

Electronic Supplementary Information (ESI)

Production of monocyclic aromatic hydrocarbons by segmented in-situ and ex-situ two-stage coupled catalytic co-pyrolysis of biomass and waste plastics

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Table. S1. Product yields under different experimental conditions.

	Solid products (wt%)		Liquid products (wt%)		Gas (wt%)		Wax (wt%)	
CAS	18.21	±2.17	32.00	±1.49	49.80	±1.69	-	
3Fe/CAS	19.53	±1.37	33.00	±1.82	47.48	±1.77	-	
5Fe/CAS	8.35	±1.23	35.00	±1.01	56.65	±0.59	-	
7Fe/CAS	4.29	±0.46	33.00	±1.28	62.71	±1.75	-	
10Fe/CAS	5.97	±0.59	38.00	±1.07	56.03	±1.55	-	
LDPE	10.07	±1.66	34.02	±1.19	55.91	±0.80	-	
3M/LDPE	8.12	±1.33	41.00	±1.56	50.88	±1.52	-	
5M/LDPE	11.90	±1.83	41.00	±1.37	47.10	±0.91	-	
7M/LDPE	8.46	±1.21	39.00	±1.70	52.54	±1.72	-	
10M/LDPE	10.15	±0.97	38.00	±1.58	51.85	±1.76	-	
I	10.54	±2.10	52.00	±1.62	37.46	±0.97		
II	11.88	±1.29	46.00	±1.25	42.12	±1.11	-	
III	0.00		42.00	±1.15	58.00	±1.25	-	
IV	0.00		46.00	±1.29	54.00	±1.20	-	
V	6.76	±0.57	41.00	±1.34	52.24	±1.75	-	
VI (Segmented co-pyrolysis)	7.25	±2.22	39.00	±1.77	51.75	±2.67	2.00	±0.43
Traditional mixed co-pyrolysis	15.11	±2.01	41.29	±1.14	27.12	±3.83	16.49	±3.05

Table. S2. Relative content of the main component types of the liquid products under different experimental conditions.

	Ketones (wt%)	Acids (wt%)	Phenols (wt%)	Furans (wt%)	Toluene (wt%)	Xylene (wt%)	Alkylbenzene (wt%)	MAHs (wt%)	Olefins (wt%)	Alkanes (wt%)	PAHs (wt%)
CAS	5.65±0.42	14.58±0.86	37.86±3.50	33.06±1.73	0.27±0.10	0.08±0.02	0.92±0.19	1.08±0.25	0.16±0.05	1.66±0.61	0.27±0.16
3Fe/CAS	5.04±0.18	5.17±1.09	28.34±1.99	40.88±2.15	0.87±0.20	0.72±0.17	2.47±0.35	2.47±0.19	3.43±0.42	3.30±0.45	0.00
5Fe/CAS	6.43±0.98	3.66±1.10	33.82±0.35	42.38±2.12	0.80±0.42	1.02±0.27	2.03±1.09	2.03±0.40	2.75±0.13	2.62±0.44	0.00
7Fe/CAS	3.96±0.39	9.67±1.54	16.29±1.37	61.08±2.96	0.28±0.13	0.48±0.13	1.52±0.38	1.64±0.36	2.44±0.35	1.72±0.53	0.49±0.30
10Fe/CAS	5.16±2.08	11.10±1.40	27.97±1.61	45.42±1.37	1.10±0.38	2.47±0.25	5.25±0.59	5.36±0.49	2.13±0.31	1.18±0.22	0.43±0.14
LDPE	5.73±0.45	7.73±0.48	37.86±1.32	13.56±1.45	3.23±0.19	8.80±0.75	19.80±1.86	20.70±1.57	4.60±0.55	5.43±0.42	1.74±0.14
3M/LDPE	0.30±0.12	0.00	6.77±0.61	1.60±0.24	10.27±0.85	21.57±2.79	61.18±3.49	67.09±1.78	11.71±1.12	2.86±0.55	7.20±0.24
5M/LDPE	0.00	0.00	7.73±0.67	1.03±0.25	11.00±1.02	23.89±1.89	66.62±2.88	72.75±1.32	8.57±1.59	0.00	8.93±0.51
7M/LDPE	0.00	0.00	8.81±0.65	1.58±0.23	9.91±0.85	22.86±1.68	61.59±1.99	67.11±2.59	13.58±1.14	1.05±0.36	6.04±0.36
10M/LDPE	0.30±0.08	0.00	9.64±0.65	1.92±0.30	8.61±1.85	19.83±2.47	57.26±1.28	64.02±1.64	15.62±1.36	0.41±0.26	6.47±0.38
I	2.25±0.15	4.07±0.23	36.82±0.78	53.10 ±1.67	0.04±0.03	0.04±0.01	0.08±0.01	0.46±0.16	0.10±0.10	0.23±0.11	0.71±0.30
II	3.96±0.39	9.67±1.54	16.29±1.37	61.08 ±2.96	0.28±0.13	0.48±0.13	1.52±0.38	1.64±0.36	2.44±0.35	1.72±0.53	0.49±0.30
III	0.00	0.00	0.00	0.00	0.00	0.50±0.23	1.93±0.63	1.93±0.63	75.61±4.77	19.88±4.06	0.00
IV	0.00	0.00	0.00	0.00	19.72±0.62	41.73±1.47	94.08±2.10	94.99±2.42	0.00	0.00	5.01±0.45
V	0.00	0.00	2.14±0.60	3.18±0.94	5.43±0.40	15.84±1.60	51.08±2.04	55.80±1.93	13.31±0.75	13.89±1.25	4.17±0.79
VI (Segmented co-pyrolysis)	0.20±0.20	0.00	0.26±0.12	2.63±0.85	11.52±1.29	27.15±3.84	68.39±6.37	72.01±4.54	11.25±3.56	2.35±1.09	8.83±1.87
Traditional mixed co-pyrolysis	0.00	0.00	1.07±0.32	3.66±0.24	4.90±0.15	18.42±1.78	53.67±2.28	58.48±2.21	8.83±0.84	14.77±2.15	7.26±3.21

Table. S3. Carbon number distribution of liquid products under different experimental conditions (Unit: wt%).

	CAS	3Fe/ CAS	5Fe/ CAS	7Fe/ CAS	10Fe/ CAS	LDPE	3M/ LDPE	5M/ LDPE	7M/ LDPE	10M/ LDPE	I	II	III	IV	V	VI (Segmented co-pyrolysis)	Traditional mixed co- pyrolysis
C5	23.52	34.18	34.44	49.34	38.16	12.54	1.34	1.03	1.17	1.19	35.55	49.34	0.00	0.00	1.76	1.02	2.47
C6	19.08	19.18	21.62	17.36	21.09	11.40	3.34	3.43	2.53	2.36	19.84	17.36	1.47	0.91	2.00	1.89	1.72
C7	20.65	11.63	9.12	4.39	8.92	13.77	17.50	16.29	16.30	14.67	7.08	4.39	4.86	19.72	10.01	16.81	6.27
C8	8.83	4.74	5.42	2.28	3.90	19.93	34.37	34.88	36.24	34.02	8.16	2.28	10.84	47.86	25.59	36.65	24.49
C9	3.93	1.42	1.89	1.08	1.91	9.22	19.37	20.82	21.06	21.58	3.68	1.08	14.75	22.13	21.03	20.29	20.72
C10	2.25	7.77	10.46	7.55	6.76	10.27	12.38	13.17	13.51	14.63	11.36	7.55	20.49	6.26	12.11	8.26	11.71
C11	0.69	1.47	6.25	1.21	4.28	4.32	7.35	7.41	6.87	7.35	7.16	1.21	9.74	3.12	7.57	4.95	8.87
C12	1.00	5.28	1.51	0.96	0.48	1.00	2.57	2.20	1.71	2.65	0.12	0.96	10.22	0.00	3.11	3.00	4.42
C13	0.15	0.11	0.96	0.27	0.38	0.45	0.32	0.77	0.34	1.09	0.00	0.27	7.41	0.00	1.67	0.56	1.71
C14	0.71	0.68	1.30	0.77	0.08	0.89	0.26	0.00	0.00	0.00	0.59	0.77	2.07	0.00	2.13	0.00	2.65
C15	0.00	0.83	0.75	0.15	0.00	1.14	0.22	0.00	0.00	0.00	0.67	0.15	2.38	0.00	1.61	0.06	2.16
C16	0.00	0.99	0.52	0.60	0.41	0.84	0.33	0.00	0.28	0.00	0.10	0.60	1.05	0.00	1.30	0.00	1.37
C17	0.45	1.34	0.74	0.47	0.00	0.49	0.19	0.00	0.00	0.07	0.00	0.47	5.13	0.00	1.63	0.33	2.08
C18	0.00	2.45	0.36	0.34	0.11	0.48	0.30	0.00	0.00	0.31	0.00	0.34	1.24	0.00	0.95	0.08	1.08
C19	0.00	0.51	0.56	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.10	0.00	0.93	0.00	2.16	0.00	2.84
C20	0.10	2.01	0.43	0.14	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.14	4.34	0.00	1.61	4.65	1.21
C21	0.30	0.09	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.90	0.49	1.15

Table. S4. Carbon number distribution of aliphatic hydrocarbons in liquid products under different experimental conditions. (Unit: wt%).

	LDPE	3M/LDPE	5M/LDPE	7M/LDPE	10M/LDPE	I	II	III	IV	V	VI (Segmented co-pyrolysis)	Traditional mixed co-pyrolysis
C5	12.54	1.34	1.03	1.17	1.19	35.55	49.34	0.00	0.00	1.76	1.02	2.47
C6	11.40	3.34	3.43	2.53	2.36	19.84	17.36	1.47	0.91	2.00	1.89	1.72
C7	13.77	17.50	16.29	16.30	14.67	7.08	4.39	4.86	19.72	10.01	16.81	6.27
C8	19.93	34.37	34.88	36.24	34.02	8.16	2.28	10.84	47.86	25.59	36.65	24.49
C9	9.22	19.37	20.82	21.06	21.58	3.68	1.08	14.75	22.13	21.03	20.29	20.72
C10	10.27	12.38	13.17	13.51	14.63	11.36	7.55	20.49	6.26	12.11	8.26	11.71
C11	4.32	7.35	7.41	6.87	7.35	7.16	1.21	9.74	3.12	7.57	4.95	8.87
C12	1.00	2.57	2.20	1.71	2.65	0.12	0.96	10.22	0.00	3.11	3.00	4.42
C13	0.45	0.32	0.77	0.34	1.09	0.00	0.27	7.41	0.00	1.67	0.56	1.71
C14	0.89	0.26	0.00	0.00	0.00	0.59	0.77	2.07	0.00	2.13	0.00	2.65
C15	1.14	0.22	0.00	0.00	0.00	0.67	0.15	2.38	0.00	1.61	0.06	2.16
C16	0.84	0.33	0.00	0.28	0.00	0.10	0.60	1.05	0.00	1.30	0.00	1.37
C17	0.49	0.19	0.00	0.00	0.07	0.00	0.47	5.13	0.00	1.63	0.33	2.08
C18	0.48	0.30	0.00	0.00	0.31	0.00	0.34	1.24	0.00	0.95	0.08	1.08
C19	0.27	0.00	0.00	0.00	0.00	0.10	0.00	0.93	0.00	2.16	0.00	2.84
C20	0.40	0.00	0.00	0.00	0.00	0.00	0.14	4.34	0.00	1.61	4.65	1.21
C21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.90	0.49	1.15

Table. S5. Main compounds identified in liquid products. (Unit: wt%).

Compounds	CAS	3Fe/ CAS	5Fe/ CAS	7Fe/ CAS	10Fe/ CAS	LDPE	3M/ LDPE	5M/ LDPE	7M/ LDPE	10M/ LDPE	I	II	III	IV	V	VI (Segmented co-pyrolysis)	Traditional mixed co- pyrolysis
Furfural	10.62	26.28	26.43	45.37	29.74	5.29	1.04	1.03	1.17	1.19	30.89	45.37	0.00	0.00	1.69	0.80	2.47
Benzene, 1,3-dimethyl-	0.00	0.00	0.00	0.48	0.00	5.17	18.51	20.02	19.51	16.76	0.00	0.48	0.00	4.51	13.26	24.16	15.86
Toluene	0.27	0.87	0.80	0.28	1.10	3.23	10.27	11.00	9.91	8.61	0.04	0.28	0.00	19.72	5.43	11.52	4.90
2- Furancarboxaldehyde, 5-methyl-	6.46	7.61	6.86	7.93	6.32	2.21	0.00	0.00	0.00	0.00	9.10	7.93	0.00	0.00	0.56	0.00	0.62
Acetic acid	13.44	2.95	2.70	8.24	8.33	6.26	0.00	0.00	0.00	0.00	3.39	8.24	0.00	0.00	0.00	0.00	0.00
Phenol	7.67	7.79	7.31	2.99	9.24	3.64	0.00	0.00	0.45	0.50	1.57	2.99	0.00	0.00	0.00	0.00	0.65
Ethylbenzene	0.00	0.00	0.00	0.00	0.00	1.33	4.26	5.13	4.25	3.75	0.00	0.00	0.00	6.13	3.07	4.14	2.78
Guaiacol	8.91	3.35	2.46	1.49	1.96	3.67	0.95	1.11	1.10	1.14	2.58	1.49	0.00	0.00	0.27	0.11	0.27
2-Propanone, 1-(4- hydroxy-3- methoxyphenyl)-	0.77	2.00	5.58	2.99	4.75	2.46	0.00	0.00	0.00	0.00	5.64	2.99	0.00	0.00	0.45	0.16	0.00
Benzene, 1-ethyl-2- methyl-	0.00	0.00	0.00	0.00	0.00	2.68	3.85	7.47	3.08	2.77	0.00	0.00	0.00	0.00	6.14	0.00	0.00
Naphthalene, 2-methyl-	0.00	0.00	0.00	0.00	0.00	0.00	3.62	4.55	3.25	2.99	0.00	0.00	0.00	3.12	2.16	2.15	3.19
Benzene, 1,2,4- trimethyl-	0.00	0.00	0.00	0.26	0.00	0.60	2.60	3.08	3.45	3.85	0.00	0.26	0.00	0.00	3.86	0.00	4.23

Furan, 3-methyl-	4.68	3.45	3.20	0.00	4.10	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phenol, 2,6-dimethoxy-	1.96	0.78	0.87	0.27	0.26	3.99	0.81	0.97	1.00	0.92	1.29	0.27	0.00	0.00	0.23	0.00	0.00
Naphthalene	0.27	0.00	0.00	0.00	0.16	0.00	1.22	1.42	0.85	0.87	0.00	0.00	0.00	1.89	0.56	0.21	1.27
2,4-Dimethylfuran	1.44	1.26	1.16	0.75	1.44	0.70	0.00	0.00	0.00	0.00	0.47	0.75	0.00	0.00	0.00	0.00	0.00
HMF	0.38	0.28	0.54	0.86	0.10	0.73	0.00	0.00	0.00	0.00	2.13	0.86	0.00	0.00	0.00	0.00	0.00
1,4-Dihydronaphthalene	0.00	0.00	0.00	0.00	0.00	0.26	1.07	1.26	0.95	1.03	0.00	0.00	0.00	0.00	0.54	0.37	0.00
Ethanone, 1-(2-furanyl)-	0.28	0.44	0.57	0.88	0.65	0.20	0.00	0.00	0.00	0.00	1.00	0.88	0.00	0.00	0.00	0.00	0.00
Acrylic acid	0.96	0.33	0.00	0.24	0.33	0.00	0.00	0.00	0.00	0.00	0.05	0.24	0.00	0.00	0.00	0.00	0.00
Cellobiose	0.00	0.48	0.33	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00

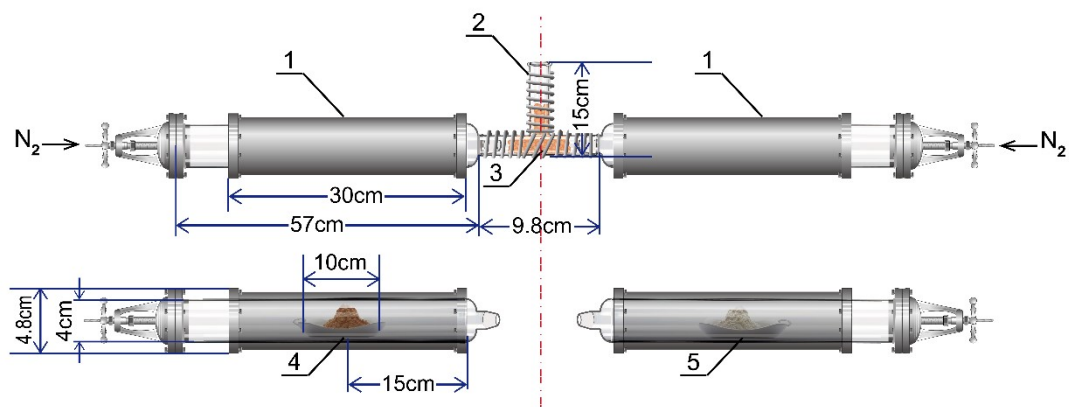


Fig. S1. Dimensioned schematic diagram of the segmented co-pyrolysis device. (1) Pyrolysis raw material heating device; (2) Catalyst heating device; (3) Ex-situ catalyst (globosity HZSM-5); (4) Quartz boat with CAS samples; (5) Quartz boat with LDPE samples.