

Supplementary information

Bio-based plastics in a circular economy: an overview of recovery pathways and implications for product design

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List of symbols:

T	Temperature
σ_{max}	Ultimate tensile stress
ε_{max}	Failure strain
H	Hardness
MFI	Melt-flow index
N	Screw rotation in extruders
ρ	Density
p_{im}	Injection moulding pressure
E	Young's modulus
σ_y	Yield stress
c	Concentration
t	Time

Abbreviations:

BMIM	1-Butyl-3-methylimidazolium hexafluorophosphate
MIMPS	1-(3-sulfonic acid)-propyl-3-methylimidazole
HDPE	High density polyethylene
LDPE	Low density polyethylene
PBS	Polybutylene succinate
PEF	Polyethylene Furanoate
PET	Polyethylene terephthalate
PHA	Polyhydroxyalkanoate
PHB	Polyhydroxybutyrate
PLA	Poly(lactic acid)
PLLA	Poly L-lactic acid
PP	Polypropylene
TPS	Thermoplastic starch

Table S1: Mechanical recycling of bio-based polymers, or petrochemical-based polymers for which bio-based alternatives exist.

Polymer	Process conditions	Results	Reference
PP* Injection grade	Injection moulding. $T = 200\text{ °C}$, $p_{im} = 594\text{ bar}$	MFI : increased after 4 cycles; after 1 cycle E : increased, σ_y : increased, ε_{max} : decreased.	(Aurrekoetxea et al., 2001)
PLA* Thermo-forming grade	Injection moulding in a twin-screw extruder. $T = 200\text{ °C}$	Rapid reduction in molecular weight. Reduction in mechanical properties after 2 reprocessing cycle.	(Badia et al., 2012c)
PLA*	Accelerated aging by UV exposure, thermal degradation and (for some samples) washing in salt water. Reprocessed by extrusion at ($T = 120\text{-}180\text{ °C}$) followed by hot pressing into films (190 °C , 14 MPa).	Slight molecular weight reduction, especially when washed. Little change in thermal properties, barrier properties, and mechanical properties (Young's modulus and hardness), although washing induced more degradation.	(Beltrán et al., 2018)
PBS*	Twin screw co-rotating extruder. $N = 100\text{ min}^{-1}$ $T = 190\text{ °C}$, 200 °C , 210 °C .	Rapid deterioration of thermal and processing properties. Stabilisers may be added to improve properties.	(Georgousopoulou et al., 2016)
LDPE* Commercial LDPE, containing slip agents and thermal stabilisers among other additives	Twin screw extruder, up to 100 times. $N = 150\text{ rev min}^{-1}$, $T = 240\text{ °C}$.	Rheological functions increase with extrusion cycles. Thermal properties did not change, but crystallinity decreased. Creep behaviour did not change up to 40 extrusion cycles.	(Jin et al., 2012)
LDPE* Agricultural films, milk pouches, bags	Adding 3 wt% heat stabiliser, 1 wt% lubricant and 30 wt% plasticiser. Samples prepared in hydraulic press at 170 °C and 300 kN for 5 min.	σ_f : 1-50% degradation, σ_f : 15% decrease to 31% increase, both depending on product.	(Kabdi & Belhaneche-bensemra, 2008)
PBS* Bionolle #1020	Reprocessing with melt-moulding at 140 °C	Mechanical properties did not change up to 3 cycles	(Kanemura et al., 2012)
HDPE* Product: container	Extrusion in a twin-screw compounder or single screw extruder. Stabiliser was added before extrusion "when necessary"	Strong relation between processing conditions and rheological/mechanical properties. High residence times lead to more degradation. Changes after 2 extrusion for low residence times; changes after 4 extrusion for high residence times.	(Kostadinova Loutcheva et al., 1997)
HDPE*	(re)processing by injection moulding, under unknown conditions.	σ_{max} : 30% lower, elongation at break ε_{max} 19% lower	(Meran et al., 2008)
LDPE*		σ_{max} : 35% lower, ε_{max} : 28% lower	
PP*		σ_{max} : 34% lower, σ_{max} : 20% lower	
HDPE Containing UV stabilisers	Extrusion up to 40 times in a twin-screw extruder. $N = 150\text{ rev min}^{-1}$, $T = 240\text{ °C}$.	MFI reduces to 0 after 30 cycles. H decreases after 10 cycles. Creep behaviour worsens after 30 cycles. Crystallinity drops after 20 cycles. After 100 cycles 80% of the initial mechanical properties are retained.	(Oblak et al., 2015)
PET* Virgin commercial	Extruded in a single- or double-screw (co- or counter-rotating)	Mechanical recycling reduces all mechanical and processing properties. Impact strength is	(Oromiehie & Mamizadeh, 2004)

and recycled beverage bottles	extruder, $N = 70, 50\ 70\ \text{rev min}^{-1}$ respectively. $240\ ^\circ\text{C} < T < 285\ ^\circ\text{C}$	affected the most, reducing by over 50% after mechanical recycling. Degradation in the properties was the largest in the counter-rotating twin screw extruder.	
PET* Post-consumer water bottles of various origins	Mixed at $T = 260 - 280\ ^\circ\text{C}$, at various speeds in dry or humid conditions.	Humidity has a larger influence than temperature on the degradation of recycled PET. Reactions with water and oxygen in the air introduce differences in the molecular structure.	(Paci & La Mantia, 1998)
HDPE*	Extrusion, $T = 230\ ^\circ\text{C}$ followed by 3D printing through Fused Filament Fabrication (FFF), $T = 240\ ^\circ\text{C}$ and 25 mm/s nozzle speed.	σ_{max} : 10% higher after 1 cycle; 10% higher after 6 cycles. ε_{max} : 17% higher after 1 cycle; 21% higher after 6 cycles. Generally, mechanical properties first increase and then decrease after 2-5 cycles.	(Vidakis et al., 2021a)
PP*	Extrusion, $T = 210\ ^\circ\text{C}$ followed by 3D printing through Fused Filament Fabrication (FFF), $T = 230\ ^\circ\text{C}$ and 30 mm/s nozzle speed.	Tensile properties (σ_{max} , ε_{max}), increase after first cycle, then decrease for 4 cycles and then sharply increased in the final cycle tested. Flexural strength and elastic modulus increase with each cycle.	(Vidakis et al., 2021b)
PLA*	Extrusion, double screw and single screw, and injection moulding.	Rapid decrease in tensile stress at break after a single reprocessing cycle. Tensile strength reduced at a lower rate. Impact strength decreased; melt-flow rate increased. Permeability to oxygen and water vapour increased after 1 reprocessing cycle.	(Zenkiewicz et al., 2009)

*Additives unknown

Table S2: Dissolution of petrochemical-based polymers for which chemically identical bio-based alternatives exist.

Polymer	Process conditions	Recovery rate	Reference
HDPE	Solvent: toluene; nonsolvent: n-hexane. $c = 0.5$ kg/kg; $T = 110$ °C.	96.7%	(Achilias et al., 2007)
LDPE	Solvent: xylene; nonsolvent: n-hexane; $c = 0.05$ - 0.20 kg/kg; $T = 100$ - 140 °C.	95.9 – 99.8%	
	Solvent: toluene; nonsolvent: n-hexane. $c = 0.05$ kg/kg; $T = 110$ °C.	97.7%	
PP	Solvent: xylene; nonsolvent: n-hexane; $c = 0.05$ - 0.15 kg/kg; $T = 100$ – 140 °C.	75.5% – 99.9%	
PET	Solvent: benzyl alcohol; nonsolvent: methanol. $c = 0.05$ kg/kg; $T = 180$ °C	99%	(Achilias et al., 2009)
HDPE	Solvent: xylene; nonsolvent: n-hexane. $c = 0.05$ kg/kg; $T = 100$ °C.	98.6%	
	Solvent: xylene; nonsolvent: methanol. $c = 0.05$ kg/kg; $T = 100$ °C.	97%	
LDPE	Solvent: xylene; nonsolvent: n-hexane; $c = 0.05$ - 0.20 kg/kg; $T = 100$ - 140 °C.	95.9% – 99.8%	
PP	Solvent: xylene; nonsolvent: n-hexane; $c = 0.05$ - 0.15 kg/kg; $T = 100$ – 140 °C.	75.5% – 99.9%	(Drain et al., 1983)
PP	Solvent: tetrachloroethylene; nonsolvent: air or nitrogen. $c = 0.10$ kg/kg; $T = 145$ °C.	Unknown	
HDPE	Solvent: xylene; nonsolvent: 2-propanediol. $c = 0.05$ kg/kg; $T = 100$ °C.	Unknown	(Kannan et al., 2017)
LDPE	Solvent: xylene; nonsolvent: 2-propanediol. $c = 0.05$ kg/kg; $T = 75$ °C.	Unknown	
PP	Solvent: tetrachloroethylene; nonsolvent: acetone. $c = 0.01$ kg/L; $T = 130$ °C.	Unknown	(Murphy et al., 1979)
LDPE	Solvent: xylene; nonsolvent: acetone. $c = 20$ kg/L; $T = 85$ °C.	80%	(Papaspnyrides et al., 1994)
	Solvent: toluene; nonsolvent: acetone. $c = 0.30$ kg/L; $T = 85$ °C.	95%	
HDPE	Solvent: xylene; nonsolvent: propanol-1. $c = 0.10$ kg/kg; $T = 100$ C	~100%	(Pappa et al., 2001)
LDPE	Solvent: xylene; nonsolvent: propanol-1. $c = 0.10$ kg/kg; $T = 85$ °C.	~100%	
PP	Solvent: xylene; nonsolvent: propanol-1. $c = 0.10$ kg/kg; $T = 135$ °C	~100%	
HDPE	Solvent: toluene; nonsolvent: acetone. $c = 0.10$ kg/L; $T = 110$ °C	100%	(Poulakis & Papaspnyrides, 1995)
PP	Solvent: xylene; nonsolvent: acetone. $c = 0.15$ kg/L; $T = 130$ °C.	100%	(Poulakis & Papaspnyrides, 1997)
PET	Solvent: n-methyl-2-pyrro-lidone; nonsolvent: n-octane and n-hexane. $c = 0.20$ kg/L; 165 °C.	100%	(Poulakis & Papaspnyrides, 2001)

Table S3: Solvolysis of bio-based polymers, or petrochemical-based polymers for which bio-based alternatives exist

Polymer	Solvolysis type	Process conditions	Products	Reference
PLA	Alcoholysis	Catalyst: 4-dimethylaminopyridine. Microwave assisted, $T = 180\text{ }^{\circ}\text{C}$ for 20 minutes. Various PLA products were tested.	Methyl lactate, yield depended on the type of product and the degree and source of contamination.	(Alberti et al., 2019)
PEF PET	Enzymatic depolymerisation	Catalyst: <i>I. sakaiensis</i> enzyme, or PETase. In a phosphate buffer at pH 7.2 for 96 hours.	Unknown	(Austin et al., 2017)
PET	Enzymatic depolymerisation	Catalyst: <i>Humicola Insolens</i> cutinase enzyme. $T = 50\text{ }^{\circ}\text{C}$, $t = <14$ days	Terephthalic acid, bis(2-hydroxyethyl terephthalate), mono(2-hydroxyethyl terephthalate)	(Carniel et al., 2021)
PET	Hydrolysis (acid)	Water containing Sulphuric acid, NaOH, calcium oxide or hydroxide. $P = 0.1\text{ MPa}$, $T = 25\text{ }^{\circ}\text{C} - 90\text{ }^{\circ}\text{C}$	Ethylene glycol Excess acid	(Carta et al., 2003)
	Hydrolysis (alkaline)	Water containing NaOH, wetting agent or surfactants, calcium oxide or hydroxide, H_2SO_4 . $P = 1.4 - 2\text{ MPa}$. $T = 210\text{ }^{\circ}\text{C} - 250\text{ }^{\circ}\text{C}$.	Terephthalic acid Ethylene glycol	
	Hydrolysis (neutral)	Water or steam with a alkali metal acetate catalyst. $P = 1 - 4\text{ MPa}$, $T = 200\text{ }^{\circ}\text{C} - 300\text{ }^{\circ}\text{C}$.	Terephthalic acid Ethylene glycol	
	Glycolysis	With a zinc acetate catalyst. $P = 0.1 - 0.6\text{ MPa}$, $T = 190 - 240\text{ }^{\circ}\text{C}$.	Bis(hydroxyethyl)-terephthalate, Ethylene glycol, Polyols	
PLA	Alcoholysis	Catalysts: Zinc-N-Heterocyclic Carbene Complexes. $T = \text{room temperature}$.	Methyl lactate	(Flidel et al., 2014)
PET	Aminolysis	Various amine reagents and catalyst: 1,5,7-triazabicyclo[4.4.0]dec-5-ene $T = 45 - 190\text{ }^{\circ}\text{C}$	Terephthalic acid and other terephthalamide compounds (yield: 66% - 89%)	(Fukushima et al., 2013)
PET	Hydrolysis	Solvent mixture: KOH, anhydrous EG, dimethyl sulfoxide (DMSO), cyclohexylamine (CHA), tetrahydrofuran (THF), HCl, ethanol and phenolphthalein. $T = 100 - 180\text{ }^{\circ}\text{C}$. $t = 5 - 140\text{ min}$.	Terephthalic acid (yield: 53.12% - 99.92%), Ethylene glycol (yield: 53.11% - 99.94%)	(Goje et al., 2004)
PLA	Enzymatic depolymerisation	Catalyst: <i>Rhodopseudomonas palustris</i> RPA1511. $T = 30\text{ }^{\circ}\text{C}$, $t = 36 - 72\text{ hours}$.	Monomeric lactide, Oligomeric lactide.	(Hajighasemi et al., 2016)
		Catalyst: <i>Alcanivorax borkumensis</i> ABO2449 $T = 30\text{ }^{\circ}\text{C}$, $T = 36 - 72\text{ hours}$.	Monomeric lactide, Oligomeric lactide.	
PLLA	Alcoholysis	Ethanol ($T = 140 - 180\text{ }^{\circ}\text{C}$) or butanol ($T = 130 - 210\text{ }^{\circ}\text{C}$) under microwave irradiation. PLLA:solvent = 1:10 mol/mol.	Lactate	(Hirao et al., 2010)

PET	Enzymatic depolymerisation	Catalyst: <i>Humicola insolens</i> cutinase enzyme, Novozym ®. $T = 55\text{ }^{\circ}\text{C}$, $t = 7\text{ days}$	Terephthalic acid mono(2-hydroxyethyl terephthalate)	(Kaabel et al., 2021)
PET	Hydrolysis	First hydrolysis in sodium hydroxide, then TPA- Na_2 was acidified to yield terephthalic acid. Catalyst: trioctylmethylammonium bromide. $T = 70\text{ }^{\circ}\text{C} - 95\text{ }^{\circ}\text{C}$, $t = 5 - 6\text{ hours}$	Terephthalic acid (yield: up to 95%), Ethylene glycol	(Kosmidis et al., 2001)
PLA	Alcoholysis	Solvent mixture: Various alcohols and methylene chloride. Catalyst: triazabicyclodecene. $T = \text{room temperature}$. Time varied by alcohol type (2 minutes for methanol, ethanol, butanol; 3 minutes for allylic and benzylic alcohols;)	Lactate with the structure of the alcohol (e.g. methyl lactate when methanol is used as the solvent).	(Leibfarth et al., 2012)
PLA	Alcoholysis	Solvent: methanol Catalyst: FeCl_3 $T = 100 - 130\text{ }^{\circ}\text{C}$, $t = \text{up to } 4\text{ hours}$	Methyl lactate (Yield: 61.3% at $100\text{ }^{\circ}\text{C}$, up to 87.2% at $130\text{ }^{\circ}\text{C}$)	(Liu et al., 2015)
PLA	Alcoholysis	Solvent: methanol Catalyst: $[\text{Bmim}]\text{FeCl}_4$ $T = 100 - 120\text{ }^{\circ}\text{C}$ $t = 2 - 3\text{ hours}$	Methyl lactate (Yield: up to 94.6%)	(Liu et al., 2017)
PET	Enzymatic depolymerisation	Catalyst: <i>Candida Antarctica</i> lipolzyme. $T = 50\text{ }^{\circ}\text{C}$, $t = 24\text{ hours}^*$.	Terephthalic acid, bis(2-hydroxyethyl terephthalate), mono(2-hydroxyethyl terephthalate)	(Neves Ricarte et al., 2021)
PEF	Enzymatic depolymerisation	Catalyst: <i>Thermobifida cellulosilytica</i> cutinase enzyme. $T = 50\text{ }^{\circ}\text{C}$, $t = 72\text{ hours}$.	2,5-Furandicarboxylic acid and some oligomers.	(Pellis et al., 2016)
PLA	Alcoholysis	Solvent: ethanol $T = \text{up to } 200\text{ }^{\circ}\text{C}$, $t = 1\text{ hour}$.	Methyl lactate, lactic acid	(Petrus et al., 2016)
PET	Enzymatic depolymerisation	Catalyst: <i>Humicola Insolens</i> cutinase enzyme. $T = 50\text{ }^{\circ}\text{C}$; $t = 24\text{ hours}^*$.	Terephthalic acid, Ethylene glycol	(Quartinello et al., 2017)
PLA	Alcoholysis	Solvent: methanol Catalyst: $\text{Zn}(\text{I})_2$, $T = 40 - 130\text{ }^{\circ}\text{C}$, $t < 15\text{ min}$.	Methyl lactate	(Román-Ramírez et al., 2019)
PLA	Alcoholysis	Solvents: methanol or ethanol. Catalyst: zinc acetate. $T = 64\text{ }^{\circ}\text{C}$ for methanol, $78\text{ }^{\circ}\text{C}$ for ethanol. $t = 15\text{ hours}$.	Methyl lactate (70% in methanol, 21% in ethanol)	(Sánchez & Collinson, 2011)
PET	Alcoholysis	Solvent: ethylene glycol. Catalyst: none, zinc acetate, zinc stearate or zinc sulfate. $T = 197\text{ }^{\circ}\text{C}$. $t = 15\text{ hours}$.	Bis(hydroxyethyl) terephthalate. Yield: no catalyst – 62%, zinc acetate – 78%, zinc stearate – 65%, zinc sulfate – 25%.	
PLA	Alcoholysis	Solvent: Methanol. Catalyst: $[\text{Bmim}]\text{Ac}$ or $[\text{Bmim}]\text{HSO}_4$.	Methyl lactate	(Song et al., 2013)

			(Yield: [Bmim]Ac – 92.5%, [Bmim]HSO ₄ – 87.9%)	
PHA (PH3B)	Alcoholysis	Solvent: methanol. Catalyst: FeCl ₃ , [MIMPS]FeCl ₄ , [MIMPS]ZnCl ₃ , or [MIMPS]HSO ₄ . <i>T</i> = 110 – 150 °C, <i>t</i> = 1 – 4 hours.	Methyl crotonate or (R)-(-)-3-hydroxybutyrate (Yield: FeCl ₃ – 81.2%, [MIMPS]FeCl ₄ – 87.4%, [MIMPS]ZnCl ₃ – 35.4%, [MIMPS]HSO ₄ – 83.7%)	(Song et al., 2018)
PHA (PH3B)	Alcoholysis	Solvent: methanol, Catalyst: [Bmim]FeCl ₄ . <i>T</i> = 110 or 140 °C.	Methyl crotonate or (R)-(-)-3-hydroxybutyrate	(Song et al., 2019)
PHA (PH3B)	Alcoholysis	Solvent: methanol, catalyst: none. <i>T</i> = 50 – 275 °C, <i>t</i> = 6 hours.	Methyl crotonate, crotonic acid, or methyl 3-hydroxybutyrate. Product yield up to 60%	(Spekreijse et al., 2015)
PET	Enzymatic depolymerisation	Catalyst: Leaf-branch compost cutinase, modified. <i>T</i> = 72 °C, <i>t</i> = 9.3-10 hours.	Terephthalic acid, Ethylene glycol	(Tournier et al., 2020)
PLLA	Hydrolysis	No catalysts. <i>T</i> = 180 – 350 °C, <i>t</i> = up to 30 minutes.	L-lactic acid	(Tsuiji et al., 2003)
PEF	Enzymatic depolymerisation	Catalyst: <i>Humicola insolens</i> cutinase enzyme. <i>T</i> = 65 °C, <i>t</i> = 72 hours.	2,5-Furandicarboxylic acid.	(Weinberger et al., 2017a,b)

* A combination of solvolysis and enzymatic depolymerisation. Solvolysis was employed to already reduce the molecular weight of the polymer, down to a mix of monomers and oligomers of a few repeating units. Enzymatic depolymerisation was deployed to reduce these oligomers further to monomers.

Table S4: Anaerobic digestion of bio-based polymers, or petrochemical-based polymers for which bio-based alternatives exist

Polymer	Anaerobic composting substrate and conditions	Degradation achieved	Reference
PHA (PHB)	Methane sludge ($T = 37\text{ }^{\circ}\text{C}$), sewage sludge ($T = 37\text{ }^{\circ}\text{C}$), $t = 42$ days.	In methane sludge: 100%; in sewage sludge: 100%.	(Abou-Zeid et al., 2001)
PHA (PHBV)		In methane sludge: 57%; in sewage sludge: 63%.	
PLLA	High-solids inoculum ASTM D5511 (equivalent to ISO 15985). $T = 52\text{ }^{\circ}\text{C}$, $t = 20$ days	72%	(Itävaara et al., 2002)
TPS (Mater-bi)	ISO 14853 in microbial inoculum from wastewater treatment plant digester. $T = 35\text{ }^{\circ}\text{C}$, $t = 28$ days	23%	(Massardier-nageotte et al., 2006)
PLA		no degradation	
TPS (Mater-bi)	ASTM D5526 (ASTM, 2018). Focus on measuring methane production. $t = 17$ days.	TPS methane production: 160.5 ml Cellulose filter paper (control) methane production: 220.8 ml	(Mohee et al., 2008)
PLA	Cow manure and vegetable waste compost.	Biodegradation started after 55 days at $35\text{ }^{\circ}\text{C}$ at 2.9%/week. At $55\text{ }^{\circ}\text{C}$, 90% degradation after 40 days.	(Yagi et al., 2009)
PLA	Cow manure and vegetable waste compost. $T = 55\text{ }^{\circ}\text{C}$; $t = 40$ days.	86-95%	(Yagi et al., 2010)
PBS	Composted in sludge from biomass plant (cow manure and vegetable waste). $55\text{ }^{\circ}\text{C}$	No degradation	(Yagi et al., 2013)
PLA		24% degraded after 30 days, 68% degraded after 60 days	
PHA (PHB)		>70% degraded after 11 days	
PBS	Composted in commercial plant, $37\text{ }^{\circ}\text{C}$	7% after 90 days, 18-27% after 277 days.	(Yagi et al., 2014)
PLA		No degradation	
PHA (PHB)		35-42% after 4 days, >90% after 10 days.	
PLA	Commercial digester on foodwaste and card packaging. $T = 37\text{ }^{\circ}\text{C}$, $t = 65$ days.	20%	(Zhang et al., 2018)

Table S5: Industrial aerobic digestion of bio-based polymers, or petrochemical-based polymers for which bio-based alternatives exist

Plastic or product	Aerobic composting substrate and conditions	Degradation achieved	Reference
TPS commercial carrier bags	Composted with mature compost Temperature not reported, $t = 90$ days.	43%	(Accinelli et al., 2012)
PLA pellets	Pellets and films of different molecular weight mixed with compost or uninoculated or inoculated vermiculite. $T = 58$ °C, $t = 60$ days.	$39.2 \pm 5.5\%$ in compost; $34.5 \pm 2.8\%$ in inoculated vermiculite No biodegradation in uninoculated vermiculite.	(Castro-aguirre et al., 2017)
PLA films		Films: biodegradation after 60 days: 63.3 – 100 %, higher biodegradation correlated to lower molecular weight)	
PLLA films	Vegetable and fruit waste. The thermophilic phase reached 70 °C in less than 10 days.	40 days: 73%	(Itävaara et al., 2002)
PLLA fabrics		20 days: 99%	
PLA	Composted with industrial compost (cow manure, wood shavings and waste feed). Entire bottle in simulated composting conditions. $T = 65$ °C, $t = 58$ days.	77.8% – 84.2%	(Kale et al., 2007)
PBS	ASTM 6003-96		(Kim et al., 2006)
PLA	Compost from agricultural and tree wastes, increased vermiculite. $T = 58$ °C, $t = 45$ days	55-75%	(Longerías et al., 2007)
PLA	Composted with organic fraction of municipal solid waste. $T = 58$ °C, $t = 80$ days.	Pure PLA: 78.9%	(Luo et al., 2019)
PLA + 15wt% TiO ₂ nanofiller,		PLA/TiO ₂ filler: 85.0%	
TPS	Composted with kitchen and yard waste and paper. $T \leq 60$ °C, $t = 72$ days.	100%	(Mohee et al., 2008)
PBS			(Rafiqah et al., 2021)
PLA	Composted with synthetic biodegradable material. ISO 20200 $T = 58$ °C, $t = 90$ days	64%	(Sarasa et al., 2009)
PLA-10 wt% corn blend		80%	
PHA (PHBV)	Pilot-scale synthetic composting conditions (ISO 16929) and $T = 58$ °C, $t = 39$ days.	100%	(Weng et al., 2010)
	laboratory conditions (ISO 14855), $T = 58$ °C, $t = 35$ days.	81%, no visual fragments after 12 weeks	
PHA (PHB)	Composted with commercial compost from municipal organic waste. ISO 14855. $T = 58$ °C, $t = 110$ days.	79.7% - 90.5%, depending on PHB composition.	(Weng et al., 2011)

Table S6: Aerobic digestion in nature of bio-based polymers, or petrochemical-based polymers for which bio-based alternatives exist

Polymer	Testing conditions	Results	Reference
TPS (Mater-bi), commercial carrier bags	Biodegradation at 25 °C for 7-10 days in soil, compost, littoral marsh and sea water	Surface erosion after 90 days: Soil (field): 3-5%, soil (lab): 36%-39%, compost (lab): 42%-45%, littoral marsh (lab): 1.4%-1.8%, littoral marsh (field): 1.2%-1.8%, sea water (lab): 1.5%-1.9%, sea water (field): 4.3%-4.7%	(Accinelli et al., 2012)
PHA (produced in-house, films and pellets)	Specimens were buried in Hoa Lac near Hanoi and in Dam Bai (50m from the sea) for 180 days.	Mass loss after 305 days in Hao Lac: PHB pellets: 55%, PHB film: 98% PHBV pellets: 45%, PHBV film: 62% Mass loss after 385 days in Dam Bai: PHB pellets: 28%, PHB film: 48% PHBV pellets: 8%, PHBV film: 14%	(Boyandin et al., 2013)
PBS (commercial, pure and with bio-flour filler)	80 days in aerobic digestion conditions with municipal solid waste or buried in soil in lab environment, both at 30 ± 2 °C.	Weight loss in soil: With filler: 7%, without filler: 4% Weight loss in compost: With filler: 17%, without filler: 13%	(Kim et al., 2006)
PBS and PHBV, both commercial films	Soil from Nagoya University farm mixed with 2 wt% farmyard manure at 30 °C for 25 days in both aerobic and anaerobic lab conditions	Weight loss under aerobic conditions: PBS: 28%, PHB: 95% after 23 days. Weight loss under anaerobic conditions: PBS: 0%, PHB: 0%	(Nishide et al., 1999)
PLA	Buried in soil in lab setting at 30 °C for 6 weeks	Weight loss: 0%	(Ohkita & Lee, 2006)
PLA	Degradation in an aquarium in Brazil for 600 days, 22 °C < T < 25 °C	Weight loss: 2.5%.	(Pelegrini et al., 2016)

References

- Abou-Zeid, D.M., Müller, R.J., Deckwer, W.D., 2001. Degradation of natural and synthetic polyesters under anaerobic conditions. *J. Biotechnol.*, 86(2), 113-126. [https://doi.org/10.1016/S0168-1656\(00\)00406-5](https://doi.org/10.1016/S0168-1656(00)00406-5).
- Accinelli, C., Saccà, M.L., Mencarelli, M., Vicari, A., 2012. Deterioration of bioplastic carrier bags in the environment and assessment of a new recycling alternative. *Chemosphere*, 89(2), 136-143. <https://doi.org/10.1016/j.chemosphere.2012.05.028>.
- Achilias, D.S., Roupakias, C., Megalokonomos, P., Lappas, A.A., Antonakou, E.V., 2007. Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP). *J. Hazard. Mater.*, 149(3), 536-542. <https://doi.org/10.1016/j.jhazmat.2007.06.076>.
- Achilias, D.S., Giannoulis, A., Papageorgiou, G.Z., 2009. Recycling of polymers from plastic packaging materials using the dissolution–reprecipitation technique. *Polym. Bull.*, 63(3), 449-465. <https://doi.org/10.1007/s00289-009-0104-5>.
- Aurrekoetxea, J., Sarrionandia, M.A., Urrutibeascoa, I., MasPOCH, M.L., 2001. Effects of recycling on the microstructure and the mechanical properties of isotactic polypropylene. *J. Mater. Sci.*, 36(11), 2607-2613. <https://doi.org/10.1023/A:1017983907260>.
- Alberti, C., Damps, N., Meißner, R.R., Enthaler, S., 2019. Depolymerization of End-of-Life Poly (lactide) via 4-Dimethylaminopyridine-Catalyzed Methanolysis. *ChemistrySelect*, 4(23), 6845-6848. <https://doi.org/10.1002/slct.201901316>.
- Austin, H.P., Allen, M.D., Donohoe, B.S., Rorrer, N.A., Kearns, F.L., Silveira, R.L., Pollard, B.C., Dominick, G., Duman, R., El Omari, K., Mykhaylyk, V., Wagner, A., Michener, W.E., Amore, A., Skaf, M.S., Crowley, M.F., Thorne, A.W., Johnson, C.W., Woodcock, H.L., McGeegan, J.E., Beckham, G.T. (2018). Characterization and engineering of a plastic-degrading aromatic polyesterase. *Proc. Natl. Acad. Sci.*, 115(19), E4350-E4357. <https://doi.org/10.1073/pnas.1718804115>.
- Badia, J.D., Strömberg, E., Karlsson, S., Ribes-Greus, A., 2012c. Material valorisation of amorphous polylactide. Influence of thermo-mechanical degradation on the morphology, segmental dynamics, thermal and mechanical performance. *Polym. Deg. Stab.*, 97(4), 670-678. <https://doi.org/10.1016/j.polymdegradstab.2011.12.019>.
- Beltrán, F.R., Arrieta, M.P., Moreno, E., Gaspar, G., Muneta, L.M., Carrasco-Gallego, R., Yáñez, S., Hidalgo-Carvajal, D., de la Orden, M.U., Martínez Urreaga, J., 2021. Evaluation of the technical viability of distributed mechanical recycling of PLA 3D printing wastes. *Polymers*, 13(8), 1247. <https://doi.org/10.3390/polym13081247>.
- Boyandin, A.N., Prudnikova, S.V., Karpov, V.A., Ivonin, V.N., Đỗ, N.L., Nguyễn, T.H., Lê, T.M.H., Filichev, N.L.; Levin, A.L., Filipenko, M.L., Volova, T.G., Gitelson, I.I., 2013. Microbial degradation of polyhydroxyalkanoates in tropical soils. *Int. Biodeterior. Biodegradation*, 83, 77-84. <https://doi.org/10.1016/j.ibiod.2013.04.014>.
- Carniel, A., Gomes, A.D.C., Coelho, M.A.Z., de Castro, A.M., 2021. Process strategies to improve biocatalytic depolymerization of post-consumer PET packages in bioreactors, and investigation on consumables cost reduction. *Bioprocess Biosyst. Eng.*, 44(3), 507-516. <https://doi.org/10.1007/s00449-020-02461-y>.
- Carta, D., Cao, G., D'Angeli, C., 2003. Chemical recycling of poly (ethylene terephthalate)(PET) by hydrolysis and glycolysis. *Environ. Sci. Pollut. Res.*, 10(6), 390-394. <https://doi.org/10.1065/espr2001.12.104.8>.

Castro-Aguirre, E., Auras, R., Selke, S., Rubino, M., Marsh, T., 2017. Insights on the aerobic biodegradation of polymers by analysis of evolved carbon dioxide in simulated composting conditions. *Polym. Degrad. Stab.*, 137, 251-271.

<https://doi.org/10.1016/j.polymdegradstab.2017.01.017>.

Drain, K.F., Murphy, W.R., Otterburn, M.S., 1983. A solvent technique for the recycling of polypropylene — degradation on recycling. *Conserv. Recy.*, 6(3), 123-137.

[https://doi.org/10.1016/0361-3658\(83\)90036-X](https://doi.org/10.1016/0361-3658(83)90036-X).

Fliedel, C., Vila-Viçosa, D., Calhorda, M. J., Dagorne, S., Avilés, T., 2014. Dinuclear Zinc–N-Heterocyclic Carbene Complexes for Either the Controlled Ring-Opening Polymerization of Lactide or the Controlled Degradation of Polylactide Under Mild Conditions. *ChemCatChem*, 6(5), 1357-1367. <https://doi.org/10.1002/cctc.201301015>.

Fukushima, K., Lecuyer, J.M., Wei, D.S., Horn, H.W., Jones, G.O., Al-Megren, H.A., Alabdulrahman, A.M., Alsewailem, F.D., McNeil, M.A., Rice, J.E., Hedrick, J.L., 2013. Advanced chemical recycling of poly (ethylene terephthalate) through organocatalytic aminolysis. *Polym. Chem.*, 4(5), 1610-1616. <https://doi.org/10.1039/C2PY20793A>.

Georgousopoulou, I.N., Vouyiouka, S., Dole, P., Papaspyrides, C.D., 2016. Thermo-mechanical degradation and stabilization of poly (butylene succinate). *Polym. Degrad. Stab.*, 128, 182-192.

<https://doi.org/10.1016/j.polymdegradstab.2016.03.012>.

Goje, A.S., Thakur, S.A., Diware, V.R., Chauhan, Y.P., Mishra, S., 2004. Chemical recycling, kinetics, and thermodynamics of hydrolysis of poly (ethylene terephthalate) waste with nonaqueous potassium hydroxide solution. *Polym. Plast. Technol. Eng.*, 43(2), 369-388.

<https://doi.org/10.1081/PPT-120029969>.

Hajjighasemi, M., Nocek, B.P., Tchigvintsev, A., Brown, G., Flick, R., Xu, X., Cui, H., Hai, T., Joachimiak, A., Golyshin, P.N., Savchenko, A., Edwards, E.A., Yakunin, A.F., 2016. Biochemical and structural insights into enzymatic depolymerization of polylactic acid and other polyesters by microbial carboxylesterases. *Biomacromolecules*, 17(6), 2027-2039.

<https://doi.org/10.1021/acs.biomac.6b00223>.

Hirao, K., Nakatsuchi, Y., Ohara, H., 2010. Alcoholysis of poly (L-lactic acid) under microwave irradiation. *Polym. Degrad. Stab.*, 95(6), 925-928.

<https://doi.org/10.1016/j.polymdegradstab.2010.03.027>.

Itävaara, M., Karjomaa, S., Selin, J.F., 2002. Biodegradation of polylactide in aerobic and anaerobic thermophilic conditions. *Chemosphere*, 46(6), 879-885. [https://doi.org/10.1016/S0045-6535\(01\)00163-1](https://doi.org/10.1016/S0045-6535(01)00163-1).

Jin, H., Gonzalez-Gutierrez, J., Oblak, P., Zupančič, B., Emri, I., 2012. The effect of extensive mechanical recycling on the properties of low density polyethylene. *Polym. Degrad. Stab.*, 97(11), 2262-2272. <https://doi.org/10.1016/j.polymdegradstab.2012.07.039>.

Kaabel, S., Therien, J.D., Deschênes, C.E., Duncan, D., Friščić, T., Auclair, K., 2021. Enzymatic depolymerization of highly crystalline polyethylene terephthalate enabled in moist-solid reaction mixtures. *Proc. Natl. Acad. Sci. U.S.A.*, 118(29), e2026452118.

<https://doi.org/10.1073/pnas.2026452118>.

Kabdi, S.A., Belhaneche-Bensemra, N., 2008. Compatibilization of regenerated low density polyethylene/poly (vinyl chloride) blends. *J. Appl. Polym. Sci.*, 110(3), 1750-1755.

<https://doi.org/10.1002/app.28175>.

- Kale, G., Kijchavengkul, T., Auras, R., Rubino, M., Selke, S.E., Singh, S.P., 2007. Compostability of bioplastic packaging materials: an overview. *Macromol. Biosci.*, 7(3), 255-277. <https://doi.org/10.1002/mabi.200600168>.
- Kanemura, C., Nakashima, S., Hotta, A., 2012. Mechanical properties and chemical structures of biodegradable poly (butylene-succinate) for material reprocessing. *Polym. Degrad. Stab.*, 97(6), 972-980. <https://doi.org/10.1016/j.polymdegradstab.2012.03.015>.
- Kannan, P., Lakshmanan, G., Al Shoaibi, A., Srinivasakannan, C., 2017. Polymer recovery through selective dissolution of co-mingled post-consumer waste plastics. *Prog. Rubber Plast. Recycl. Technol.*, 33(2), 75–84. <https://doi.org/10.1177/147776061703300202>.
- Kim, H. S., Kim, H.J., Lee, J.W., Choi, I.G., 2006. Biodegradability of bio-flour filled biodegradable poly(butylene succinate) bio-composites in natural and compost soil. *Polym. Degrad. Stab.*, 91(5), 1117-1127. <https://doi.org/10.1016/j.polymdegradstab.2005.07.002>.
- Kosmidis, V.A., Achilias, D.S., Karayannidis, G.P., 2001. Poly (ethylene terephthalate) recycling and recovery of pure terephthalic acid. Kinetics of a phase transfer catalyzed alkaline hydrolysis. *Macromol. Mater. Eng.*, 286(10), 640-647. [https://doi.org/10.1002/1439-2054\(20011001\)286:10<640::AID-MAME640>3.0.CO;2-1](https://doi.org/10.1002/1439-2054(20011001)286:10<640::AID-MAME640>3.0.CO;2-1)
- Kostadinova Loutcheva, M., Proietto, M., Jilov, N., La Mantia, F.P., 1997. Recycling of high density polyethylene containers. *Polym. Degrad. Stab.*, 57(1), 77-81. [https://doi.org/10.1016/S0141-3910\(96\)00230-3](https://doi.org/10.1016/S0141-3910(96)00230-3).
- Leibfarth, F.A., Moreno, N., Hawker, A.P., Shand, J.D., 2012. Transforming polylactide into value-added materials. *J. Polym. Sci., Part A: Polym. Chem.*, 50(23), 4814-4822. <https://doi.org/10.1002/pola.26303>.
- Liu, H., Song, X., Liu, F., Liu, S., Yu, S., 2015. Ferric chloride as an efficient and reusable catalyst for methanolysis of poly (lactic acid) waste. *J. Polym. Res.*, 22(7), 1-7. <https://doi.org/10.1007/s10965-015-0783-6>.
- Liu, H., Zhao, R., Song, X., Liu, F., Yu, S., Liu, S., Ge, X., 2017. Lewis acidic ionic liquid [Bmim] FeCl₄ as a high efficient catalyst for methanolysis of poly (lactic acid). *Catal. Lett.*, 147(9), 2298-2305. <https://doi.org/10.1007/s10562-017-2138-x>.
- Longieras, A., Tanchette, J.B., Erre, D., Braud, C., Copinet, A., 2007. Compostability of poly (lactide): degradation in an inert solid medium. *J. Polym. Environ.*, 15(3), 200-206. <https://doi.org/10.1016/j.polymdegradstab.2017.01.017>.
- Luo, Y., Lin, Z., Guo, G., 2019. Biodegradation assessment of poly (lactic acid) filled with functionalized titania nanoparticles (PLA/TiO₂) under compost conditions. *Nanoscale Res. Lett.*, 14(1), 1-10. <https://doi.org/10.1186/s11671-019-2891-4>.
- Massardier-Nageotte, V., Pestre, C., Cruard-Pradet, T., Bayard, R., 2006. Aerobic and anaerobic biodegradability of polymer films and physico-chemical characterization. *Polym. Degrad. Stab.*, 91(3), 620-627. <https://doi.org/10.1016/j.polymdegradstab.2005.02.029>.
- Meran, C., Ozturk, O., Yuksel, M., 2008. Examination of the possibility of recycling and utilizing recycled polyethylene and polypropylene. *Mater. Des.*, 29(3), 701-705. <https://doi.org/10.1016/j.matdes.2007.02.007>.
- Mohee, R., Unmar, G.D., Mudhoo, A., Khadoo, P., 2008. Biodegradability of biodegradable/degradable plastic materials under aerobic and anaerobic conditions. *Waste Manag.*, 28(9), 1624-1629. <https://doi.org/10.1016/j.wasman.2007.07.003>.

- Murphy, W.R., Otterburn, M.S., Ward, J.A., 1979. Solvent recycling of polypropylene: 1. Properties of the recycled polymer. *Polymer*, 20(3), 333-336. [https://doi.org/10.1016/0032-3861\(79\)90097-1](https://doi.org/10.1016/0032-3861(79)90097-1).
- Neves Ricarte, G., Lopes Dias, M., Sirelli, L., Antunes Pereira Langone, M., Machado de Castro, A., Zarur Coelho, M.A., Dias Ribeiro, B., 2021. Chemo-enzymatic depolymerization of industrial and assorted post-consumer poly(ethylene terephthalate)(PET) wastes using a eutectic-based catalyst. *J. Chem. Technol. Biotechnol.*, 96(11), 3237-3244. <https://doi.org/10.1002/jctb.6882>.
- Nishide, H., Toyota, K., Kimura, M., 1999. Effects of soil temperature and anaerobiosis on degradation of biodegradable plastics in soil and their degrading microorganisms. *Soil Sci. Plant Nutr.*, 45(4), 963-972. <https://doi.org/10.1080/00380768.1999.10414346>.
- Oblak, P., Gonzalez-Gutierrez, J., Zupančič, B., Aulova, A., Emri, I., 2015. Processability and mechanical properties of extensively recycled high density polyethylene. *Polym. Degrad. Stab.*, 114, 133-145. <https://doi.org/10.1016/j.polymdegradstab.2015.01.012>.
- Ohkita, T., Lee, S.H., 2006. Thermal degradation and biodegradability of poly (lactic acid)/corn starch biocomposites. *J. appl. Polym. Sci.*, 100(4), 3009-3017. <https://doi.org/10.1002/app.23425>.
- Oromiehie, A., Mamizadeh, A., 2004. Recycling PET beverage bottles and improving properties. *Polym. Int.*, 53(6), 728-732. <https://doi.org/10.1002/pi.1389>.
- Paci, M., La Mantia, F.P., 1998. Competition between degradation and chain extension during processing of reclaimed poly (ethylene terephthalate). *Polym. Degrad. Stab.*, 61, 417-420. [https://doi.org/10.1016/S0141-3910\(97\)00227-9](https://doi.org/10.1016/S0141-3910(97)00227-9).
- Papaspyrides, C.D., Poulakis, J.G., Varelides, P.C., 1994. A model recycling process for low density polyethylene. *Resour. Conserv. Recy.*, 12(3-4), 177-184. [https://doi.org/10.1016/0921-3449\(94\)90005-1](https://doi.org/10.1016/0921-3449(94)90005-1).
- Pappa, G., Boukouvalas, C., Giannaris, C., Ntaras, N., Zografos, V., Magoulas, K., Lygeros, A., Tassios, D., 2001. The selective dissolution/precipitation technique for polymer recycling: a pilot unit application. *Resour., Conserv. Recy.*, 34(1), 33-44. [https://doi.org/10.1016/S0921-3449\(01\)00092-1](https://doi.org/10.1016/S0921-3449(01)00092-1).
- Pelegrini, K., Donazzolo, I., Brambilla, V., Coulon Grisa, A.M., Piazza, D., Zattera, A.J., Brandalise, R.N., 2016. Degradation of PLA and PLA in composites with triacetin and buriti fiber after 600 days in a simulated marine environment. *J. Appl. Polym. Sci.*, 133(15). <https://doi.org/10.1002/app.43290>.
- Pellis, A., Haernvall, K., Pichler, C.M., Ghazaryan, G., Breinbauer, R., Guebitz, G.M., 2016. Enzymatic hydrolysis of poly (ethylene furanoate). *J. biotechnol.*, 235, 47-53. <https://doi.org/10.1016/j.jbiotec.2016.02.006>.
- Petrus, R., Bykowski, D., Sobota, P., 2016. Solvothermal alcoholysis routes for recycling polylactide waste as lactic acid esters. *ACS Catal.*, 6(8), 5222-5235. <https://doi.org/10.1021/acscatal.6b01009>.
- Poulakis, J.G., Papaspyrides, C.D., 1995. The dissolution/reprecipitation technique applied on high-density polyethylene: I. Model recycling experiments. *Adv. Polym. Technol.*, 14(3), 237-242. <https://doi.org/10.1002/adv.1995.060140307>.
- Poulakis, J.G., Papaspyrides, C.D., 1997. Recycling of polypropylene by the dissolution/reprecipitation technique: I. A model study. *Resour., Conserve. Recy.*, 20(1), 31-41. [https://doi.org/10.1016/S0921-3449\(97\)01196-8](https://doi.org/10.1016/S0921-3449(97)01196-8).
- Poulakis, J.G., Papaspyrides, C.D., 2001. Dissolution/reprecipitation: a model process for PET bottle recycling. *J. Appl. Polym. Sci.*, 81(1), 91-95. <https://doi.org/10.1002/app.1417>.

Quartinello, F., Vajnhandl, S., Volmajer Valh, J., Farmer, T.J., Vončina, B., Lobnik, A., Herrero Acero, E., Pellis, A., Guebitz, G.M., 2017. Synergistic chemo-enzymatic hydrolysis of poly (ethylene terephthalate) from textile waste. *Microb. Biotechnol.*, 10(6), 1376-1383. <https://doi.org/10.1111/1751-7915.12734>.

Rafiqah, S., Khalina, A., Harmaen, A.S., Tawakkal, I.A., Zaman, K., Asim, M., Nurrazi, M.N., Lee, C.H., 2021. A review on properties and application of bio-based poly (butylene succinate). *Polymers*, 13(9), 1436. <https://doi.org/10.3390/polym13091436>.

Román-Ramírez, L.A., Mckeown, P., Jones, M.D., Wood, J., 2019. Poly (lactic acid) degradation into methyl lactate catalyzed by a well-defined Zn (II) complex. *ACS Catal.*, 9(1), 409-416. <https://doi.org/10.1021/acscatal.8b04863>.

Sánchez, A.C., Collinson, S.R., 2011. The selective recycling of mixed plastic waste of polylactic acid and polyethylene terephthalate by control of process conditions. *Eur. Polym. J.*, 47(10), 1970-1976. <https://doi.org/10.1016/j.eurpolymj.2011.07.013>.

Sarasa, J., Gracia, J.M., Javierre, C., 2009. Study of the biodisintegration of a bioplastic material waste. *Bioresource technology*, 100(15), 3764-3768. <https://doi.org/10.1016/j.biortech.2008.11.049>.

Song, X., Zhang, X., Wang, H., Liu, F., Yu, S., Liu, S., 2013. Methanolysis of poly (lactic acid)(PLA) catalyzed by ionic liquids. *Polym. Degrad. Stab.*, 98(12), 2760-2764. <https://doi.org/10.1016/j.polymdegradstab.2013.10.012>.

Song, X., Liu, F., Wang, H., Wang, C., Yu, S., Liu, S., 2018. Methanolysis of microbial polyester poly (3-hydroxybutyrate) catalyzed by Brønsted-Lewis acidic ionic liquids as a new method towards sustainable development. *Polym. Degrad. Stab.*, 147, 215-221. <https://doi.org/10.1016/j.polymdegradstab.2017.12.009>.

Song, X., Wang, H., Wang, C., Liu, F., Yu, S., Liu, S., Song, Z., 2019. Chemical recycling of bio-based poly (3-hydroxybutyrate) wastes under methanolysis condition catalyzed by Fe-containing magnetic ionic liquid. *J. Polym. Environ.*, 27(4), 862-870. <https://doi.org/10.1007/s10924-018-1347-8>.

Spekreijse, J., Le Nôtre, J., Sanders, J.P., Scott, E.L., 2015. Conversion of polyhydroxybutyrate (PHB) to methyl crotonate for the production of biobased monomers. *J. Appl. Polym. Sci.*, 132(35). <https://doi.org/10.1002/app.42462>.

Tournier, V., Topham, C.M., Gilles, A., David, B., Folgoas, C., Moya-Leclair, E., Kamionka, E., Desrousseaux, M.L., Texier, H., Gavalda, S., Cot, M., Guémard, E., Dalibey, M., Nomme, J., Cioci, G., Barbe, S., Chateau, M., André, I., Duquesne, S., Marty, A., 2020. An engineered PET depolymerase to break down and recycle plastic bottles. *Nature*, 580(7802), 216-219. <https://doi.org/10.1038/s41586-020-2149-4>.

Tsuji, H., Daimon, H., Fujie, K., 2003. A new strategy for recycling and preparation of poly (L-lactic acid): hydrolysis in the melt. *Biomacromolecules*, 4(3), 835-840. <https://doi.org/10.1021/bm034060j>.

Vidakis, N., Petousis, M., Maniadi, A., 2021a. Sustainable Additive Manufacturing : Mechanical Response of High-Density Polyethylene over Multiple Recycling Processes. *Recycling*, 6(4), 1–14. <https://doi.org/10.3390/recycling6010004>.

Vidakis, N., Petousis, M., Tzounis, L., Maniadi, A., Velidakis, E., Mountakis, N., Papageorgiou, D., Liebscher, M., Mechtcherine, V., 2021b. Sustainable additive manufacturing: Mechanical response of polypropylene over multiple recycling processes. *Sustainability*, 13(1), 159. <https://doi.org/10.3390/su13010159>.

Weinberger, S., Canadell, J., Quartinello, F., Yenzi, B., Arias, A., Pellis, A., Guebitz, G. M., 2017a. Enzymatic degradation of poly (ethylene 2, 5-furanoate) powders and amorphous films. *Catalysts*, 7(11), 318. <https://doi.org/10.3390/catal7110318>.

Weinberger, S., Haernvall, K., Scaini, D., Ghazaryan, G., Zumstein, M. T., Sander, M., Pellis, A., Guebitz, G. M., 2017b. Enzymatic surface hydrolysis of poly (ethylene furanoate) thin films of various crystallinities. *Green Chem.*, 19(22), 5381-5384. <https://doi.org/10.1039/C7GC02905E>.

Weng, Y.X., Wang, Y., Wang, X.L., Wang, Y.Z., 2010. Biodegradation behavior of PHBV films in a pilot-scale composting condition. *Polymer Testing*, 29(5), 579-587. <https://doi.org/10.1016/j.polymertesting.2010.04.002>.

Weng, Y.X., Wang, X.L., & Wang, Y.Z., 2011. Biodegradation behavior of PHAs with different chemical structures under controlled composting conditions. *Polymer Testing*, 30(4), 372-380. <https://doi.org/10.1016/j.polymertesting.2011.02.001>.

Yagi, H., Ninomiya, F., Funabashi, M., Kunioka, M., 2009. Anaerobic biodegradation tests of poly (lactic acid) under mesophilic and thermophilic conditions using a new evaluation system for methane fermentation in anaerobic sludge. *International journal of molecular sciences*, 10(9), 3824-3835. <https://doi.org/10.3390/ijms10093824>.

Yagi, H., Ninomiya, F., Funabashi, M., Kunioka, M., 2010. Bioplastic biodegradation activity of anaerobic sludge prepared by preincubation at 55° C for new anaerobic biodegradation test. *Polym. Degrad. Stab.*, 95(8), 1349-1355. <https://doi.org/10.1016/j.polymdegradstab.2010.01.023>.

Yagi, H., Ninomiya, F., Funabashi, M., Kunioka, M., 2013. Thermophilic anaerobic biodegradation test and analysis of eubacteria involved in anaerobic biodegradation of four specified biodegradable polyesters. *Polym. Degrad. Stab.ility*, 98(6), 1182-1187. <https://doi.org/10.1016/j.polymdegradstab.2013.03.010>.

Yagi, H., Ninomiya, F., Funabashi, M., Kunioka, M., 2014. Mesophilic anaerobic biodegradation test and analysis of eubacteria and archaea involved in anaerobic biodegradation of four specified biodegradable polyesters. *Polym. Degrad. Stab.*, 110, 278-283. <https://doi.org/10.1016/j.polymdegradstab.2014.08.031>.

Zhang, W., Heaven, S., Banks, C.J., 2018. Degradation of some EN13432 compliant plastics in simulated mesophilic anaerobic digestion of food waste. *Polym. Degrad. Stab.*, 147, 76-88. <https://doi.org/10.1016/j.polymdegradstab.2017.11.005>.

Żenkiewicz, M., Richert, J., Rytlewski, P., Moraczewski, K., Stepczyńska, M., & Karasiewicz, T., 2009. Characterisation of multi-extruded poly (lactic acid). *Polym. Test.*, 28(4), 412-418. <https://doi.org/10.1016/j.polymertesting.2009.01.012>.