Supporting Information

Chemical Upcycling of Biodegradable Plastic Waste: A Critical Review

Ning Li [a], Zhixun Li[a], Yangli Cui[a, b], Lan Liang [a], Wenchao Peng [c], Zhanjun Cheng[a*], Beibei Yan[a], Guanyi Chen [a, b, d]

[a] School of Environmental Science and Engineering, Tianjin Engineering Research Center for Organic Wastes Safe Disposal and Energy Utilization, Tianjin University, Tianjin 300072, China

[b] School of Ecology and Environment, Tibet University/Key Laboratory of Plateau Environmental Engineering and Pollution Control, Lhasa 850000, China

[c] School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China

[d] School of Mechanical Engineering, Tianjin University of Commerce, Tianjin 300134, China

[*] Corresponding author.

E-mail: zjcheng@tju.edu.cn (Z. Cheng)

Text S1 Search Formula of the Core Collection in Web of Science

For resource transformation of BPs, the search terms were according to "TS=((Polylactic acid AND upcycling) OR (Polybutylene succinate AND upcycling) OR (Polybutylene adipate-co-terephthalate AND upcycling) OR (Poly(ε-caprolactone) AND upcycling) OR (polyhydroxyalkanoate AND upcycling) OR (polyhydroxybutyrate AND upcycling))".

Text S2 Computational Details of Greenhouse gas emissions

Indirect carbon emissions

Indirect carbon emissions (ICE) primarily refer to those generated by the operational energy consumption of various disposal technologies. ICE of BPs conversion can be categorized into pre-processing, melting, and polymerization, with pre-processing involving sorting, crushing, washing, and drying. The specific formula is given in Equation 1.

$$E_{CO_2 - E} = EL \times 0.581 \quad (1)$$

Where: $E_{CO_2 - E}$ represents CO_2 emissions from electricity consumption (kg CO_2 eq); EL is electricity consumption (kW•h); 0.581 is the CO_2 emission factor for electricity consumption.

Direct carbon emissions

Chemical recycling may cause chemical reagent pollution, which is harmful to landfill sites. Therefore, the study assumes the unrecovered portion is directly disposed of through incineration. In chemical recycling of BPs, the primary source of direct carbon emissions is the incineration of incompletely recycled plastic, as calculated in equation (2).

$$E_{CO_2 - C} = W_0 \times (1 - R_C) \times OF \quad (2)$$

Where: $E_{CO_2 - C}$ represents CO_2 emissions from the decomposition of waste biobiodegradable plastics during chemical recycling and disposal (kg CO_2 eq); R_C is the chemical recycling rate of waste biobiodegradable plastics.

Carbon offset

The chemical recycling process recovers plastic monomers or raw materials. For example, the production of 1 kg of plastic monomers (such as lactic acid) results in carbon emissions of 1.2 to 1.7 kg CO_2 eq.[1] The carbon offset from the chemical recycling process is calculated in

equation (3).

$$R_{CR}=W_0 \times R_C \times C_{LA} \quad (3)$$

Where: R_{CR} is the carbon offset of the chemical recovery process (kg CO_2 eq); C_{LA} is the carbon emission of the lactic acid production process (kg CO_2 eq per kg).

Table S1 Pyrolysis of biodegradable plastics

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (°C min^{-1})	t (min)	T (°C)	Purge gas	E_a (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
1	PLA	2.5	–	–	–	20	290	N_2	–	60	acetaldehyde,lactide monomer,oligomers of lactide	–	
2	PHB	2.5	–	–	–	20	170	N_2	–	25	crotonic acid	–	
3	PCL	2.5	–	–	–	20	250	N_2	–	0	ε-caprolactone	–	
4	PLA	2.5	–	–	10	–	240-375	He	80-160	100	acetaldehyde,lactide monomer,oligomers of lactide	–	2
5	PHB	2.5	–	–	10	–	210-268	He	111±7	100	crotonic acid	–	
6	PCL	2.5	–	–	10	–	220-355	He	74±4	100	ε-caprolactone	–	
7	PLA	2.5	–	–	3	–	240-350	He	80-160	100	acetaldehyde、lactide monomer、oligomers of lactide	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
8	PHB	2.5	–	–	3	–	210-250	He	111±7	100	crotonic acid	–	
9	PCL	2.5	–	–	3	–	220-305	He	74±4	100	ε-caprolactone	–	
10	PLA	2.5	–	–	5	–	240-360	He	80-160	100	acetaldehyde,lactide monomer,oligomers of lactide	–	
11	PHB	2.5	–	–	5	–	210-260	He	111±7	100	crotonic acid	–	2
12	PCL	2.5	–	–	5	–	220-325	He	74±4	100	ε-caprolactone	–	
13	PLA	2.5	–	–	7	–	240-365	He	80-160	100	acetaldehyde,lactide monomer,oligomers of lactide	–	
14	PHB	2.5	–	–	7	–	210-265	He	111±7	100	crotonic acid	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (°C min-1)	t (min)	T (°C)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
15	PCL	2.5	–	–	7	–	220-335	He	74±4	100	ε-caprolactone		2
16	PBAT	10	–	–	10	–	165-332	N_2	–	94.18	bio-gas,bio-oil and PM	11.77, 38,48	3
17	PBAT	2000	–	–	–	20	550	N_2	–	94.18	bio-gas,bio-oil	10.37, 87.3	
18	PBS	10	–	–	10	–	332-461	N_2	–	98.11	bio-gas,bio-oil and PM	8.37, 51, 39	
19	PBS	2000	–	–	–	20	550	N_2	–	98.11	bio-gas,bio-oil	7.79, 90.58,	
20	PCL	10	–	–	10	–	317-481	N_2	–	97.29	bio-gas,bio-oil and PM	22.39, 26, 50	
21	PCL	2000	–	–	–	20	550	N_2	–	97.29	bio-gas,bio-oil	21.76, 76.63	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
22	PLA	5	–	–	10	–	334.6-365.2	Ar	180.35	100	bio-gas	63.23	4
23	PLA	5	–	–	10	–	297.5-332.5	Ar	129.97	87.6	–	–	
24	PLA	5	–	–	10	–	289.7-325.9	Ar	–	76.76	bio-oil	80.17	
25	PLA	5	–	–	10	–	282.4-324.7	Ar	–	66.76	–	–	
26	PBS	6	–	–	20	–	336.1-443.3	N_2	–	98	–	–	5
27	PBS	6	–	–	20	–	333.3-439.4	N_2	–	92.1	–	–	
28	PBS	6	–	–	20	–	332.2-431.9	N_2	–	90.2	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
29	PBS	6	–	–	20	–	333.1-429.7	N_2	–	88.7	–	–	5
30	PLA	–	–	–	10	–	300-380	N_2	197	99	–	–	6
31	RSPR/PLA	–	–	–	10	–	245-378	N_2	122.6	75	–	–	
32	PLA	5	–	–	5	–	272.8-370.8	N_2	118-165	97	–	–	7
33	10%SCB/PLA	5	–	–	5	–	207.8-366.8	N_2	113.7-141.7	90	–	–	
34	20%SCB/PLA	5	–	–	5	–	186.8-346.8	N_2	101.3-140.4	90.5	–	–	
35	30%SCB/PLA	5	–	–	5	–	167.8-351.8	N_2	79.8-210.1	82	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
36	PLA	10	–	–	10	–	287-389	N_2	–	99.43	–	–	8
37	20% BF/PLA	10	–	–	10	–	253-364	N_2	–	93.2	–	–	
38	30% BF/PLA	10	–	–	10	–	252-363	N_2	–	91.16	–	–	
39	40% BF/PLA	10	–	–	10	–	232-363	N_2	–	90.36	–	–	
40	PLA	100	Fe@C	0.05	–	1440	200	Ar	–	75	lactide	54	9
41	PLA	100	Fe@NC	0.05	–	1440	200	Ar	–	85	lactide	57	
42	PLA	100	Ni@NC	0.05	–	1440	200	Ar	–	13	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
43	PLA	100	$Fe_{10}Ni_1$ @NC	0.05	–	1440	200	Ar	–	96	lactide	73	9
44	PLA	100	NC	0.05	–	1440	200	Ar	–	12			
45	PLA	100	–	–	–	1440	200	Ar	–	10			
46	PLA	10	Ni/SiO_2	1	10	–	380-430	N_2	–	91.6	solid,liquid,gas	14.2, 58.5, 27.3	10
47	PLA	10	Ni/SiO_2	1	10	–	380-430	CO_2	–	98.9	solid,liquid,gas	14.9, 60.1, 26	
48	PLLA/ CaO	5	–	–	5	–	180-300	N_2	125	100	L,L-lactide	12.1	11
49	PLLA/ MgO	5	–	–	5	–	210-300	N_2	130	100	L,L-lactide	2.6	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (℃ min-1)	t (min)	T (℃)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
50	PLA	1000	–	–	10	–	300-425	N_2	–	70	bio-gas,bio-oil	12, 66	12
51	PLA	1000	–	–	10	–	300-425	CO_2	–	75	bio-gas,bio-oil	7, 72	
52	PLA	20	–	–	10	–	282.8-393.6	N_2	–	96.24	Acetaldehyde、meso-Lactide、D,L-Lactide	6.42, 7.34, 21.66	13
53	PLA/ 0.5WT	20	–	–	10	–	237.7-332.2	N_2	–	61.13	Acetaldehyde、meso-Lactide、D,L-Lactide	0.11, 25.18, 18.5	
54	PLA/ 0.75WT	20	–	–	10	–	230.8-315.5	N_2	–	36.08	Acetaldehyde、meso-Lactide、D,L-Lactide	0.26, 7.61, 5.75	
55	PLA/ 0.25WT	20	–	–	10	–	231.3-330.6	N_2	–	66.73	Acetaldehyde、meso-Lactide、D,L-Lactide	0.26, 10.58, 13.26	
56	PLA	40	–	–	5	–	260.8-368.8	N_2	–	100	–	–	14

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Heating rates (°C min-1)	t (min)	T (°C)	Purge gas	Ea (kJ/ mol)	Con (%)	Product	Yield (%)	Ref
57	PLA	40	–	–	10	–	269.8-394.8	N_2	–	100	–	–	14
58	PLA	40	–	–	20	–	292.8-408.8	N_2	–	100	–	–	
59	PLA	40	–	–	30	–	306.8-433.8	N_2	–	100	–	–	
60	PLA	6	–	–	10	–	286.8-380.8	N_2	–	100	–	–	15
61	PLA25W75	6	–	–	10	–	230.8-367.8	N_2	–	87	–	–	
62	PLA50W50	6	–	–	10	–	233.8-367.8	N_2	–	92	–	–	
63	PLA75W25	6	–	–	10	–	235.8-367.8	N_2	–	96	–	–	

Table S2 Hydrolysis of biodegradable plastics

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
1	PLA-0.1%MWCNT	–	–	–	7.4	1440	37	9.34	–	–	16
2	PLA-0.5%MWCNT	–	–	–	7.4	1440	37	5.94	–	–	
3	PLA-1%MWCNT	–	–	–	7.4	1440	37	4.59	–	–	
4	PLA-5%MWCNT	–	–	–	7.4	1440	37	3.54	–	–	
5	PLA	–	–	–	7.4	1440	37	12.5	–	–	
6	PCL	30	–	–	7.4	840	37	0.4	–	–	17
7	PCL	30	–	–	1	840	37	11.6	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
8	PLGA Diameters:8.94	40	–	–	7.4	672	37	17.2	–	–	18
9	PLGA Diameters:52.37	40	–	–	7.4	672	37	22.3	–	–	
10	PHB	6	–	–	14	90	30	20	–	–	19
11	PHB	6	–	–	14.3	90	30	35	–	–	
12	PHB	6	–	–	14.17	90	30	26	–	–	
13	PHB Crystallinity: 53%	6	–	–	14.3	90	30	35	–	–	
14	PHB Crystallinity: 59%	6	–	–	14.3	90	30	22	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
15	PHB Crystallinity: 65%	6	–	–	14.3	90	30	20.9	–	–	19
16	PHB Crystallinity: 74%	6	–	–	14.3	90	30	19.4	–	–	
17	PHB Crystallinity: 53%	6	–	–	14.3	90	35	60.4	–	–	
18	PHB Crystallinity: 65%	6	–	–	14.3	90	35	41.1	–	–	
19	PHB Crystallinity: 65%	6	–	–	14.3	90	35	34.5	–	–	
20	PHB Crystallinity: 65%	6	–	–	14.3	90	35	31.9	–	–	
21	PHB Crystallinity: 65%	6	–	–	14.3	90	40	90	–	–	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
22	PHB Crystallinity: 59%	6	–	–	14.3	90	40	78	–	–	19
23	PHB Crystallinity: 65%	6	–	–	14.3	90	40	63	–	–	
24	PHB Crystallinity: 74%	6	–	–	14.3	90	40	53	–	–	
25	PLA	400	48%HBr	4.47	–	100	4	100	LA	99	20
26	PLA	400	33%HBr-HAC	4.2	–	100	11	100	2BA	55.2	
27	PLA	400	48%HBr	4.47	–	100	16	100	LA、2BA	13, 86	
28	PLA	400	48%HBr	4.47	–	80	24	100	LA、2BA	97, 2	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
29	PLA	400	48%HBr	4.47	–	90	24	100	LA、2BA	95, 4	
30	PLA	400	48%HBr	4.47	–	110	6	100	LA、2BA	81, 18	
31	PLA	400	48%HBr	4.47	–	100	6	100	LA、2BA	97, 2	
32	PLA	400	48%HBr	4.47	–	90	6	100	LA、2BA	98, 1	20
33	PLA	400	33%HBr-HAC	4.2	–	80	24	100	LA、2BA	50, 30	
34	PLA	400	33%HBr-HAC	4.2	–	90	6	100	LA、2BA	60, 23	
35	PLA	400	33%HBr-HAC	4.2	–	110	6	100	LA、2BA	5, 45	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
36	PLA	400	33%HBr-HAC	4.2	–	100	6	100	LA、2BA	24, 36	20
37	PLA	400	33%HBr-HAC	4.2	–	80	6	100	LA、2BA	76, 5	
38	PLA	5000	ionic liquid, Bu_4PBr	10	1	10	190	100	acrylic acid	65	21
39	PLA	720	Ru_4Mo_1/TiO_2	0.01	–	12	160	100	1,2-propanediol	99	
40	PBS	1000	Ru_4Mo_1/TiO_2	0.1	–	48	180	100	1,4-butanediol	87	
41	PCL	1000	Ru_4Mo_1/TiO_2	0.1	–	48	180	100	1,6-hexanediol	75	
42	PBAT	1000	Ru_4Mo_1/TiO_2	0.1	–	48	180	100	1,6-hexanediol、1,4-butanediol	80, 88	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
43	PBAT	2000	1,4-butanediol -alkali combined	–	–	1	130	99	terephthalic、adipic acids	82.3, 74.1	22
44	PBS	50000	succinic acid	25	–	5	150	100	succinic acid、1,4-butanediol	79, 65.2	23
45	PLA	20	–	–	7	24	130	100	LA	100	24
46	PLA	20	ZnO	0.052	7	24	130	100	LA	100	
47	PLA	20	–	–	7	24	130	12	LA	12	
48	PLA	20	ZnO	0.052	7	24	130	100	LA	100	
49	PLA	20	TiO_2	0.052	7	24	130	18	LA	18	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
50	PLA	20	Bohemite	0.052	7	24	130	17	LA	17	24
51	PLA	20	Nb_2O_5	0.052	7	24	130	12	LA	12	
52	PLA	20	CeO_2	0.052	7	24	130	10	LA	10	
53	PLA	20	Al_2O_3	0.052	7	24	130	17	LA	17	
54	PLA	20	Dowex	0.052	7	24	130	11	LA	11	
55	PLA	20	ZnO	0.052	7	24	110	54	LA	54	
56	PLA	50	–	–	–	18	140	99	ammonium lactate	94	25

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	pH	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
57	PLA	50	TiO_2-P25	0.1	–	18	140	99	ammoniu m lactate	95	25
58	PLA	50	2% Pt/TiO_2	0.1	–	18	140	99	ammoniu m lactate	93	
59	PLA	50	2% Ir/TiO_2	0.1	–	18	140	99	ammoniu m lactate	83	
60	PLA	50	2% Ru/SiO_2	0.1	–	18	140	99	ammoniu m lactate	93	
61	PLA	50	2% Ru/C	0.1	–	18	140	99	ammoniu m lactate	80	
62	PLA	50	2% Ru/TiO_2	0.1	–	18	140	99	ammoniu m lactate	65	
63	PLA	50	2% Ru/TiO_2	0.1	–	18	140	99	alanine	36	

Table S3 Alcoholysis of biodegradable plastics

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
1	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	99.9	methyl lactate	99	26
2	PLA	1	SBA-15-Pr-MIM-Cl	0.03	MeOH	4	120	63.4	methyl lactate	42.6	
3	PLA	1	SBA-15-Pr-MIM-HCO3	0.03	MeOH	4	120	96.5	methyl lactate	92.4	
4	PLA	1	SBA-15-Pr-DMAP-OH	0.03	MeOH	4	120	90.8	methyl lactate	86.8	
5	PLA	1	SBA-15-Pr-DABCO-OH	0.03	MeOH	4	120	93.1	methyl lactate	88.5	
6	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	49.6	methyl lactate	44.3	
7	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	99.9	methyl lactate	99	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
8	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	72.6	methyl lactate	59.6	26
9	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	84.6	methyl lactate	72.4	
10	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	98.3	methyl lactate	94.6	
11	PLA	1	SBA-15-Pr-MIM-OH	0.03	MeOH	4	120	89.3	methyl lactate	82	
12	PLA	4	ChCl - $2ZnCl_2$ @ZIF-8(1:5)	0.3	MeOH	3	110	98.2	methyl lactate	96.3	27
13	PLA	4	–	–	MeOH	3	110	0	–	0	
14	PLA	4	ChCl - $2ZnCl_2$	0.3	MeOH	3	110	91.6	methyl lactate	79.2	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
15	PLA	4	ChCl - $2ZnCl_2$ @ZIF-8(1:3)	0.3	MeOH	3	110	86.2	methyl lactate	83.1	27
16	PLA	4	ChCl - $2ZnCl_2$ @ZIF-8(1:4)	0.3	MeOH	3	110	92.6	methyl lactate	85.2	
17	PLA	4	ChCl - $2ZnCl_2$ @ZIF-8(1:6)	0.3	MeOH	3	110	86.4	methyl lactate	77.5	
18	PLA	4	ZIF-8	0.3	MeOH	3	110	88.1	methyl lactate	84.6	
19	PLA	4	$ZnCl_2$	0.4	MeOH	3	120	89.6	methyl lactate	70.1	28
20	PLA	4	ChCl-$MnCl_2$	0.4	MeOH	3	120	14.9	methyl lactate	14.1	
21	PLA	4	ChCl-$FeCl_3$	0.4	MeOH	3	120	89	methyl lactate	74.2	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
22	PLA	4	ChCl-$CoCl_2$	0.4	MeOH	3	120	16.6	methyl lactate	14.7	
23	PLA	4	ChCl-$NiCl_2$	0.4	MeOH	3	120	–	methyl lactate	–	
24	PLA	4	ChCl-$CuCl_2$	0.4	MeOH	3	120	59.9	methyl lactate	54.3	
25	PLA	4	ChCl-$ZnCl_2$	0.4	MeOH	3	120	96.1	methyl lactate	87.8	28
26	PLA	4	ChCl-$2ZnCl_2$	0.4	MeOH	3	120	98.3	methyl lactate	93.8	
27	PLA	4	ChCl-$3ZnCl_2$	0.4	MeOH	3	120	96	methyl lactate	89.4	
28	PLA	4	ChCl-$4ZnCl_2$	0.4	MeOH	3	120	93.7	methyl lactate	88.4	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
29	PLLA	10	Li	0.1	EtOH	1	200	97	ethyl lactate	82	29
30	PLLA	10	Na	0.1	EtOH	1	200	95	ethyl lactate	79	
31	PLLA	10	K	0.1	EtOH	1	200	95	ethyl lactate	83	
32	PLLA	10	Mg	0.1	EtOH	1	200	100	ethyl lactate	89	
33	PLLA	10	Ca	0.1	EtOH	1	200	98	ethyl lactate	91	
34	PLLA	10	Sr	0.1	EtOH	1	200	95	ethyl lactate	85	
35	PLLA	10	Ba	0.1	EtOH	1	200	94	ethyl lactate	81	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
36	PLLA	10	Na(OEt)	0.1	EtOH	1	200	94	ethyl lactate	80	29
37	PLLA	10	K(OEt)	0.1	EtOH	1	200	95	ethyl lactate	83	
38	PLLA	10	$Ca(OMe)_2$	0.1	EtOH	1	200	97	ethyl lactate	78	
39	PLLA	10	$Sn(OEt)_4$	0.1	EtOH	1	200	99	ethyl lactate	81	
40	PLLA	10	$Sn(Oct)_2$	0.1	EtOH	1	200	99	ethyl lactate	87	
41	PLLA	10	LiMe	0.1	EtOH	1	200	98	ethyl lactate	83	
42	PLLA	10	$ZnEt_2$	0.1	EtOH	1	200	99	ethyl lactate	85	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
43	PLLA	10	$SnEt_2Cl_2$	0.1	EtOH	1	200	98	ethyl lactate	87	
44	PLLA	10	$AlEt_3$	0.1	EtOH	1	200	93	ethyl lactate	64	
45	PLLA	10	NaOH	0.1	EtOH	1	200	94	ethyl lactate	77	
46	PLLA	10	KOH	0.1	EtOH	1	200	93	ethyl lactate	77	29
47	PLLA	10	$SnCl_2$	0.1	EtOH	1	200	98	ethyl lactate	86	
48	PLLA	10	$ZnCl_2$	0.1	EtOH	1	200	100	ethyl lactate	85	
49	PLLA	10	TED	0.1	EtOH	1	200	94	ethyl lactate	81	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
50	PLA	1	[HDBU][Im]	0.1	MeOH	1	70	100	methyl lactate	87	30
51	PLA	1	[Bmim][OAc]	0.1	MeOH	3	120	96	methyl lactate	90	
52	PHB	1	[HDBU][Im]	0.1	MeOH	2	100	100	methyl 3-hydroxybutyrate	33	
53	PHB	1	[MIMPS]$FeCl_4$	0.1	MeOH	3	140	99	methyl 3-hydroxybutyrate	87	
54	PLA	200	*para*-toluenesulphonic acid	5.28	MeOH	2	151	94.8	methyl lactate	93.8	31
55	PHB	200	*para*-toluenesulphonic acid	4.42	EtOH	4	151	80	ethyl 3-hydroxybutyrate	76	
56	PLA	0.5	ZrO_2/SiO_2	0.05	MeOH	2	160	100	methyl lactate	100	32

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (°C)	Con (%)	Product	Yield (%)	Ref
57	PLA	1	Raney Co	0.1	EtOH	16	187	100	1,2-propanediol	74.8	33
58	PLA	18	[BMIM][OdmGly]	1.527	DMC/MeOH	3	70	71.6	methyl lactate	61.1	34
59	PLA	18	[BMIM][OdmGly]	1.432	DMC/MeOH	3	70	85.2	methyl lactate	73.1	
60	PLA	18	[BMIM][OdmGly]	1.45	DMC/MeOH	3	70	93.4	methyl lactate	69	
61	PLA	18	[BMIM][Im]	1.272	DMC/MeOH	3	70	87.8	methyl lactate	59	
62	PLA	18	[BMIM][Im]	1.176	DMC/MeOH	3	70	44.4	methyl lactate	26.4	
63	PLA	18	[HTBD][OdmGly]	1.432	DMC/MeOH	3	70	90.1	methyl lactate	71.1	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
64	PLA	18	[HTBD][OdmGly]	1.432	MeOH	3	65	39.3	methyl lactate	25.9	34
65	PLA	18	[HTBD][OdmGly]	1.432	DMC/EtOH	3	80	45.6	methyl lactate	21	
66	PBS	0.117	$[La(acac)_3]$	0.004	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	99、93	35
67	PBS	0.117	$[Ti(acac)_4]$	0.004	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	99、93	
68	PBS	0.117	$[Mn(acac)_2]$	0.002	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	99、90	
69	PBS	0.117	$[Mn(acac)_3]$	0.005	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	99、96	
70	PBS	0.117	$[Fe(acac)_3]$	0.002	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	99、95	

No.	BP	BP Weight (mg)	Catalyst	Catalyst weight (g)	Solvent	t (h)	T (℃)	Con (%)	Product	Yield (%)	Ref
71	PBS	0.017	[$Co(acac)_2$]	0.001	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	94、84	35
72	PBS	0.017	[$Co(acac)_2$]	0.002	MeOH	4	135	100	Dimethyl succinate、1,4-Butanediol	93、83	

Table S4 Photocatalysis of biodegradable plastics

No.	BP	BP Weight	Catalyst	Catalyst weight	Solvent	t (h)	T (℃)	Product	Yield (%)	Ref
1	PLA	125 mg	$ZnIn_2S_4$	12.5 mg	KOH	12	25	lactic acid, pyruvic acid, H_2	61.7 mg, 4.4 mg, 142.8 μmol g^{-1} h^{-1}	36
2	PLA	10 g	CdS/NiS	5 mg	KOH	4	7	H_2	50.2 mmol g^{-1} h^{-1}	
3	PLA	10 g	CdS/NiS	5 mg	KOH	4	25	H_2	62.9 mmol g^{-1} h^{-1}	37
4	PBAT	10 g	CdS/NiS	5 mg	KOH	4	7	H_2	16.6 mmol g^{-1} h^{-1}	
5	PLA	200 mg	RP @ $Co_xP_y/Cd_{0.5}Zn_{0.5}S$	25 mg	NaOH	5	35	H_2	503.9 μmol/h	38
6	PLA	100 mg	CoP/CdS	10 mg	$NH_3 \cdot H_2O$	5	80	alanine	2.4 mmol g^{-1} h^{-1}	39
7	PLA	3.6 g	Pt/CdS	30 mg	9% LA solution	1	150	pyruvic acid, H_2	98.1%, 200 mmol g^{-1} h^{-1}	40

No.	BP	BP Weight	Catalyst	Catalyst weight	Solvent	t (h)	T (°C)	Product	Yield (%)	Ref
8	PLA	2 g	Pd-CdS	5 mg	deionized water	100	125	pyruvic acid, H_2	95.9%, 49.8 μmol/h	41
9	PLA	1 g	Pt-decorated $Bi_{12}O_{17}Cl_2$	0.2 g	deionized water	10	25	formic acid	55.10%	42
10	PLA	0.7 g	α-Fe_2O_3	0.07 g	dichlorom ethane	90	25	lactide	32%	43
11	PLA	100 mg	CdS/CdO_x QDs	10 mg	NaOH	24	25	H_2	64.3 mmol g^{-1} h^{-1}	44
12	PLA	0.8 g	d-$NiPS_3$/CdS	3 mg	Na_2SO_4	0.5	350	organic acid, H_2	78 μmol, 40 mmol g^{-1} h^{-1}	45
13	PLA	1 g	ZnO @ UiO66-NH_2	0.1 g	deionized water	35	25	acetic acid	91.60%	46
14	PLA	1.5 g	MoS_2/CdS	100 mg	KOH	5	5	H_2	6.68 mmol g^{-1} h^{-1}	47

Table S5 Electrocatalytic of biodegradable plastics

No.	BP	BP Weight (mg)	Catalyst	Solvent	current density (mA/cm^2)	potential (V)	t (h)	T (°C)	Product	Faradaic efficiency (%)	Ref
1	PBAT	2 g	NiNF-T, platinum sheet, Hg/HgO	70 wt% 1,4-butanediol solution, KOH	100	1.43	1	25	succinic acid	97.6	22
2	PBS	98.45 g	(Ni $(OH)_2$/NF and Cr^{3+}-Ni $(OH)_2$/NF), carbon rod, Hg/HgO	maleic acid + NaOH	100	1.5	2	25	succinic acid	181.5	48
3	PLA	1 mg/L	Pt cathode, Pt anode	dioxane/water (vol. 9: 1), 0.25 M $LiClO_4$	40	–	–	60	lactic acid	22	49
4	PLA	5 mg/L	Pt cathode, Pt anode	dioxane/water (vol. 9: 1), 0.25 M $LiClO_4$	40	–	–	60	lactic acid	36	
5	PLA	5 mg/L	Pt cathode, Pt anode	dioxane/water (vol. 9: 1), 0.25 M $LiClO_4$	5	–	–	60	lactic acid	14	
6	PLA	5 mg/L	Pt cathode, Pt anode	dioxane/water (vol. 9: 1), 0.25 M $LiClO_4$	10	–	–	60	lactic acid	28	
7	PLA	5 mg/L	Pt cathode, Pt anode	dioxane/water (vol. 9: 1), 0.25 M $LiClO_4$	50	–	–	100	lactic acid	87	

No.	BP	BP Weight (mg)	Catalyst	Solvent	current density (mA/cm^2)	potential (V)	t (h)	T (°C)	Product	Faradaic efficiency (%)	Ref
8	PLA	0.2 M KLA	Working electrode: Ni_2P/NF, Counter: platinum foil, Reference electrodes: Hg/HgO	KOH	100	1.5	100	25	acetate, acetonate	80, 5	50
9	PLA	10 g	Working electrode: $NiSe_2$/NF, Counter: platinum foil, Reference electrodes: SCE	KOH	100	1.54	100	25	acetate	95	51
10	PLA	0.3 M lactate	Pd/Ni $(OH)_2$/NF as both anode and cathode	KOH	50	–	8	60	alanine	85	52
11	PLA	1 mM	Working electrode: $CoSe_2$/NF, Counter: carbon rod, Reference electrodes: SCE	KOH	10	1.37	10	25	acetic acid	97	53

References

1. W. Saibuatrong, N. Cheroennet and U. Suwanmanee, *J. Cleaner Prod.*, 2017, **158**, 319-334.
2. Y. Aoyagi, K. Yamashita and Y. Doi, *Polym. Degrad. Stab.*, 2002, **76**, 53-59.
3. Z. Dong, Y. Zhou, Q. Chen, C. Zhang, N. Wang and Q. Xu, *Chem. Eng. J.*, 2024, **491**, 152099.
4. C. Sun, Z. Yang, Z. Zheng, W. Li, H. Tan, Y. Huang and Y. Zhang, *Sustainable Mater. Technol.*, 2023, **35**, e00549.
5. K. Papadopoulou, E. Tarani, N. M. Ainali, K. Chrissafis, C. Wurzer, O. Mašek and D. N. Bikiaris, *Molecules*, 2023, **28**, 5330.
6. B. Chen, S. Ma, S. Kumar, Z. Yao, W. Feng, J. Zhao, X. Zhang, D. Cai, H. Cao and I. Watson, *Carbon Resour. Convers.*, 2024, **7**, 100226.
7. Z. Huang, Y.-s. Li, C.-x. Zhao and Y.-j. Liu, *Fuel*, 2024, **372**, 132228.
8. Y. Cao, Z. Chen, M. Boukhir, B. Dong, J. Zhang, S. Gu and S. Zhang, *Bioresour. Technol.*, 2024, **391**, 129932.
9. T. Y. Su, G. P. Lu, K. K. Sun, P. Y. Wu and C. Cai, *J. Environ. Chem. Eng.*, 2023, **11**, 111397.
10. S.-H. Cho, Y. Kim, S. Lee, K.-Y. Andrew Lin, W.-H. Chen, S. Jung, D. Lee, D. Hyun Moon, Y. J. Jeon and E. E. Kwon, *Chem. Eng. J.*, 2023, **466**, 143307.
11. Y. Fan, H. Nishida, T. Mori, Y. Shirai and T. Endo, *Polymer*, 2004, **45**, 1197-1205.
12. S. Lee, T. H. You, I. S. Cho and J. Lee, *Chem. Eng. J.*, 2023, **466**, 143297.
13. M. Liang, H. Pan, Y. Zhu, H. Zhu, M. Su, Y. Xie, Y. Zheng, X. Jiang, R. Li and J. Zhang, *Biomass Convers. Biorefin.*, 2023, **14**, 26035–26050.
14. Z. Alhulaybi, I. Dubdub, M. Al-Yaari, A. Almithn, A. F. Al-Naim and H. Aljanubi, *Polymers*, 2023, **15**, 12.
15. X. Ma, J. L. Wang, L. Li, X. Wang and J. H. Gong, *Renew. Energy*, 2024, **225**, 120267.
16. J. Y. Diaz Varela, L. G. Burciaga Jurado, I. Olivas Armendáriz, C. A. Martínez Pérez and C. Chapa González, *Sci. Rep.*, 2024, **14**, 8405.

17. M. Ponjavic, M. S. Nikolic, S. Stevanovic, J. Nikodinovic-Runic, S. Jeremic, A. Pavic and J. Djonlagic, *J. Bioact. Compat. Polym.*, 2020, **35**, 517-537.
18. C. Busatto, J. Pesoa, I. Helbling, J. Luna and D. Estenoz, *J. Appl. Polym. Sci.*, 2017, **134**, 45464.
19. A. Tapadiya and N. Vasanthan, *Int. J. Biol. Macromol.*, 2017, **102**, 1130-1137.
20. J. Liang, P. Tang, J. Fu, X. Lan, Y. Wu, Q. Zhang and S. Kang, *Biomass Convers. Biorefin.*, 2024, **15**, 3373–3384.
21. Y. C. Jiao, M. Wang and D. Ma, *Chin. J. Chem.*, 2023, **41**, 2071-2076.
22. W. Pang, B. Li, Y. Wu, Q. Zeng, J. Yang, Y. Zhang and S. Tian, *Chem. Eng. J.*, 2024, **486**, 150342.
23. W.-Z. Zheng, X. Li, P.-Y. Xu, Z.-Y. Zhang, P.-L. Wang, B. Lu, D. Huang, Z.-C. Zhen, J.-H. Ji and G.-X. Wang, *Resour., Conserv. Recycl.*, 2024, **209**, 107771.
24. F. Liguori, C. Moreno-Marrodán, W. Oberhauser, E. Passaglia and P. Barbaro, *RSC Sustainability*, 2023, **1**, 1394-1403.
25. S. H. Tian, Y. C. Jiao, Z. R. Gao, Y. Xu, L. K. Fu, H. Fu, W. Zhou, C. Q. Hu, G. S. Liu, M. Wang and D. Ma, *J. Am. Chem. Soc.*, 2021, **143**, 16358-16363.
26. A. K. Manal, G. Saini and R. Srivastava, *Green Chem.*, 2024, **26**, 3814-3831.
27. X. Zhu, H. Zhao, H. Wang, D. Yang, F. Liu and X. Song, *J. Polym. Environ.*, 2024, **32**, 2884-2896.
28. X. Zhu, H. Wang, B. Liu, D. Yang, F. Liu and X. Song, *Polym. Degrad. Stab.*, 2024, **219**, 110625.
29. R. Petrus, D. Bykowski and P. Sobota, *ACS Catal.*, 2016, **6**, 5222-5235.
30. M. Liu, J. Guo, Y. Gu, J. Gao and F. Liu, *ACS Sustainable Chem. Eng.*, 2018, **6**, 15127-15134.
31. V. Jašek, J. Fučík, L. Ivanová, D. Veselý, S. Figalla, L. Mravcova, P. Sedlacek, J. Krajčovič and R. Přikryl, *Polymers*, 2022, **14**, 5236.
32. B. Ye, R. Zhou, C. Wang, Z. Wang, Z. Zhong and Z. Hou, *Appl. Catal., A*, 2023, **649**, 118936.
33. J. L. Xu, K. Zhou, L. L. Qin, Z. M. Tan, S. J. Huang, P. G. Duan and S. M. Kang, *Polymers*, 2023, **15**, 413.

34. D. Hubble, S. Nordahl, T. Y. Zhu, N. Baral, C. D. Scown and G. Liu, *ACS Sustainable Chem. Eng.*, 2023, **11**, 8208-8216.

35. R. Abe, N. Komine, K. Nomura and M. Hirano, *Chem. Commun.*, 2022, **58**, 8141-8144.

36. Y. Q. Zheng, P. Fan, R. J. Guo, X. H. Liu, X. T. Zhou, C. Xue and H. B. Ji, *RSC Adv.*, 2023, **13**, 12663-12669.

37. C. Zhu, J. Wang, J. Lv, Y. Zhu, Q. Huang and C. Sun, *Int. J. Hydrogen Energy*, 2024, **51**, 91-103.

38. R. Li, F. Wang, F. Lv, P. Wang, X. Guo, J. Feng, D. Li and Y. Chen, *Int. J. Hydrogen Energy*, 2024, **51**, 406-414.

39. C. X. Liu, K. S. Liu, Y. J. Xu, Z. Wang, Y. X. Weng, F. L. Liu and Y. Chen, *Angew. Chem., Int. Ed.*, 2024, **63**, e202401255.

40. Y. Xiang, J. Zhang, F. Huang, N. T. Xiao, Y. Y. Fan, J. H. Zhang, H. Zheng, J. W. Chen and F. Zhang, *Chin. J. Catal.*, 2024, **59**, 149-158.

41. Y. X. Miao, Y. X. Zhao, J. Y. Gao, J. H. Wang and T. R. Zhang, *J. Am. Chem. Soc.*, 2024, **146**, 4842-4850.

42. F. Y. Wu, C. M. Li, Y. B. Dou, J. C. Zhou, T. Jiang, Y. C. Yao, N. Y. Lee, S. Y. Lim, C. Hélix-Nielsen and W. J. Zhang, *Sci. Total Environ.*, 2023, **902**, 165899.

43. A. Garratt, K. Nguyen, A. Brooke, M. J. Taylor and M. G. Francesconi, *ACS Environ. Au*, 2023, **3**, 342-347.

44. T. Uekert, M. F. Kuehnel, D. W. Wakerley and E. Reisner, *Energy Environ. Sci.*, 2018, **11**, 2853-2857.

45. S. Zhang, H. B. Li, L. Wang, J. D. Liu, G. J. Liang, K. Davey, J. R. Ran and S. Z. Qiao, *J. Am. Chem. Soc.*, 2023, **145**, 6410-6419.

46. J. B. Qin, Y. B. Dou, J. C. Zhou, V. M. Candelario, H. R. Andersen, C. Hélix-Nielsen and W. J. Zhang, *Adv. Funct. Mater.*, 2023, **33**, 2214839.

47. M. M. Du, Y. Zhang, S. L. Kang, X. Y. Guo, Y. X. Ma, M. Y. Xing, Y. Zhu, Y. Chai and B. C. Qiu, *ACS Catal.*, 2022, **12**, 12823-12832.

48. B. Zhou, K. Shi, X. Teng, Z. H. Li, L. S. Chen and J. L. Shi, *Angew. Chem., Int. Ed.*, 2024, **63**, e202411502.

49. S. D. Mürtz, M. S. Lehnertz, J. Kümper, E. Häger, A. Markus, T. Becker, S. Herres-Pawlis and R. Palkovits, *Green Chem.*, 2024, **26**, 6423-6428.

50. Y. Chen, X. Zhang, C. Liu, W. Xue, M. Wei, S. Hu, Q. Jiang, T. Zheng, X. Li and C. Xia, *ACS Appl. Mater. Interfaces*, 2024, **16**, 20570–20576.

51. B. Lan, Y. Chen, N. Xiao, N. Liu, C. Juan, C. Xia and F. Zhang, *J. Energy Chem.*, 2024, **97**, 575-584.

52. Y. X. Ma, X. Y. Guo, M. M. Du, S. L. Kang, W. L. Dong, V. Nicolosi, Z. L. Cui, Y. Zhang and B. C. Qiu, *Green Chem.*, 2024, **26**, 3995-4004.

53. Y. Li, Y. X. Zhao, H. Zhao, Z. L. Wang, H. Li and P. Q. Gao, *J. Mater. Chem. A*, 2022, **10**, 20446-20452.