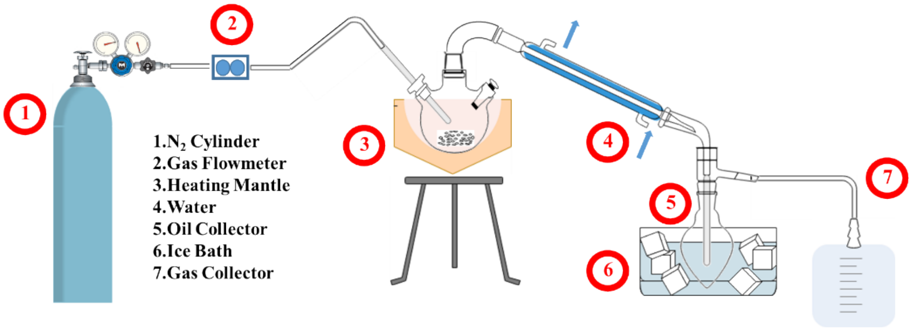

Figure S3. Schematic of homemade catalytic pyrolysis of LLDPE by the zeolites.

Table S5. Gas composition (%) by intensity of LLDPE cracking by the reference HY zeolite and HY-BS.

Catalysts **Component (%) by peak intensity**	**Ref. zeolite HY**	**HY-BS**
Ethene	1.42	0.32
Ethene yield	1.02	0.24
Propylene	8.56	11.74
Propylene yield	6.16	8.85
Ethene+ Propylene	9.98	12.07
Propylene/Ethene	6.03	36.39
2-butene tra	3.48	6.36
1-butene	2.02	3.43
Iso butene	4.48	14.29
2-butene Cis	2.52	4.43
Total butenes	12.5	28.52
Total butenes yield	8.99	21.41
C1+C2+C3	4.49	0.55
C4	19.87	10.03
C5	19.89	8.73
C5 yield	14.32	6.55
Light alkenes	22.48	40.59

Light alkenes yield	16.18	30.47
Light alkane	24.36	10.58
Alkanes yield	17.54	7.94
Alkenes/Alkane	0.92	3.84
HTC=(nC4+iC4)/C4=	1.59	0.35
Total Coke %	19.68	14.92%
Coke%	17.50%	16.5%
liquid	8.33%	10%
Gas	71.99%	75.08%

Table S6. Chemical composition (%) by intensity of the liquid oils obtained by HY zeolite and HY-BS.

Sample name	Material name	Type	Area %
Ref. Zeolite Y	**Heavy aromatics**	Naphthalene, 1-methyl-Naphthalene, 2-methyl-Naphthalene, 1,2,3,4-tetrahydro Naphthalene, 2-ethyl-Naphthalene, 1,4-dimethyl-Naphthalene, 1,6-dimethyl-Naphthalene, 2,3-dimethyl-Naphthalene, 2,7-dimethyl-Naphthalene , 1,3-dimethyl-Naphthalene, 2-(1-methylethyl)-Naphthalene , 2,3,6-trimethyl-Naphthalene , 1,6,7-trimethyl-Naphthalene, 1,4,6-trimethyl-Naphthalene, 1,4,5-trimethyl-Naphthalene, 1,4,5,8-Tetramethylnaphthalene, 1,2,3,4-tetramethyl-Naphthalene, 1,2-Bis(trimethylsilyl)benzene, 1,2,3,5-tetramethyl-Benzene, 1,2,4,5-tetramethyl-Benzene, 1,2,4,5-tetramethyl-Benzene, 1-ethyl-2,4,5-trimethyl-Benzene, 1,2-diethyl-3,4-dimethyl-Benzene, 1,2-bis(1-methylethyl)-Benzene, 1,3,5-triethyl-Benzene, pentamethyl-Benzene, hexamethyl-Benzene	**76.27**
	alkane	2,5,8,11-Tetraoxadodecane	**1.24**
	alkene	4,4-dimethyl-2-Pentene, 1-propoxy-1-Propene, Cyclopentene	**1.02**
HY-BS	**Heavy aromatics**	1-methyl-Naphthalene, 2-methyl-Naphthalene, 2-ethyl-Naphthalene, 2,6-dimethyl-Naphthalene, 1,7-dimethyl-Naphthalene, 1,3-dimethyl-Naphthalene, 2,3-dimethyl-Naphthalene, 2,3,6-trimethyl-Naphthalene, 1,6,7-trimethyl-Naphthalene, 1,4,5,8-Tetramethylnaphthalene, 1,2,3,4-tetramethyl-Naphthalene, Benzene, 1-ethyl-3-methyl- Benzene, 1,2,3-trimethyl- Benzene, 1-ethyl-3,5-dimethyl- Benzene, 1-ethyl-2,3-dimethyl-Benzene, 1-ethyl-2,4-dimethyl- Benzene, 4-ethyl-1,2-dimethyl- Benzene, 1-ethyl-2,4,5-trimethyl- Benzene, 1,2,3,5-tetramethyl- Benzene, 1,2,4,5-tetramethyl- Benzene, 2,4-diethyl-1-methyl- Benzene, pentamethyl-Benzene, 1,3,5-trimethyl-2-propyl- Benzene, (3-methyl-2-butenyl)-Benzene, Toluene, Styrene,	**55.35**
	alkane	Decane, 5-methyl-Decane, 4-methyl-Decane, 2-methyl-Decane, 3-methyl-	**20.53**

		Decane, 4-ethyl-Decane, ,7-dimethyl- Decane, 3,8-dimethyl- Decane, 5-Ethyldecane, Hexadecane, 10-Methylnonadecane, Undecane, 4-methyl-Undecane, 2-methyl- Undecane, Dodecane, 2-methyl-Dodecane, 3-methyl-Dodecane, 4-methyl-Dodecane, 2-methyl-Tridecane, Tetradecane,	
	alkene	2-Pentene, Azulene	**1.27**

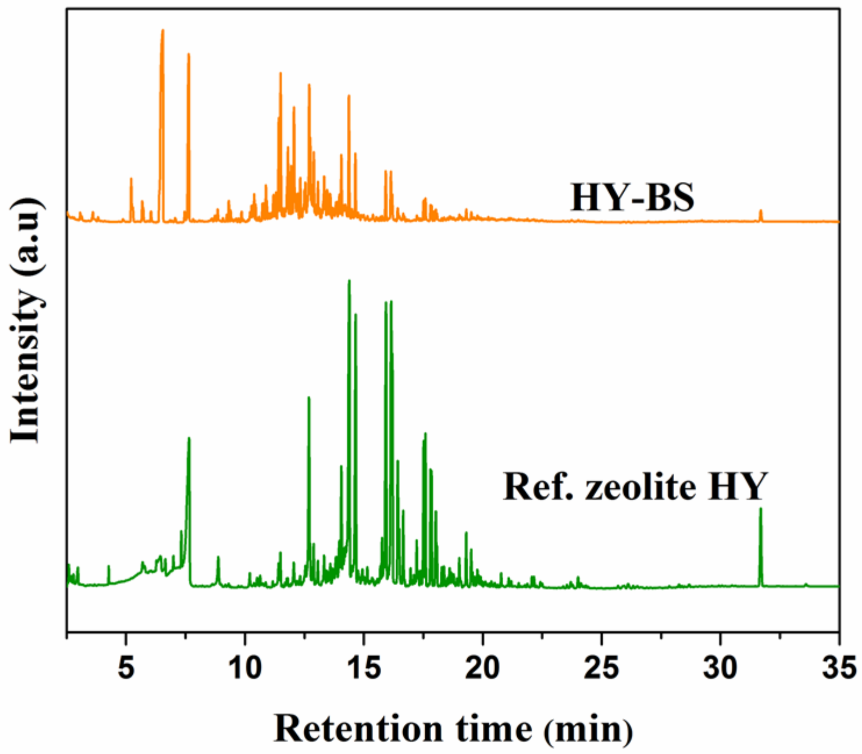

Figure S4. GC-mass spectra of catalytic cracking liquid oil by HY zeolite and HY-BS.

Table S7. Thermal and catalytic pyrolysis characteristics of LLDPE.

Sample	**Heating rate (°C min^{-1})**	**TS (°C)^{a}**	**Tmax (°C)^{b}**	**TF (°C)^{c}**
LLDPE	5	383	459	494
	10	397	461	507
	20	402	470	518
LLDPE + HY zeolite	5	191	359	414
	10	206	379	429
	20	213	403	448
LLDPE + HY-BS	5	275	378	410
	10	280	382	420
	20	285	387	440

[a]: The temperature at which LLDPE degradation was initiated. [b]: The temperature at which 50 wt% of LLDPE was decreased. [c]: The temperature at which LLDPE degradation was complete.

Table S8. Activation Energy value of LLDPE pyrolysis with the FWO, KAS, Tang, Starink, and Friedman method.

	FWO		**KAS**		**Tang**		**Starink**		**Friedman method**	
α	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**
0.2	308.00	0.9705	312.1	0.9683	312.29	0.9684	312.35	0.9684	304.44	0.9818
0.3	302.63	0.9803	306.4	0.9788	306.55	0.9789	306.60	0.9789	264.41	0.9652
0.4	298.37	0.9852	301.8	0.9841	301.98	0.9841	302.03	0.9841	289.89	0.9947
0.5	295.30	0.9892	298.5	0.9884	298.67	0.9884	298.72	0.9884	302.93	0.9988
0.6	293.73	0.9923	296.74	0.9917	296.94	0.9917	296.99	0.9917	296.64	0.9986
0.7	292.11	0.9943	294.95	0.9938	295.17	0.9939	295.20	0.9939	266.20	0.9998
0.8	287.79	0.9964	290.29	0.9962	290.53	0.9962	290.56	0.9962	308.82	1.0000
0.9	284.21	0.9988	286.42	0.9987	286.66	0.9987	286.69	0.9987	271.45	0.9995
average	**295.27**	**0.9883**	**298.39**	**0.9875**	**298.60**	**0.9875**	**298.64**	**0.9875**	**288.10**	**0.9923**

Table S9. Activation Energy value of LLDPE pyrolysis in the presence of the reference HY zeolite with the FWO, KAS, Tang, Starink, and Friedman method.

	FWO		**KAS**		**Tang**		**Starink**		**Friedman method**	
α	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**	**E(kj mol^{-1})**	**R^2**
0.2	18.24	0.9428	10.81	0.8555	11.23	0.8643	11.13	0.8626	11.60	0.9392

0.3	34.93	0.998	27.15	0.9973	27.61	0.9974	27.51	0.9974	56.42	0.9998
0.4	45.10	0.9987	37.39	0.9984	37.86	0.9984	37.76	0.9984	70.40	0.9921
0.5	59.74	0.9999	52.45	0.9999	52.92	0.9999	52.83	0.9999	114.87	1.0000
0.6	75.46	0.9995	68.74	0.9992	69.20	0.9992	69.11	0.9992	130.50	0.9958
0.7	88.45	0.9991	82.21	0.9987	82.66	0.9987	82.58	0.9987	119.17	0.9934
0.8	101.25	0.9987	95.50	0.9983	95.95	0.9984	95.87	0.9984	141.28	0.9979
0.9	117.94	0.9989	112.86	0.9985	113.29	0.9986	113.22	0.9986	164.87	1.0000
average	**67.64**	**0.992**	**60.89**	**0.9807**	**61.34**	**0.9819**	**61.25**	**0.9817**	**101.14**	**0.9898**

Table S10. Activation Energy value of LLDPE pyrolysis in the presence of HY-BS with the FWO, KAS, Tang, Starink, and Friedman method.

	FWO		**KAS**		**Tang**		**Starink**		**Friedman method**	
α	**E(kJ mol^{-1})**	**R^2**	**E(kJ mol^{-1})**	**R^2**	**E(kJ mol^{-1})**	**R^2**	**E(kJ mol^{-1})**	**R^2**	**E(kJ mol^{-1})**	**R^2**
0.2	97.72	0.9794	92.58	0.9744	92.98	0.9748	92.91	0.9747	160.43	0.999
0.3	135.67	0.9761	132.23	0.9722	132.59	0.9724	132.54	0.9723	208.76	0.992
0.4	168.10	0.9764	166.20	0.9732	166.51	0.9734	166.49	0.9734	257.09	0.9935
0.5	201.21	0.9767	200.91	0.9741	201.18	0.9743	201.18	0.9743	301.65	0.9922
0.6	237.78	0.9694	239.29	0.9666	239.5	0.9668	239.94	0.9667	346.23	0.9650
0.7	271.15	0.9373	274.28	0.9325	274.45	0.9328	274.5	0.9327	363.81	0.8656
0.8	284.62	0.8545	288.35	0.8449	288.52	0.8455	288.56	0.8453	327.52	0.6855

0.9	273.85	0.7621	276.93	0.7476	277.11	0.7484	277.15	0.7482	260.25	0.6069
average	**208.76**	**0.929**	**208.85**	**0.9232**	**209.11**	**0.9236**	**209.16**	**0.9235**	**278.22**	**0.8875**

Table S11. Thermodynamic parameters of solo LLDPE pyrolysis.

α	**E (kJ mol$^{-1)}$**	**A (S^{-1})**	**R^2**	**ΔH (kJ mol^{-1})**	**ΔG (kJ mol^{-1})**	**ΔS (J mo1^{-1}.K^{-1})**
0.2	308.00	9.52E+19	0.9705	301.90	212.53	121.75
0.3	302.63	3.88E+19	0.9803	296.53	212.64	114.29
0.4	298.37	1.901E+19	0.9852	292.27	212.73	108.37
0.5	295.30	1.14E+19	0.9892	289.20	212.79	104.09
0.6	293.73	8.76E+18	0.9923	287.63	212.82	101.92
0.7	292.11	6.68E+18	0.9943	286.01	212.86	99.66
0.8	287.79	3.24E+18	0.9964	281.69	212.95	93.65
0.9	284.22	1.78E+18	0.9988	278.11	213.03	88.68
average	**295.27**	**2.31E+19**		**289.17**	**212.79**	

Table S12. Thermodynamic parameters of catalytic pyrolysis of LLDPE by acidic HY zeolite.

α	**E (kJ mol$^{-1)}$**	**A (S^{-1})**	**R^2**	**ΔH (kJ mol^{-1})**	**ΔG (kJ mol^{-1})**	**ΔS (J mo1^{-1}.K^{-1})**
0.2	18.24	2.49E-02	0.9428	12.82	202.19	-290.44
0.3	34.93	1.04E+00	0.998	29.51	198.66	-259.45
0.4	45.10	8.72E+00	0.9987	39.68	197.28	-241.72
0.5	59.74	1.72E+02	0.9999	54.32	195.75	-216.92
0.6	75.46	3.96E+03	0.9995	70.04	194.49	-190.87
0.7	88.45	5.09E+04	0.9991	83.03	193.63	-169.63
0.8	101.25	6.18E+05	0.9987	95.83	192.90	-148.88
0.9	117.94	1.57E+07	0.9989	112.52	192.07	-122.00
average	**67.64**	**2.05E+06**		**62.22**	**195.90**	

Table S13. Thermodynamic parameters of catalytic pyrolysis of LLDPE by the acidic-basic HY-BS.

α	**E(kJ mol^{-1})**	**A(S^{-1})**	**R^2**	**ΔH (kJ mol^{-1})**	**ΔG(kJ mol^{-1})**	**ΔS(J mo1^{-1}.K^{-1})**
0.2	97.72	1.70E+07	0.9794	92.28	194.05	-155.38

0.3	135.67	2.51E+10	0.9761	130.23	192.26	-94.71
0.4	168.10	1.20E+13	0.9764	162.65	191.10	-43.43
0.5	201.21	6.28E+15	0.9767	195.76	190.12	8.62
0.6	237.78	6.13E+18	0.9694	232.34	189.21	65.85
0.7	271.15	3.20E+21	0.9373	265.70	188.49	117.88
0.8	284.62	3.99E+22	0.8545	279.17	188.23	138.85
0.9	273.85	5.30E+21	0.7621	268.40	188.44	122.08
average (0.2-0.9)	**208.76**	**6.05E+21**		**203.32**	**190.24**	

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