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APPENDICES

Appendix A Calculation

A.1 Weight average of standard refinery gas

$$\overline{MW} = \frac{\sum G_i \times (MW)_i}{\sum G_i}$$

From $PV_i = nRT$ and $n_i = \frac{G_i}{(MW)_i}$

Thus, $PV_i = \frac{G_i}{(MW)_i} RT$

$$G_i = V_i (MW)_i \times \frac{P}{RT}$$

Hence, $\sum G_i \times (MW)_i = \frac{V_i (MW)_i}{\sum V_i (MW)_i}$

A.2 Response factor (Schomberg, 1990)

Response factors for FID (Flame Ionization Detector) were calculated on the weight basis as shown in the following equation using methane as the standard component.

$$f_i = \frac{A_{std}}{A_i} \times \frac{G_i}{G_{std}} \times f_{std}$$

Where f_i is the response factor of the component

f_{std} is the response factor of the standard

A_i is the area of component

A_{std} is the area of standard

G_i is the mass of the component

G_{std} is the mass of the standard, which is methane in this case

$$\text{From } G_i = V_i (MW)_i \times \frac{P}{RT}$$

$$\text{So, } \frac{G_i}{G_{std}} = \frac{V_i (MW)_i}{V_{std} (MW)_{std}}$$

The mass fraction (m_i) of any component, m_i can be calculated as the following equation

$$m_i = \frac{A_i \times f_i}{\sum A_i \times f_i}$$

$$\text{Thus, } m_i = \frac{A_i \left[\frac{A_{std}}{A_i} \times \frac{G_i}{G_{std}} \times f_{std} \right]}{\sum A_i \left[\frac{A_{std}}{A_i} \times \frac{G_i}{G_{std}} \times f_{std} \right]}$$

Therefore,

$$m_i = \frac{G_i}{\sum G_i}$$

Volume fraction (V)

From $V = \frac{V_i}{\sum V_i}$ and

$$PV_i = \frac{G_i}{(MW)_i} RT$$

$$V_i = \frac{G_i}{(MW)_i} \times \frac{RT}{P}$$

Hence,
$$V = \frac{\frac{G_i}{(MW)_i} \times \frac{RT}{P}}{\sum \frac{G_i}{(MW)_i} \times \frac{RT}{P}}$$

From $m_i = \frac{G_i}{\sum G_i}$

So,

$$V = \frac{\frac{m_i}{(MW)_i}}{\sum \frac{m_i}{(MW)_i}}$$

Appendix B Raw data

B.1 Effect of using superacid catalyst (SO_4^{2-} / commercial ZrO_2) on pyrolyzed products

Table B1 Pyrolyzed gas product of PE with the catalyst to polymer ratio 1:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.12859588	10.46319296	10.57446648	11.40466238	11.87445528
Ethylene	18.30593071	19.18069307	19.16977952	21.07634425	22.34677851
Ethane	11.63645877	11.34397782	11.57349224	12.13917168	11.32410018
Propylene	13.67682686	13.27208175	13.60018313	14.30792464	13.87917124
Propane	5.858520131	4.809435638	5.001823743	4.142186377	3.538619173
C4	14.52460019	13.68052959	13.89690567	13.3855744	13.2866526
C5	9.447810947	10.4072336	10.20824168	9.587948887	9.517381835
C6	10.94501094	10.92198839	10.60314817	10.14849745	9.541274834
C7	4.6064556	4.886277105	4.493358546	2.954338868	3.865965172
C8	0.869789977	1.034590083	0.878600822	0.853351069	0.825601179

Table B2 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 1:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.626513125	1.606523005	1.834516268	1.605179424	1.49266109
7	1.96620143	2.033351299	2.180525457	1.873855865	1.927898473
8	2.333113931	2.499014046	2.544802994	2.250275564	2.412459896
9	2.719055816	2.983338131	2.917333407	2.649396066	2.92545501
10	3.113414409	3.461157711	3.2861847	3.058837638	3.439306906
11	3.503370935	3.905109819	3.638064079	3.463423756	3.922886257
12	3.874389644	4.289196314	3.959146398	3.846035415	4.345791095
13	4.211039654	4.592324634	4.236135503	4.188934527	4.682774866
14	4.49814861	4.800979243	4.457448215	4.475447115	4.917196097
15	4.72219674	4.910426362	4.614346643	4.691765278	5.042669502
16	4.872757328	4.924311877	4.701814913	4.828533025	5.062701491
17	4.943715554	4.852970798	4.719003005	4.881877427	4.988704149
18	4.933994611	4.711043366	4.669144225	4.853655103	4.837145947
19	4.847606266	4.515022595	4.558969796	4.75087561	4.626628934
20	4.693002104	4.281197464	4.397753606	4.584467121	4.375465832
21	4.481874336	4.02422069	4.196185956	4.367688927	4.100025449
22	4.227675572	3.7563212	3.965279833	4.114527556	3.813853723
23	3.944155716	3.487049829	3.715466787	3.838346713	3.527421113
24	3.644155004	3.223395232	3.455966352	3.550940754	3.248292416
25	3.338783234	2.970112219	3.194441293	3.262019202	2.981529011
26	3.037003551	2.730138559	2.936898932	2.97906155	2.730179112
27	2.745558205	2.505017121	2.68777263	2.707438135	2.495762646
28	2.469134872	2.295275996	2.450113389	2.450690284	2.278700079
29	2.210669149	2.100745475	2.225831633	2.21087256	2.078664688
30	1.97169758	1.920807567	2.015945302	1.988903641	1.894856317
31	1.752702259	1.754583055	1.820806818	1.784877342	1.726204357
32	1.553413482	1.601065272	1.640295039	1.598322577	1.571511689
33	1.373056444	1.45921092	1.473967969	1.428406441	1.429551866
34	1.210540908	1.327997642	1.32117805	1.27408503	1.299130727
35	1.064599842	1.206456766	1.181155017	1.134210066	1.179121835
36	0.933886059	1.093688115	1.053062464	1.00760042	1.06848322

37	0.817036265	0.988862217	0.936034193	0.893087082	0.96626122
38	0.712710951	0.891214452	0.829195701	0.789538853	0.871585677
39	0.619616998	0.80003286	0.731675088	0.695874539	0.783659618
40	0.536518179	0.714643776	0.642606595	0.611065943	0.701745531
41	0.462237189	0.634394468	0.561128919	0.534134694	0.625149617
42	0.395651539	0.558634636	0.486379537	0.464144810	0.553204763
43	0.335684544	0.486696364	0.417485438	0.400192098	0.485252445
44	0.28125171	0.417872011	0.353549939	0.341390531	0.420623336
45	0.231442015	0.351388897	0.293634515	0.286855459	0.358615886
46	0.185092694	0.286378965	0.236733814	0.235682406	0.298471725
47	0.141155131	0.221840827	0.181741035	0.186919862	0.23934613
48	0.098448039	0.156590508	0.127399516	0.139533373	0.180271097
49	0.055632106	0.0891958	0.072234507	0.092357047	0.120107624
50	0.011117162	0.017887077	0.014456241	0.044026766	0.05748245

Table B3 Pyrolyzed gas product of PE with the catalyst to polymer ratio 2:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	8.029259714	9.751591201	7.939055293	6.76909442	11.21459618
Ethylene	12.96458368	16.88592781	12.73119961	10.57483662	19.19678472
Ethane	12.36143675	11.98024661	10.94300457	10.76478147	12.47442633
Propylene	13.22665071	13.89697043	13.0882309	12.52329513	13.22815445
Propane	8.536085329	5.949942638	8.013113477	8.720317194	4.875630827
C4	15.05443742	12.515476	15.24571018	15.97071513	13.61906402
C5	12.08967686	10.45032159	11.79053589	12.58618895	10.17846854
C6	12.11504155	11.75690358	12.72053984	13.63353994	10.19839085
C7	3.834677262	5.667388018	6.254557259	7.049720874	4.245760112
C8	1.788150732	1.145232121	1.274052968	1.407510281	0.768723963

Table B4 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 2:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.854086777	1.296422926	1.512294433	1.358185205	1.49266109
7	2.191657304	1.760381982	1.849981177	1.836855299	1.927898473
8	2.547231114	2.294633577	2.219642097	2.376678538	2.412459896
9	2.911951641	2.872736023	2.613114452	2.945948798	2.92545501
10	3.275133107	3.45762778	3.019234823	3.50484829	3.439306906
11	3.624620846	4.007013624	3.424050376	4.012216717	3.922886257
12	3.947393257	4.480554687	3.811418958	4.432772556	4.345791095
13	4.23041262	4.846738046	4.164056002	4.742603807	4.682774866
14	4.461674189	5.087417576	4.464997288	4.931568438	4.917196097
15	4.63133274	5.199005826	4.699321315	5.002509521	5.042669502
16	4.732726759	5.190572675	4.855851645	4.968212676	5.062701491
17	4.763100867	5.080016727	4.928493718	4.847431166	4.988704149
18	4.723865992	4.889714569	4.916898749	4.661121862	4.837145947
19	4.620330763	4.642738986	4.826295173	4.429563789	4.626628934
20	4.460957931	4.360197121	4.666538125	4.170558539	4.375465832
21	4.256303828	4.059759296	4.450618652	3.898593642	4.100025449
22	4.017851816	3.755160309	4.192975735	3.624708499	3.813853723
23	3.756940604	3.456354254	3.907910807	3.35678909	3.527421113
24	3.483929398	3.170025832	3.608543047	3.100069715	3.248292416
25	3.207662846	2.900236555	3.305769257	2.857690392	2.981529011
26	2.935227516	2.649066452	3.008255367	2.631221447	2.730179112
27	2.671944639	2.41717845	2.722315059	2.421113057	2.495762646
28	2.421524411	2.204277837	2.452186575	2.227056997	2.278700079
29	2.186309181	2.009465795	2.200388426	2.048264255	2.078664688
30	1.967547225	1.831499134	1.968101382	1.883669757	1.894856317
31	1.765657235	1.668973134	1.755524103	1.732077733	1.726204357
32	1.580460684	1.520444512	1.562175419	1.592260776	1.571511689
33	1.411372376	1.384509535	1.387134515	1.46302385	1.429551866
34	1.257548271	1.259849573	1.229221481	1.343242464	1.299130727
35	1.117994676	1.145253657	1.087126374	1.231882172	1.179121835
36	0.991645141	1.039625258	0.959496853	1.128004873	1.06848322

37	0.877411878	0.941978584	0.844994247	1.030765971	0.96626122
38	0.774217961	0.851428187	0.742326575	0.939405364	0.871585677
39	0.681015543	0.767174497	0.650265378	0.853234367	0.783659618
40	0.596794165	0.688487058	0.567651474	0.77162002	0.701745531
41	0.520582114	0.614686515	0.493393296	0.693967701	0.625149617
42	0.45144278	0.545125891	0.426460174	0.619702513	0.553204763
43	0.388467124	0.479171239	0.365871921	0.548249545	0.485252445
44	0.330762627	0.416181326	0.310685242	0.479012721	0.420623336
45	0.27743845	0.355485642	0.259976781	0.411351597	0.358615886
46	0.227585853	0.29635957	0.212821918	0.344555034	0.298471725
47	0.180252248	0.237995062	0.168267719	0.277810177	0.23934613
48	0.134406272	0.179464493	0.125297498	0.210164574	0.180271097
49	0.088890043	0.119674497	0.08278316	0.14047842	0.120107624
50	0.042352893	0.057305381	0.039419649	0.06736286	0.05748245

B.2 Effect of using superacid catalyst (SO_4^{2-} / synthesized ZrO_2) on pyrolyzed products

Table B5 Pyrolyzed gas product of PE with the catalyst to polymer ratio 1:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.455547	8.02607914	7.774316524	10.66769528	9.290818299
Ethylene	19.4518173	14.0402267	13.25711706	19.32022278	17.21356795
Ethane	12.76735918	11.36105516	11.16388469	11.50390188	11.83603011
Propylene	14.25372458	13.38096188	13.62380831	13.91381516	13.69702655
Propane	5.058366983	7.07965039	7.953832059	4.683322438	5.535326709
C4	13.55262038	14.67148193	15.38988194	13.63577017	13.94026651
C5	9.473882986	11.2001671	11.36948589	9.816655661	10.46623697
C6	10.18063464	12.64642457	12.55250296	10.74299538	11.5085444
C7	4.03945596	6.323778743	5.829796101	4.772577775	5.431869718
C8	0.766590994	1.270174388	1.085374467	0.943043489	1.08031278

Table B6 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 1:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.691451143	1.153458397	1.466230171	0.493742381	1.54587505
7	2.064168278	1.544184679	1.870180306	1.056974133	1.961114107
8	2.472868666	2.008433317	2.325994713	2.018989959	2.427536744
9	2.909378976	2.537624104	2.820933542	3.155839841	2.931909626
10	3.362075282	3.113630973	3.335761327	4.321434144	3.454397721
11	3.815719211	3.708442476	3.845535002	5.323068361	3.969281246
12	4.251661266	4.28584452	4.32164991	6.034212973	4.446976173
13	4.648624797	4.805437151	4.73504795	6.415535492	4.857323573
14	4.984241357	5.228521695	5.060078961	6.496118643	5.173666334
15	5.237349268	5.524520722	5.278162581	6.341044136	5.37681772
16	5.390795084	5.676103596	5.380320377	6.023921838	5.457879302
17	5.434175197	5.681470711	5.367931559	5.610524004	5.419131313
18	5.365777775	5.553250667	5.25161177	5.152134626	5.272820835
19	5.193084178	5.314670955	5.048674469	4.684950786	5.038333304
20	4.931589233	4.994450208	4.779963312	4.232332897	4.738643884
21	4.602242276	4.6219286	4.466845151	3.807883318	4.396966489
22	4.228231891	4.223454523	4.128904789	3.418342232	4.034229566
23	3.831943383	3.820368819	3.782549994	3.065923964	3.667610568
24	3.432706633	3.428400406	3.444461681	2.7500433	3.31003556
25	3.045582973	3.058034704	3.111673735	2.468516788	2.970377166
26	2.6811041	2.715395802	2.802031681	2.218359896	2.654051518
27	2.345684912	2.403287746	2.51816492	1.99629314	2.363767485
28	2.042393116	2.122175893	2.251384959	1.799047956	2.100263773
29	1.771817135	1.87100373	2.01174161	1.623539563	1.862945922
30	1.532867452	1.647817188	1.795005647	1.466954119	1.650390874
31	1.323432129	1.4502106	1.599767364	1.326782372	1.460720523
32	1.140867438	1.27562614	1.424345146	1.200821082	1.29186227
33	0.98233833	1.121541998	1.266960908	1.087155988	1.141720048
34	0.845037672	0.985580853	1.125852766	0.984135052	1.008278706
35	0.726315297	0.865564067	0.999341775	0.89033736	0.889661191
36	0.623744255	0.759530672	0.885866513	0.804540903	0.784153849

37	0.535145804	0.665734748	0.78399609	0.725691081	0.690211215
38	0.45858896	0.582630496	0.692429372	0.652870874	0.606448367
39	0.392375484	0.508851071	0.609985878	0.58527305	0.531626327
40	0.335017442	0.443184938	0.535592012	0.522174414	0.464634045
41	0.285211723	0.384551895	0.468264896	0.4629118	0.404469093
42	0.241813962	0.331979786	0.407095098	0.406259328	0.350218154
43	0.203813047	0.28458215	0.351228692	0.353406208	0.301037663
44	0.170306476	0.241536499	0.299848574	0.301934175	0.256134389
45	0.140476212	0.202062463	0.252154352	0.251793359	0.214745301
46	0.113564171	0.165398637	0.207339704	0.202275007	0.176115604
47	0.088845989	0.130776469	0.16456546	0.152578996	0.13947333
48	0.065601037	0.097388906	0.122925982	0.10177335	0.103998226
49	0.043075796	0.064350548	0.081405312	0.048741912	0.068781686
50	0.020436221	0.030644667	0.038818071	0.039419649	0.032773078

Table B7 Pyrolyzed gas product of PE with the catalyst to polymer ratio 2:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.12859588	10.46319296	10.57446648	11.40466238	11.87445528
Ethylene	18.30593071	19.18069307	19.16977952	21.07634425	22.34677851
Ethane	11.63645877	11.34397782	11.57349224	12.13917168	11.32410018
Propylene	13.67682686	13.27208175	13.60018313	14.30792464	13.87917124
Propane	5.858520131	4.809435638	5.001823743	4.142186377	3.538619173
C4	14.52460019	13.68052959	13.89690567	13.3855744	13.2866526
C5	9.447810947	10.4072336	10.20824168	9.587948887	9.517381835
C6	10.94501094	10.92198839	10.60314817	10.14849745	9.541274834
C7	4.6064556	4.886277105	4.493358546	2.954338868	3.865965172
C8	0.869789977	1.034590083	0.878600822	0.853351069	0.825601179

Table B8 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 2:6 at various percentages of sulfate

% sulfate	0	2	4	6	8
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.937064985	0.09578	1.488922437	0.832351184	1.737340757
7	2.429744616	0.719632938	1.890153526	1.165869639	2.099380573
8	2.980283524	1.336698217	2.348275411	1.584043979	2.493498043
9	3.573731448	2.254249902	2.855919594	2.087588188	2.912513411
10	4.186620314	3.446690243	3.399822875	2.667525598	3.346527245
11	4.786687796	4.784759674	3.960015071	3.302617643	3.782695883
12	5.334344768	6.059944899	4.509710589	3.958491457	4.205190032
13	5.786558506	7.058452487	5.016436084	4.589676802	4.595519889
14	6.103167548	7.640107282	5.444841708	5.145190316	4.933434451
15	6.254492846	7.774771851	5.761236004	5.577018813	5.198544175
16	6.227976348	7.525840264	5.939165159	5.849324668	5.372638304
17	6.031308839	7.005306879	5.964602493	5.94536227	5.442383437
18	5.690624518	6.330567854	5.83901168	5.869707792	5.401795486
19	5.244385161	5.598373353	5.579071053	5.645292162	5.253740172
20	4.735302302	4.876139584	5.213067507	5.306783076	5.009883018
21	4.203030905	4.204110871	4.775229928	4.892915143	4.688973966
22	3.67943081	3.601901674	4.299861029	4.440066397	4.313913596
23	3.186778693	3.075423389	3.81682007	3.978257713	3.908422868
24	2.738267972	2.67485604	3.349061463	3.529608361	3.494153296
25	2.339764492	2.236721612	2.912100009	3.108601827	3.088776714
26	1.991925976	1.910077907	2.514800812	2.723348449	2.705184175
27	1.69213263	1.634260001	2.160811258	2.377180557	2.351600455
28	1.435992102	1.401491155	1.850108537	2.070166402	2.032273536
29	1.218388409	1.204850738	1.580358011	1.800350373	1.748406267
30	1.034144725	1.038372042	1.347962444	1.564673617	1.499088209
31	0.878399419	0.897012748	1.148797711	1.359605943	1.28209263
32	0.746788022	0.776565545	0.978685578	1.181548868	1.094489164
33	0.635503812	0.67354711	0.833669565	1.027072024	0.933075927
34	0.541288457	0.585085817	0.710154995	0.893035846	0.794660511
35	0.461386574	0.508818032	0.604961787	0.77664102	0.676226508
36	0.393485084	0.442797014	0.515325105	0.675433504	0.575019614

% sulfate	0	2	4	6	8
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass
37	0.33564946	0.385415232	0.438867602	0.587284633	0.488580852
38	0.2862633	0.335339374	0.373558392	0.510358868	0.414747247
39	0.243974156	0.291456586	0.317667832	0.443076929	0.351634043
40	0.207646576	0.252830278	0.269723157	0.384078797	0.297607666
41	0.176322142	0.218663829	0.228467462	0.332188903	0.251255044
42	0.149185744	0.18827051	0.192822897	0.286384525	0.211352498
43	0.125537065	0.161048897	0.161858052	0.24576753	0.176835736
44	0.104766132	0.136460337	0.134758903	0.209539096	0.146771414
45	0.08633175	0.1140107	0.110802386	0.176976689	0.120330004
46	0.069741595	0.093231638	0.089331357	0.147412355	0.096759167
47	0.054532592	0.07366206	0.069729433	0.120211096	0.075356275
48	0.040249974	0.054827491	0.051393761	0.094747819	0.05543819
49	0.026422937	0.036215307	0.033703068	0.070380883	0.036305433
50	0.012533979	0.017242956	0.015977209	0.04641954	0.017196582

B.3 Effect of using superbasic catalyst (KNO_3 / commercial ZrO_2) on pyrolyzed products

Table B9 Pyrolyzed gas product of PE with the catalyst to polymer ratio 1:6 at various percentages of potassium nitrate

% Potassium nitrate	0	10	15	20	25	30
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.1285959	9.71087506	9.65346737	8.98439144	9.533162	10.8046056
Ethylene	18.3059307	17.4388936	17.5649198	16.2277332	17.5578541	20.5316279
Ethane	11.6364588	11.1136031	11.3644913	10.6361838	11.1947187	11.1794148
Propylene	13.6768269	14.3041043	14.5674224	13.9630359	14.2946933	13.9890415
Propane	5.85852013	5.70978375	6.36613367	6.30758386	5.95368738	4.23487683
C4	14.5246002	14.1262174	14.7581429	14.3326314	14.1137328	13.4032165
C5	9.44781095	10.0742679	11.3038935	10.4618379	10.0723781	11.2665688
C6	10.9450109	11.4172443	7.11663555	12.2421266	11.3493994	9.53305662
C7	4.6064556	5.14112756	6.16284222	5.78722163	4.98138397	4.01998673
C8	0.86978998	0.96388316	1.14205132	1.05725426	0.94849032	1.03760468

Table B10 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 1:6 at various percentages of potassium nitrate

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.626513125	1.93863663	1.826291152	2.003245632	1.944157755	1.3883863
7	1.96620143	2.298703384	2.188034416	2.345383701	2.304594363	1.9272093
8	2.333113931	2.681945196	2.577273233	2.70576042	2.688098982	2.5614834
9	2.719055816	3.081030697	2.986632193	3.078471416	3.087321376	3.2596797
10	3.113414409	3.486868966	3.406592853	3.456711735	3.493155616	3.9732821
11	3.503370935	3.888545254	3.825403253	3.832701808	3.894676941	4.6437072
12	3.874389644	4.273327228	4.229101818	4.197522799	4.279149513	5.2131766
13	4.211039654	4.62684918	4.601782113	4.540903338	4.632212534	5.6361219
14	4.49814861	4.93360903	4.926247954	4.851053774	4.938379273	5.8872466

15	4 72219674	5 177899432	5 185178622	5 114701858	5 18196964	5 3638723
16	4 872757328	5 345215393	5 362815638	5 317525383	5 348517791	5 8827127
17	4 943715554	5 424029571	5 446996801	5 445167473	5 426544951	5 6732029
18	4 933994611	5 407634325	5 431150455	5 484915514	5 409390146	5 3700879
19	4 847606266	5 295595884	5 31572406	5 427899849	5 296686878	5 0073844
20	4 693002104	5 094351315	5 108563525	5 271362608	5 094892232	4 6144053
21	4 481874336	4 816662005	4 824020177	5 020295817	4 816794526	4 2141352
22	4 227675572	4 479973882	4 480953133	4 687743313	4 479841606	3 8230389
23	3 944155716	4 104078921	4 10013681	4 293416283	4 103810747	3 4518539
24	3 644155004	3 708661145	3 701716017	3 860879785	3 70836017	3 1067533
25	3 338783234	3 311268021	3 303236377	3 414112133	3 311007031	2 7905435
26	3 037003551	2 926027809	2 918508939	2 974412535	2 925850438	2 5037135
27	2 745558205	2 563163714	2 557289727	2 558370509	2 563089318	2 2452691
28	2 469134872	2 229152238	2 225572536	2 1771186	2 229182317	2 0133524
29	2 210669149	1 92728382	1 926233582	1 836654191	1 927408361	1 8056765
30	1 97169758	1 658392792	1 659798043	1 538803597	1 658595567	1 6198145
31	1 752702259	1 421585647	1 425171283	1 282408057	1 421848131	1 4533809
32	1 553413482	1 214869736	1 220251907	1 06443776	1 215173695	1 3041357
33	1 373056444	1 035644242	1 042400161	0 880886663	1 035973235	1 1700376
34	1 210540908	0 881053822	0 888769221	0 727412205	0 881393911	1 0492618
35	1 064599842	0 748224899	0 756522745	0 599747012	0 74856484	0 9401976
36	0 933886059	0 634411003	0 642966107	0 493934234	0 634742124	0 8414326
37	0 817036265	0 537072568	0 545616418	0 406439601	0 53738848	0 7517299
38	0 712710951	0 453912268	0 462231589	0 334184343	0 454208507	0 3700032
39	0 619616998	0 382881867	0 390813523	0 274531794	0 383155528	0 5952908
40	0 536518179	0 322171898	0 329595947	0 225248904	0 322421288	0 5267299
41	0 462237189	0 270191693	0 27702376	0 184457901	0 270416026	0 4635322
42	0 395651539	0 225544454	0 231728145	0 150584786	0 22574358	0 4049614
43	0 335684544	0 187000001	0 192499742	0 122309713	0 187174184	0 3503105
44	0 28129171	0 153466373	0 15826084	0 098520695	0 153616094	0 298879
45	0 231442015	0 123960373	0 128036523	0 078270858	0 124086169	0 2499496
46	0 185092694	0 097576233	0 100923857	0 060738312	0 097678552	0 2027608
47	0 141155131	0 07345067	0 076057305	0 045186886	0 073529734	0 1564746
48	0 098448039	0 050721413	0 052567404	0 030924948	0 050777089	0 1101357
49	0 055632106	0 028474601	0 029528065	0 017258174	0 028506258	0 0626172
50	0 011117162	0 005673758	0 005885175	0 003429821	0 005680101	0 0125468

Table B11 Pyrolyzed gas product of PE with the catalyst to polymer ratio 2:6 at various percentages of potassium nitrate

% Potassium nitrate	0	100	15	20	25	30
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.1285959	10.3592499	9.49474406	12.6971071	13.3467782	13.99999
Ethylene	18.3059307	20.099359	18.013474	23.9317043	27.5927246	28.102312
Ethane	11.6364588	11.3863575	10.4672639	12.2222237	9.82865557	9.923214
Propylene	13.6768269	14.0507145	13.5149184	14.824139	15.8977079	16.23231
Propane	5.85852013	4.47133548	4.78623014	3.25606368	2.42664204	2.33333
C4	14.5246002	13.3024736	13.2047494	13.0802549	13.4095593	13.25698
C5	9.44781095	9.79326788	10.6979003	8.39042073	7.91479861	7.51234
C6	10.9450109	10.9260567	12.307572	8.15147668	6.84534641	6.23547
C7	4.6064556	4.68009984	6.16612892	2.85291165	2.18161655	2.00536
C8	0.86978998	0.93108547	1.347019	0.5936983	0.55617087	0.42365

Table B12 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 2:6 at various percentages of potassium nitrate

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.626513125	1.179719411	1.98316675	1.45023473	1.61727782	1.5659269
7	1.96620143	1.588666277	2.082094851	1.553055179	1.708721651	1.6561485
8	2.333113931	2.004518028	2.166272353	1.647597888	1.790990048	1.737699
9	2.719055816	2.395730311	2.23555284	1.732921306	1.863570512	1.8100467
10	3.113414409	2.737724829	2.290289189	1.808474868	1.926292669	1.8729881
11	3.503370935	3.015323558	2.33125432	1.874086024	1.979304222	1.9266269
12	3.874389644	3.22253591	2.359553253	1.929928679	2.023034679	1.9713418
13	4.211039654	3.360754391	2.37653352	1.976477846	2.05815052	2.0077444
14	4.49814861	3.436383794	2.38369939	2.01445537	2.085505402	2.036633

15	4.72219674	3.458599735	2.382633756	2.044771296	2.106088638	2.0589434
16	4.872757328	3.437576584	2.374930023	2.068464756	2.120974627	2.0757001
17	4.943715554	3.383266502	2.362135094	2.086647454	2.131275339	2.0879706
18	4.933994611	3.304668724	2.345703549	2.100451926	2.138097297	2.0968233
19	4.847606266	3.209473366	2.32696241	2.110985932	2.142503901	2.10329
20	4.693002104	3.103960693	2.307085407	2.119293607	2.145483449	2.1083342
21	4.481874336	2.993056748	2.287075413	2.126323399	2.147922745	2.1128246
22	4.227675572	2.880472549	2.267753606	2.132902404	2.150585902	2.1175131
23	3.944155716	2.768878093	2.249753946	2.139716367	2.154097711	2.1230179
24	3.644155004	2.660081253	2.23352164	2.147294509	2.158930813	2.1298099
25	3.338783234	2.555195043	2.21931446	2.15598222	2.165395888	2.1382018
26	3.037003551	2.454785455	2.207205923	2.166012728	2.173634078	2.1483401
27	2.745558205	2.358997455	2.197089552	2.177340887	2.183610927	2.1601978
28	2.469134872	2.267659692	2.188683644	2.189798444	2.195111263	2.1735685
29	2.210669149	2.180369948	2.181536139	2.203010203	2.207734534	2.188061
30	1.97169758	2.096563913	2.175029354	2.216406778	2.220890343	2.2030939
31	1.752702259	2.015569855	2.168384537	2.229221769	2.233794039	2.2178898
32	1.553413482	1.936651537	2.160666297	2.240489415	2.245462459	2.2314706
33	1.373056444	1.85904134	2.150787121	2.24904298	2.254710111	2.2426526
34	1.210540908	1.781965175	2.137512304	2.253514316	2.260146284	2.2500425
35	1.064599842	1.704660431	2.119465702	2.252335254	2.260173803	2.2520352
36	0.933886059	1.626387862	2.095136829	2.243741641	2.252990373	2.2468145
37	0.817036265	1.546438111	2.062889855	2.225781032	2.236593662	2.2323571
38	0.712710951	1.464133336	2.020975172	2.196325169	2.208791487	2.206443
39	0.619616998	1.378824295	1.96754419	2.153088539	2.167218667	2.1666712
40	0.536518179	1.289883109	1.900668091	2.093654352	2.109362233	2.1104861
41	0.462237189	1.196691858	1.818361265	2.015509357	2.032596822	2.0352133
42	0.395651539	1.098627089	1.718610154	1.916088884	1.934232057	1.9381087
43	0.335684544	0.995040249	1.599408216	1.792833434	1.811573667	1.816422
44	0.28129171	0.885233993	1.458797664	1.643257969	1.661999832	1.6674768
45	0.231442015	0.768434234	1.294918594	1.46503481	1.483053878	1.4887675
46	0.185092694	0.643757716	1.106066008	1.256090673	1.272553792	1.2780743
47	0.141155131	0.510174806	0.890755137	1.014717887	1.028718198	1.0335962
48	0.098448039	0.366467116	0.647795291	0.739699184	0.750307304	0.7540984
49	0.055632106	0.211179569	0.376372255	0.430444589	0.436775905	0.4390732
50	0.011117162	0.042566589	0.076138955	0.087137906	0.088433876	0.0889071

B.4 Effect of using superbasic catalyst (KNO_3 / Synthesized ZrO_2) on pyrolyzed products

Table B13 Pyrolyzed gas product of PE with the catalyst to polymer ratio 1:6 at various percentages of potassium nitrate

% Potassium nitrate	0	100	15	20	25	30
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	10.455547	4.92312682	5.18985247	6.24870606	6.84437866	7.07822663
Ethylene	19.4518173	7.17596514	7.89372895	10.1430899	11.6360699	12.0186416
Ethane	12.7673592	9.32866166	8.79501161	9.62235476	9.73364504	9.89233916
Propylene	14.2537246	13.6843246	13.3705103	13.7246009	13.0466257	13.6483685
Propane	5.05836698	11.5993334	10.4207113	9.38904803	7.86794046	8.1854519
C4	13.5526204	17.6715835	16.8109406	16.1786929	14.9233229	15.2595952
C5	9.47388299	12.5759491	12.6738037	12.0578081	11.8420299	11.914397
C6	10.1806346	14.4680535	15.1483851	14.1903062	14.5433215	13.7770601
C7	4.03945596	7.15401615	7.98240951	7.08296642	7.93416291	6.86425836
C8	0.76659099	1.41898617	1.71464642	1.3624267	1.62850296	1.36166159

Table B14 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 1:6 at various percentages of potassium nitrate

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.854086777	1.187389783	1.472935088	1.640330818	1.152321912	
7	2.191657304	1.547163266	1.683260511	1.801494586	1.355938194	1.3554492
8	2.547231114	1.903139864	1.880163136	1.948682854	1.552799472	1.5491277
9	2.911951641	2.232986284	2.058413782	2.079517448	1.736926414	1.7305809
10	3.275133107	2.520566685	2.214478016	2.192603647	1.903860364	1.8954546
11	3.624620846	2.756626908	2.3464835	2.287462896	2.05073745	2.0409091
12	3.947393257	2.938072825	2.454035221	2.364411788	2.176185476	2.1655371
13	4.23041262	3.066548223	2.537943345	2.424410772	2.280109013	2.2691706
14	4.461674189	3.146859349	2.59991876	2.468902521	2.363420706	2.3526314
15	4.63133274	3.185571523	2.642276554	2.499655039	2.427762982	2.4174668
16	4.732726759	3.189917256	2.667672623	2.518619598	2.475249443	2.4657007
17	4.763100867	3.167034633	2.678885901	2.527809167	2.508242266	2.4996164
18	4.723865992	3.12349239	2.6786494	2.529199533	2.529172126	2.5215793
19	4.620330763	3.065035989	2.66952726	2.524652777	2.54040047	2.5338991
20	4.460957931	2.996489306	2.653831732	2.515861176	2.544120216	2.5387296
21	4.256303828	2.921757152	2.63357273	2.504308731	2.542288873	2.5380004
22	4.017851816	2.843887126	2.610432565	2.491247179	2.536587729	2.5333736
23	3.756940604	2.765161691	2.585759217	2.477683407	2.528400979	2.5262214
24	3.483929398	2.687201384	2.560572526	2.464375436	2.518809444	2.5176179
25	3.207662846	2.611067523	2.535578845	2.451834561	2.508594478	2.5083413
26	2.935227516	2.537357929	2.511190764	2.440331652	2.498248565	2.4988834
27	2.671944639	2.466292609	2.487549456	2.429906078	2.487989995	2.489463
28	2.421524411	2.397788444	2.464547936	2.420376095	2.477779739	2.4800423
29	2.186309181	2.331523148	2.441854186	2.411349919	2.467339245	2.4703435
30	1.967547225	2.266989352	2.418933478	2.402236999	2.456168365	2.4598669
31	1.765657235	2.203539941	2.395069622	2.392259239	2.443562976	2.4479078
32	1.580460684	2.140425764	2.369385055	2.380462139	2.42863214	2.4335736
33	1.411372376	2.076826733	2.340859811	2.365725961	2.410314817	2.4158003
34	1.257548271	2.011877149	2.308349529	2.346777136	2.38739627	2.393369
35	1.117994676	1.944685932	2.270602625	2.322200201	2.358524359	2.3649222
36	0.991645141	1.874352214	2.226276783	2.290450607	2.322225957	2.3289804

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
37	0.877411878	1.799976625	2.173954859	2.249868747	2.276923699	2.2839589
38	0.774217961	1.720668472	2.112160245	2.198695555	2.22095326	2.2281854
39	0.681015543	1.635548881	2.039371718	2.13509002	2.152581332	2.1599181
40	0.596794165	1.543749959	1.954037738	2.057148938	2.070024444	2.0773649
41	0.520582114	1.444409949	1.854590167	1.962929209	1.971468746	1.9787035
42	0.45144278	1.336664363	1.739457413	1.850473021	1.85509094	1.8621024
43	0.388467124	1.219633094	1.607077071	1.717836238	1.719080562	1.7257436
44	0.330762627	1.09240354	1.45590828	1.563120461	1.561663978	1.5678469
45	0.27743845	0.95400983	1.28444424	1.384509258	1.38113064	1.3866962
46	0.227585853	0.803408342	1.091225623	1.18030933	1.175862422	1.1806691
47	0.180252248	0.639449845	0.874856032	0.948997554	0.94436726	0.948271
48	0.134406272	0.460848798	0.63402121	0.689275188	0.685318757	0.688175
49	0.088890043	0.266150684	0.367514333	0.400130896	0.397604067	0.3992699
50	0.042352893	0.053698772	0.074270608	0.080914621	0.080383048	0.0807206

Table B15 Pyrolyzed gas product of PE with the catalyst to polymer ratio 2:6 at various percentages of potassium nitrate

% Potassium nitrate	0	100	15	20	25	30
Gas	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.	% Vol.
Methane	11.4046624	5.72424877	6.45340663	7.61057345	7.87577662	8.60004053
Ethylene	21.0763442	9.13183374	10.8454218	13.483536	12.9362004	15.5339775
Ethane	12.1391717	9.43857886	10.0262868	10.7071354	10.9131603	10.6187846
Propylene	14.3079246	13.6537269	12.6375996	13.2819258	13.4140139	13.9026449
Propane	4.14218638	9.86113528	8.08186921	7.20119055	7.69566765	6.67208125
C4	13.3855744	16.3641116	14.7604043	14.7518676	14.9915943	14.5162384
C5	9.58794889	12.2523774	11.9997687	11.376119	11.4047935	10.9347571
C6	10.1484975	14.5021126	14.9178764	13.3513168	13.0345496	12.3152115
C7	2.95433887	7.45165812	8.5330232	6.8026068	6.3369056	5.71887005
C8	0.85335107	1.62021673	1.74434338	1.43372865	1.39733807	1.18739424

Table B16 % Mass of pyrolyzed liquid product with the catalyst to polymer ratio 2:6 at various percentages of potassium nitrate

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
6	1.854086777					
7	2.191657304	1.452666093				
8	2.547231114	1.682516541	1.9857	1.799389581	1.628362928	1.7136402
9	2.911951641	1.898398682	1.476334972	1.906694803	1.754594424	1.7930436
10	3.275133107	2.093844035	1.688977663	2.001287982	1.868376597	1.8633386
11	3.624620846	2.264520876	1.884195041	2.082771472	1.968737683	1.9244886
12	3.947393257	2.408186669	2.057553875	2.151263844	2.055357739	1.9767474
13	4.23041262	2.524429004	2.20667962	2.207325802	2.128487727	2.0206219
14	4.461674189	2.614293009	2.330976892	2.251873058	2.188847782	2.0568271
15	4.63133274	2.679875478	2.431250712	2.286084541	2.237516777	2.0862378
16	4.732726759	2.723941286	2.509307405	2.311312598	2.275822775	2.1098396
17	4.763100867	2.749593972	2.567585977	2.329000022	2.305241142	2.1286807
18	4.723865992	2.760013704	2.608846702	2.340606938	2.327304575	2.1438279
19	4.620330763	2.758263043	2.63592609	2.347549068	2.34352712	2.156326
20	4.460957931	2.7471535	2.651556291	2.351147681	2.355342557	2.167163
21	4.256303828	2.729162464	2.658240938	2.352590642	2.364056534	2.1772405
22	4.017851816	2.706389334	2.658177061	2.352903432	2.370810895	2.1873482
23	3.756940604	2.680540507	2.65321253	2.352928686	2.37655843	2.1981442
24	3.483929398	2.652934459	2.644829569	2.353312679	2.382046113	2.2101386
25	3.207662846	2.624519935	2.634146435	2.354497256	2.387804947	2.2236796
26	2.935227516	2.595901975	2.621931095	2.356715829	2.394144769	2.2389433
27	2.671944639	2.567372005	2.608622243	2.359992261	2.401152570	2.2559241
28	2.421524411	2.538939407	2.594354366	2.364141711	2.408693259	2.2744263
29	2.186309181	2.510362909	2.578984597	2.368772742	2.416411905	2.2940568
30	1.967547225	2.481180825	2.562119911	2.373290244	2.423737109	2.3142171
31	1.765657235	2.450739625	2.543143833	2.376898936	2.429884998	2.3340962
32	1.580460684	2.418220641	2.521242192	2.378607454	2.433863915	2.3526631
33	1.411372376	2.382664877	2.49542775	2.377233151	2.434479877	2.3686601
34	1.257548271	2.342995977	2.464563676	2.371407973	2.430343151	2.380597
35	1.117994676	2.298041423	2.427385898	2.35958584	2.419876375	2.3867472
36	0.991645141	2.246552015	2.382524372	2.340052102	2.401324817	2.3851471

% potassium nitrate	0	10	15	20	25	30
Carbon number	% Mass	% Mass	% Mass	% Mass	% Mass	% Mass
37	0.877411878	2.187219594	2.328523289	2.310935729	2.372769426	2.3735995
38	0.774217961	2.118692981	2.263860185	2.270224918	2.332143398	2.3496835
39	0.681015543	2.039591959	2.186963884	2.215786865	2.277253016	2.3107724
40	0.596794165	1.948519184	2.096231164	2.145392452	2.20580356	2.2540618
41	0.520582114	1.844069846	1.990042057	2.056746585	2.115431048	2.1766098
42	0.45144278	1.724838986	1.86677373	1.947524925	2.003740612	2.0753929
43	0.388467124	1.589426465	1.724813024	1.815417717	1.868352242	1.9473782
44	0.330762627	1.436439764	1.562567904	1.658181413	1.706954674	1.789615
45	0.27743845	1.264495028	1.378478384	1.473698774	1.517368148	1.599346
46	0.227585853	1.072217162	1.17102786	1.260048135	1.29761679	1.3741403
47	0.180252248	0.858240202	0.938756339	1.015582544	1.04601136	1.1120457
48	0.134406272	0.621209867	0.680277743	0.739019443	0.761243117	0.811759
49	0.088890043	0.359790947	0.394304328	0.429541586	0.442489502	0.4728101
50	0.042352893	0.072683247	0.079682405	0.086909719	0.089532211	0.0957531

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