PLASTIGO

Politechnika Częstochowska

Wydział Inżynierii Mechanicznej

Szukaj rozwiązań! Poznaj możliwości recyklingu mechanicznego tworzyw

dr hab. inż. Tomasz Stachowiak prof. PCz
Wydział Inżynierii Mechanicznej
Politechnika Częstochowska

Plan prezentacji:

- Recykling a co to jest?
- Jakie rodzaje recyklingu możemy wykorzystać ?
- Recykling mechaniczny fakty i mity
- Dlaczego recykling bywa trudny?

https://eldorado-plast.com/w-jaki-sposob-przebiega-recykling-plastiku/

Recykling a co to jest?

Recykling
Nazwa angielska: Recycling

Definicja:
Odzysk, w ramach którego odpady są ponownie przetwarzane na produkty, materiały lub substancje wykorzystywane w pierwotnym celu lub innych celach; obejmuje to ponowne przetwarzanie materiału organicznego (recykling organiczny), ale nie obejmuje odzysku energii i ponownego przetwarzania na materiały, które mają być wykorzystane jako paliwa lub do celów wypełniania wyrobisk.

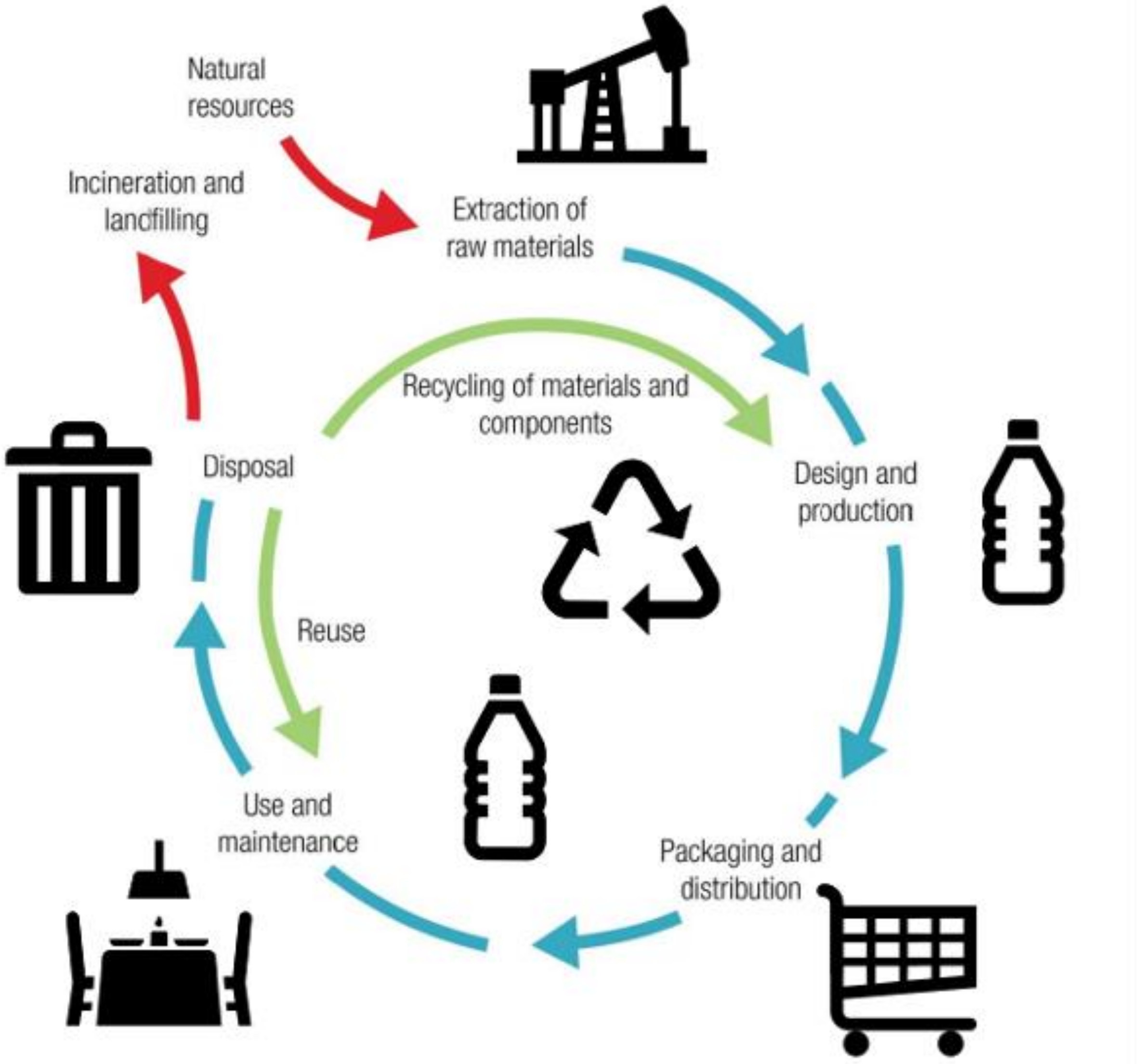
Źródło definicji:
ustawa z dnia 14 grudnia 2012 r. o odpadach
Miejsce publikacji: (Dz. U. z 2023 r. poz. 1587, z późn. zm.)

https://stat.gov.pl/metainformacje/slownik-pojec/pojecia-stosowane-w-statystyce-publicznej/1182,pojecie.html

Recycling
noun

Recycling, recovery and reprocessing of waste materials for use in new products. The basic phases in recycling are the collection of waste materials, their processing or manufacture into new products, and the purchase of those products, which may then themselves be recycled. Typical materials that are recycled include iron and steel scrap, aluminum cans, glass bottles, paper, wood, and plastics. The materials reused in recycling serve as substitutes for raw materials obtained from such increasingly scarce natural resources as petroleum, natural gas, coal, mineral ores, and trees. Recycling can help reduce the quantities of solid waste deposited in landfills, which have become increasingly expensive. Recycling also reduces the pollution of air, water, and land resulting from waste disposal.

https://www.britannica.com/science/recycling



źródło : Recycling of Polymers Methods, Characterization and Applications, Wiley-VCH, 2017

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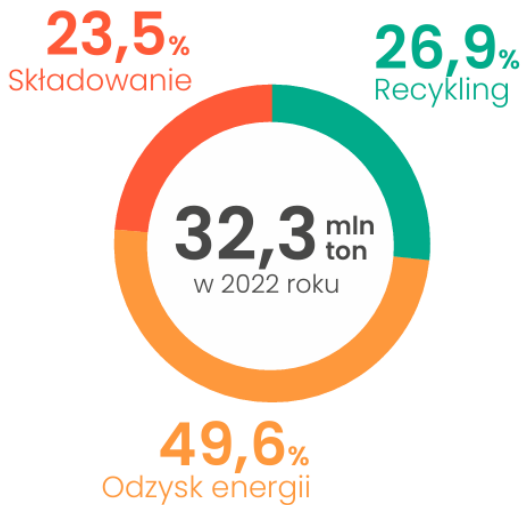
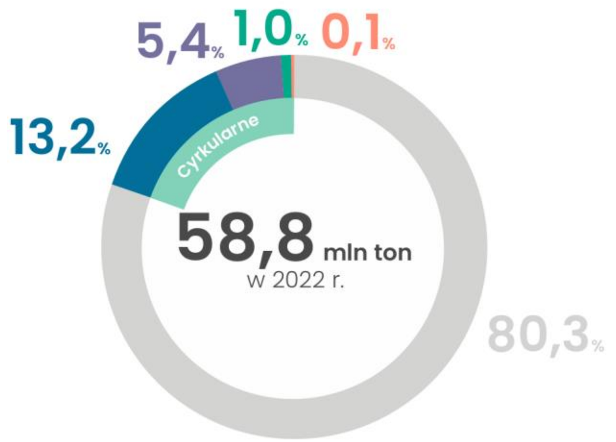
Odzysk energii i składowanie odpadów tworzyw sztucznych





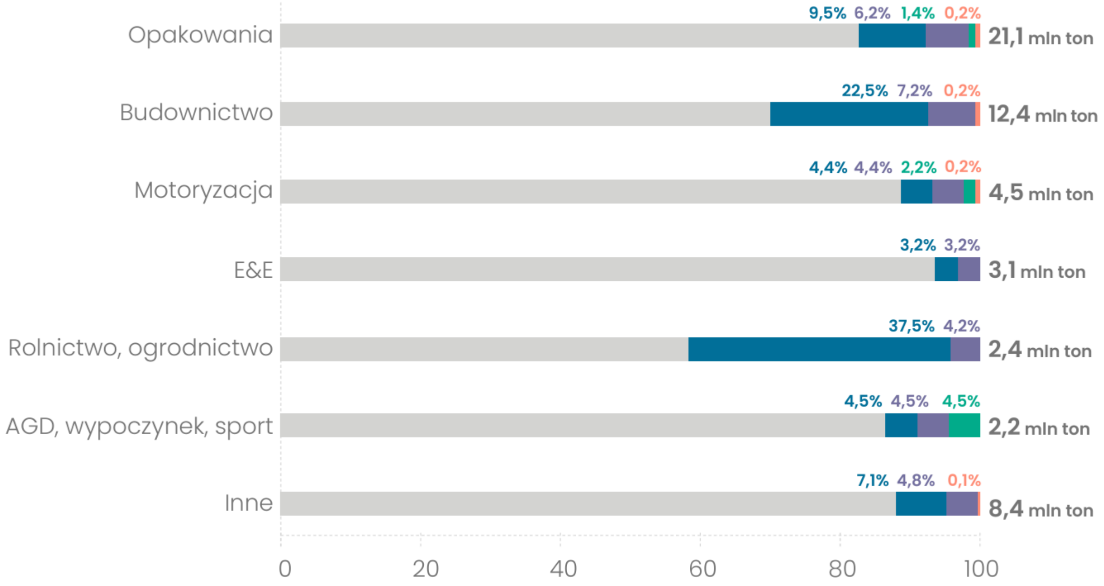
19,7% wyprodukowanych tworzyw sztucznych było cyrkularnych.

- Surowce kopalne
- Recykling mechaniczny (odpady pokonsumenckie)
- Recykling mechaniczny (odpady prekonsumenckie)
- Surowce bio-pochodne
- Recykling chemiczny (odpady pokonsumenckie)

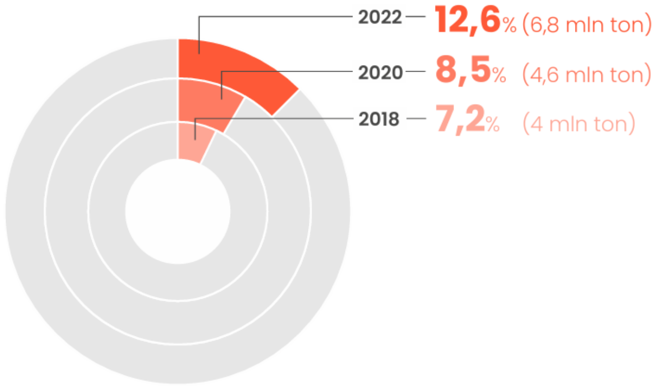
https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2023/

Przetwórstwo cyrkularnych tworzyw sztucznych

2022, UE27+3



Zawartość recyklatów pokonsumenckich w nowych wyrobach



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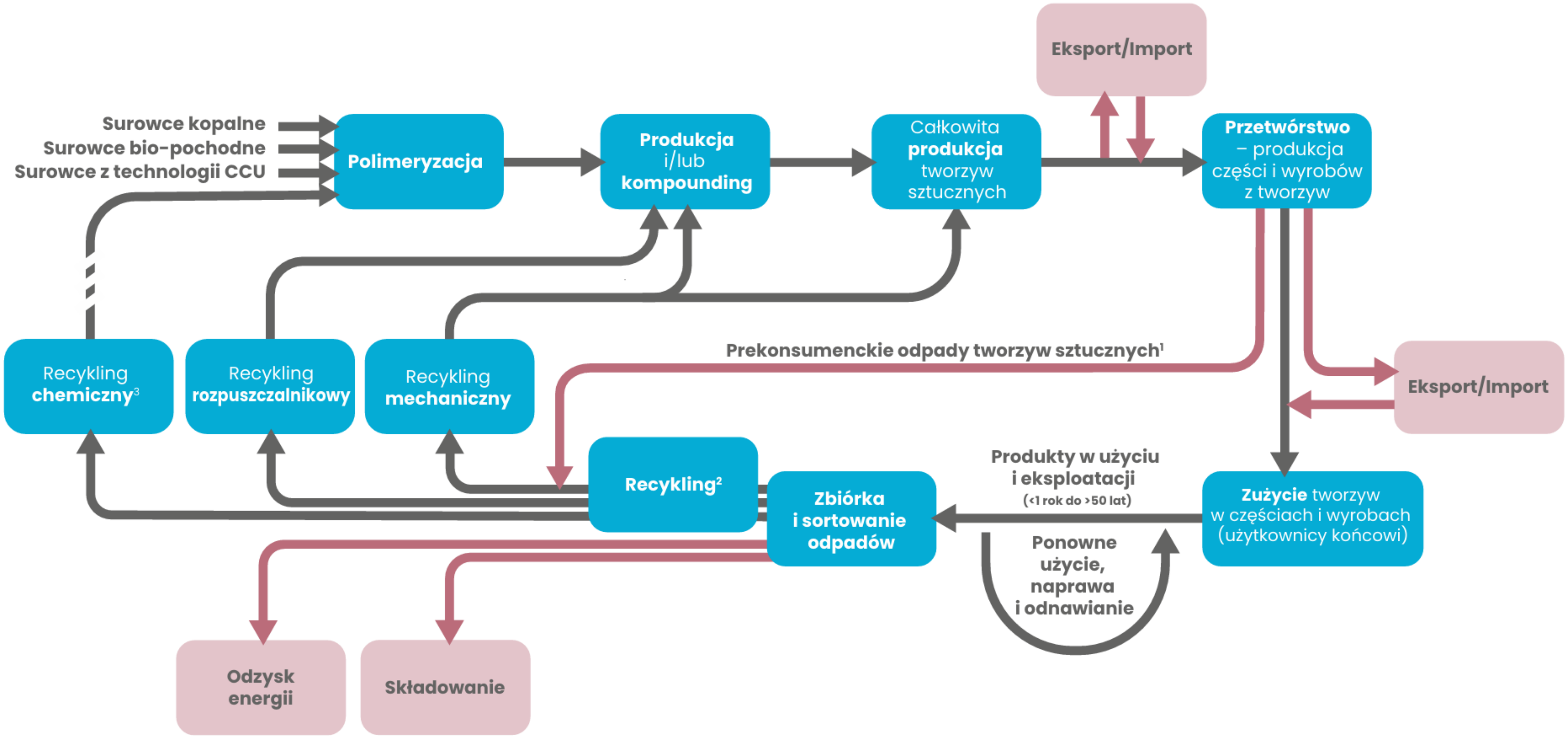
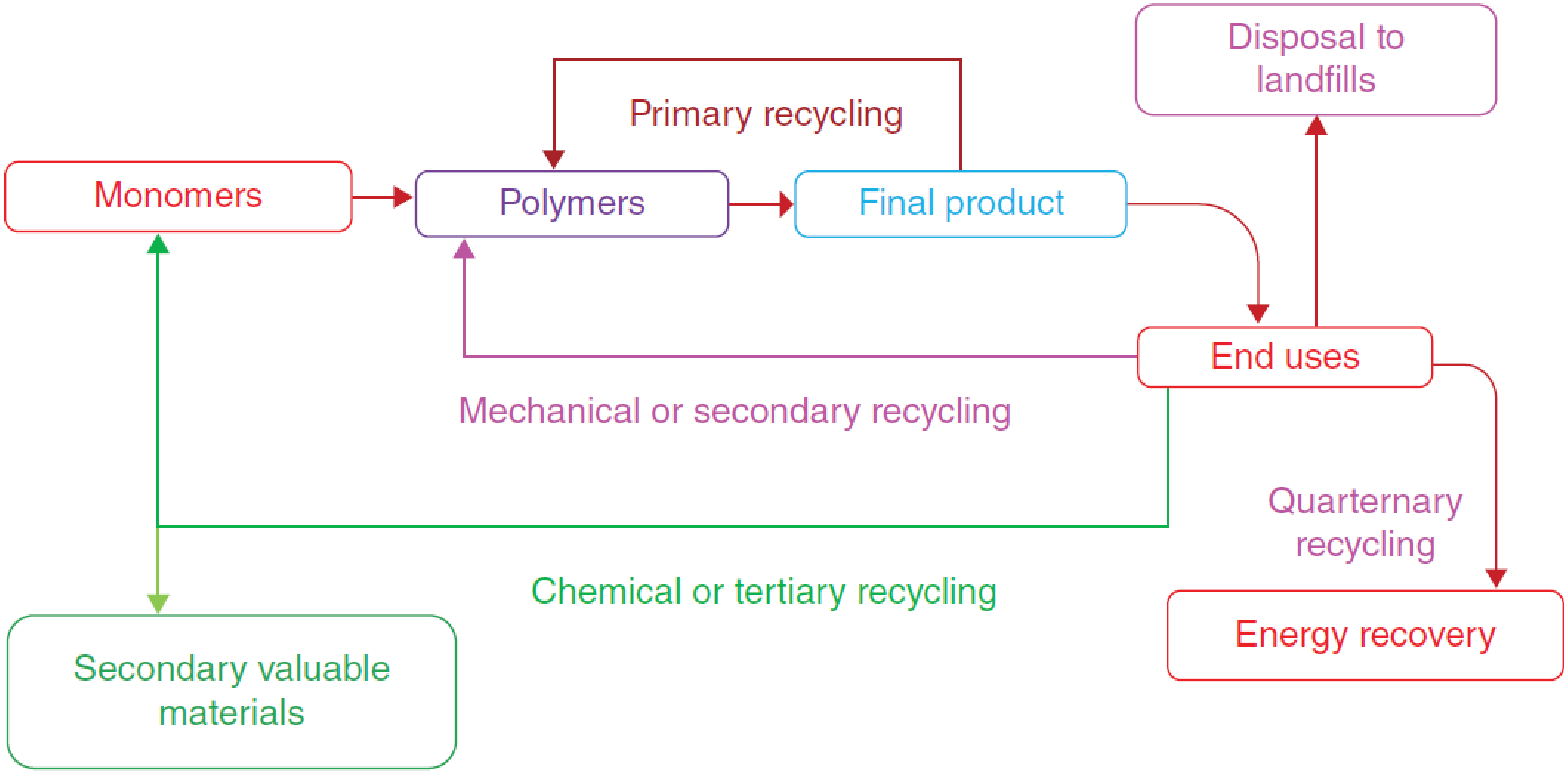
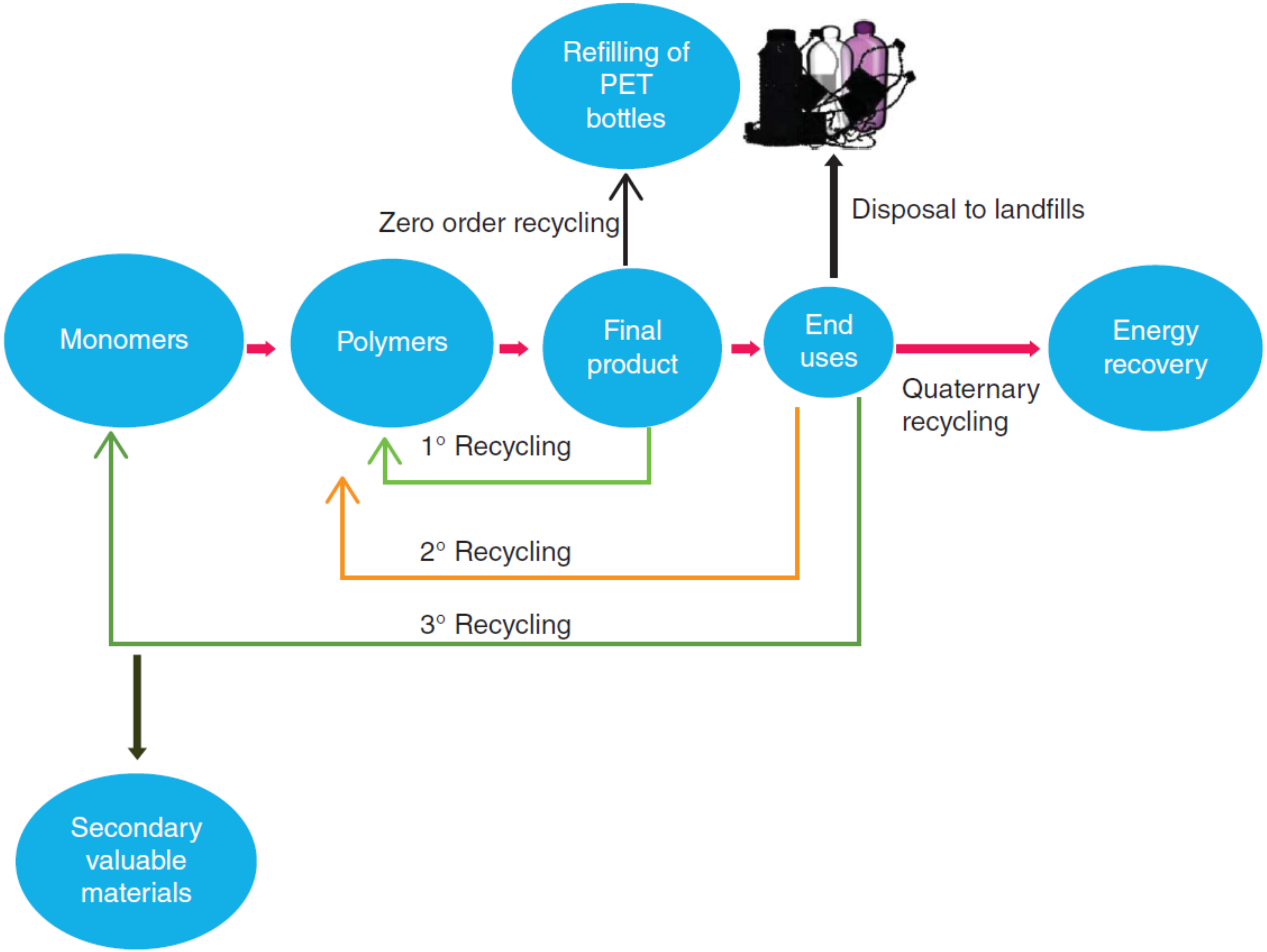
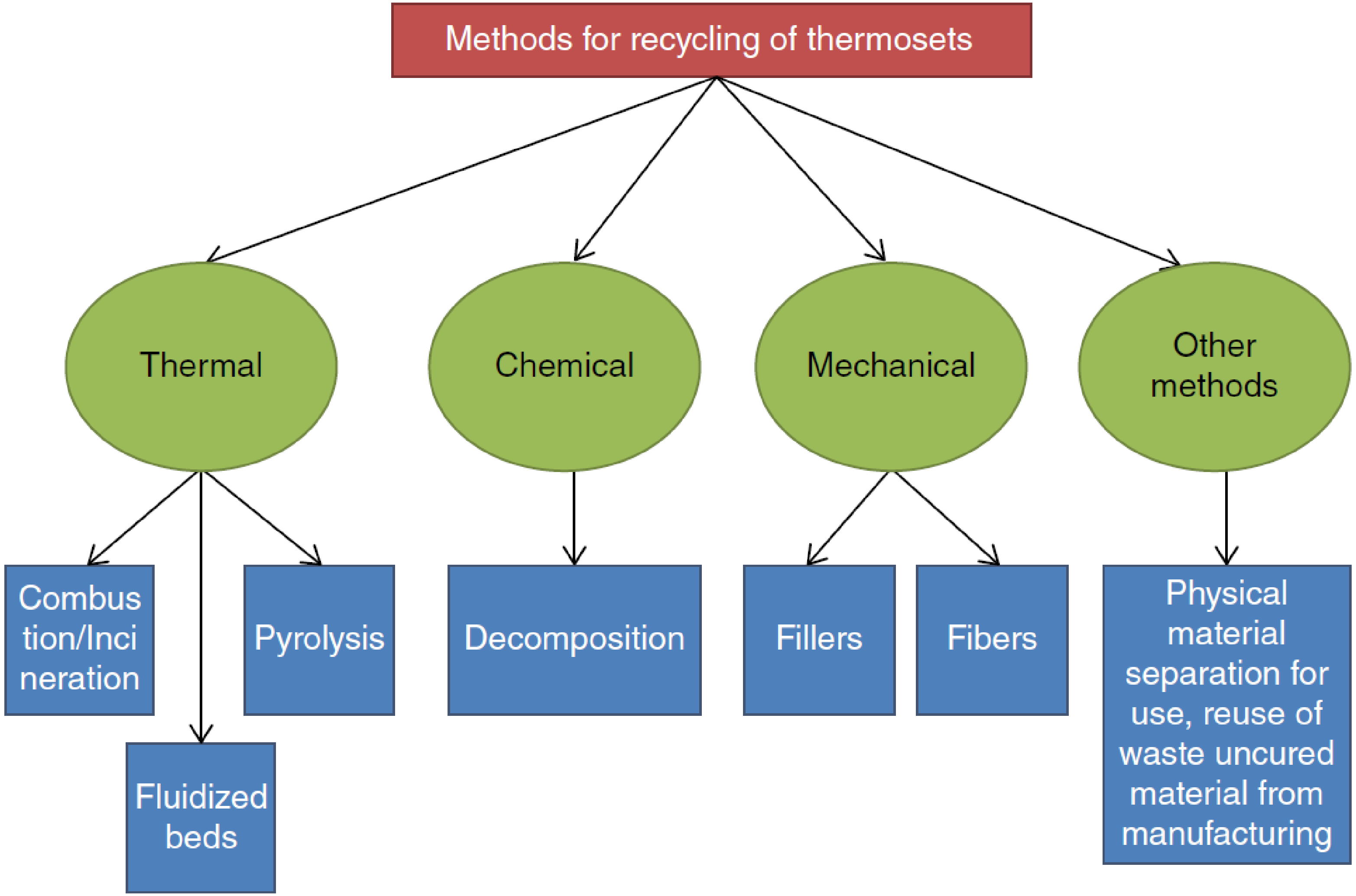
Jakie rodzaje recyklingu możemy wykorzystać

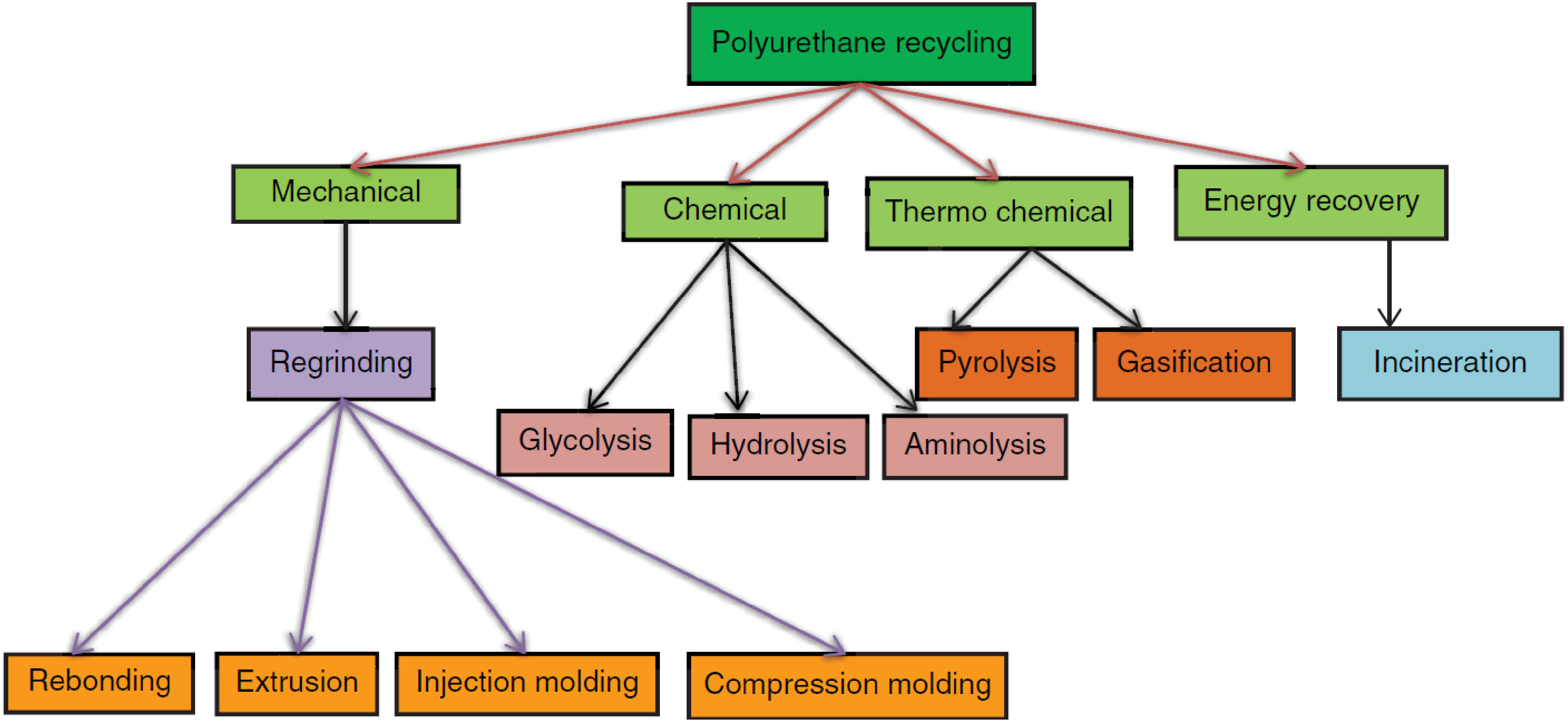


https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2023/

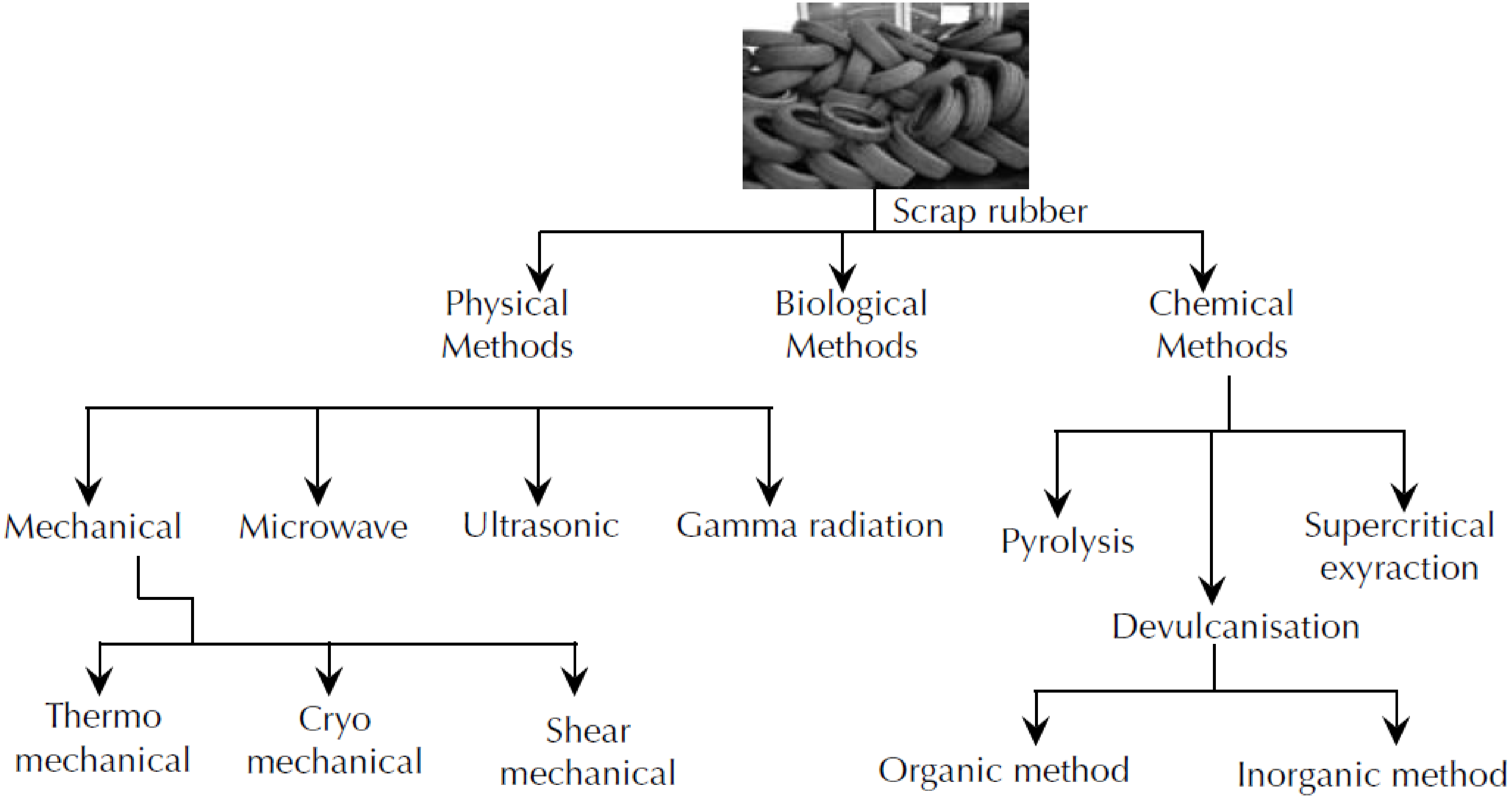

Disposal to landfills
Primary recycling
Monomers
Polymers
Final product
End uses
Mechanical or secondary recycling
Quarternary recycling
Chemical or tertiary recycling
Energy recovery
Secondary valuable materials


Refilling of PET bottles
Zero order recycling
Disposal to landfills
Monomers
Polymers
Final product
End uses
Energy recovery
Quaternary recycling
1° Recycling
2° Recycling
3° Recycling
Secondary valuable materials

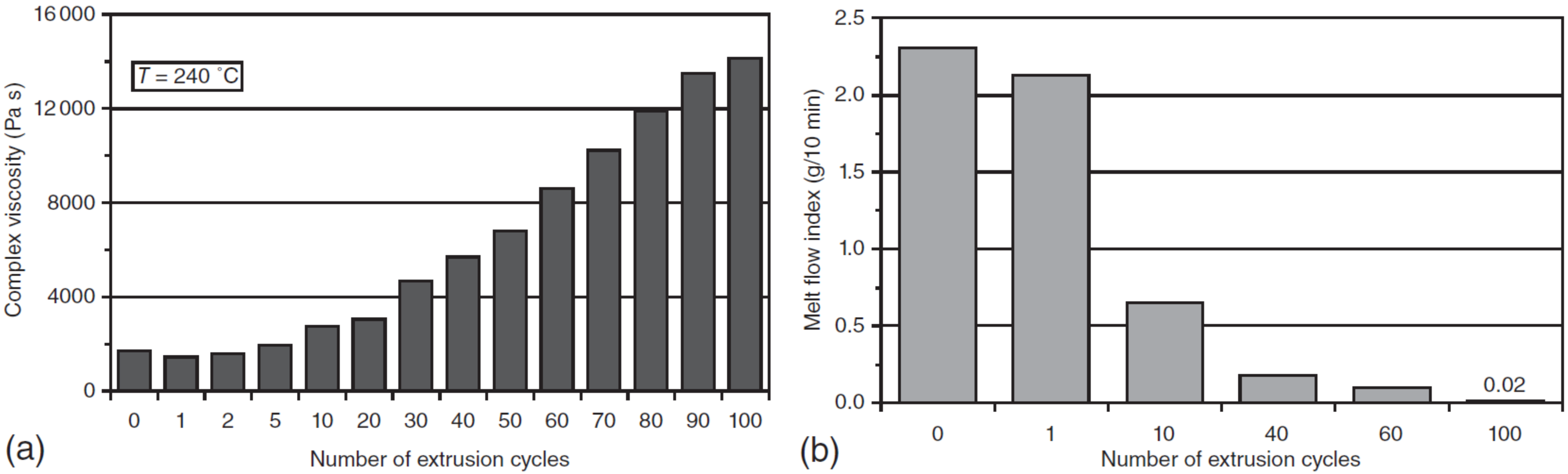

Methods for recycling of thermosets
Thermal
Chemical
Mechanical
Other methods
Combus tion/Inci neration
Pyrolysis
Fluidized beds
Decomposition
Fillers
Fibers
Physical material separation for use, reuse of waste uncured material from manufacturing



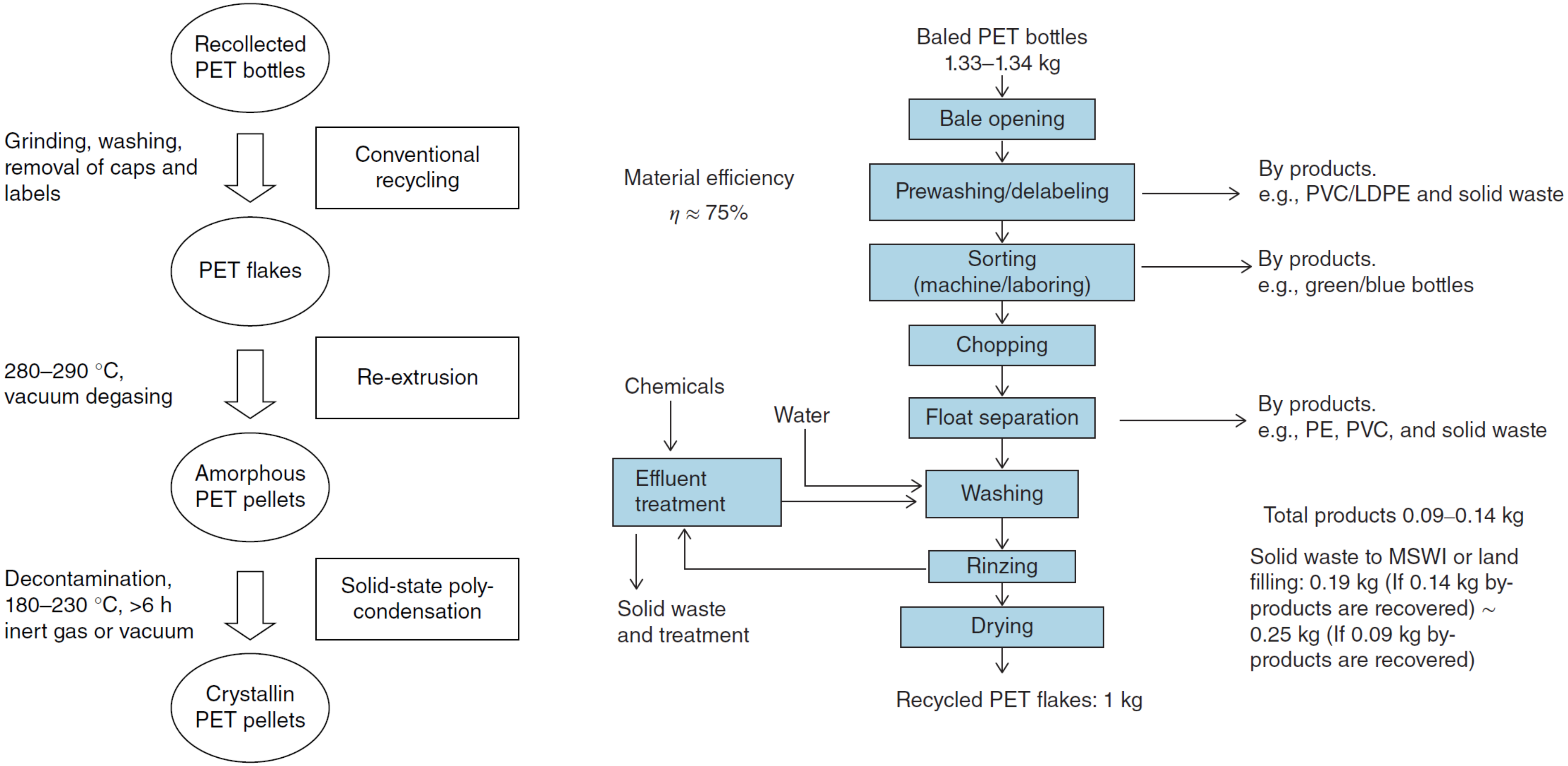
Polyurethane recycling
Mechanical
Chemical
Thermo chemical
Energy recovery
Regrinding
Glycolysis
Hydrolysis
Aminolysis
Pyrolysis
Gasification
Incineration
Rebonding
Extrusion
Injection molding
Compression molding



Different recycling methods of rubber.

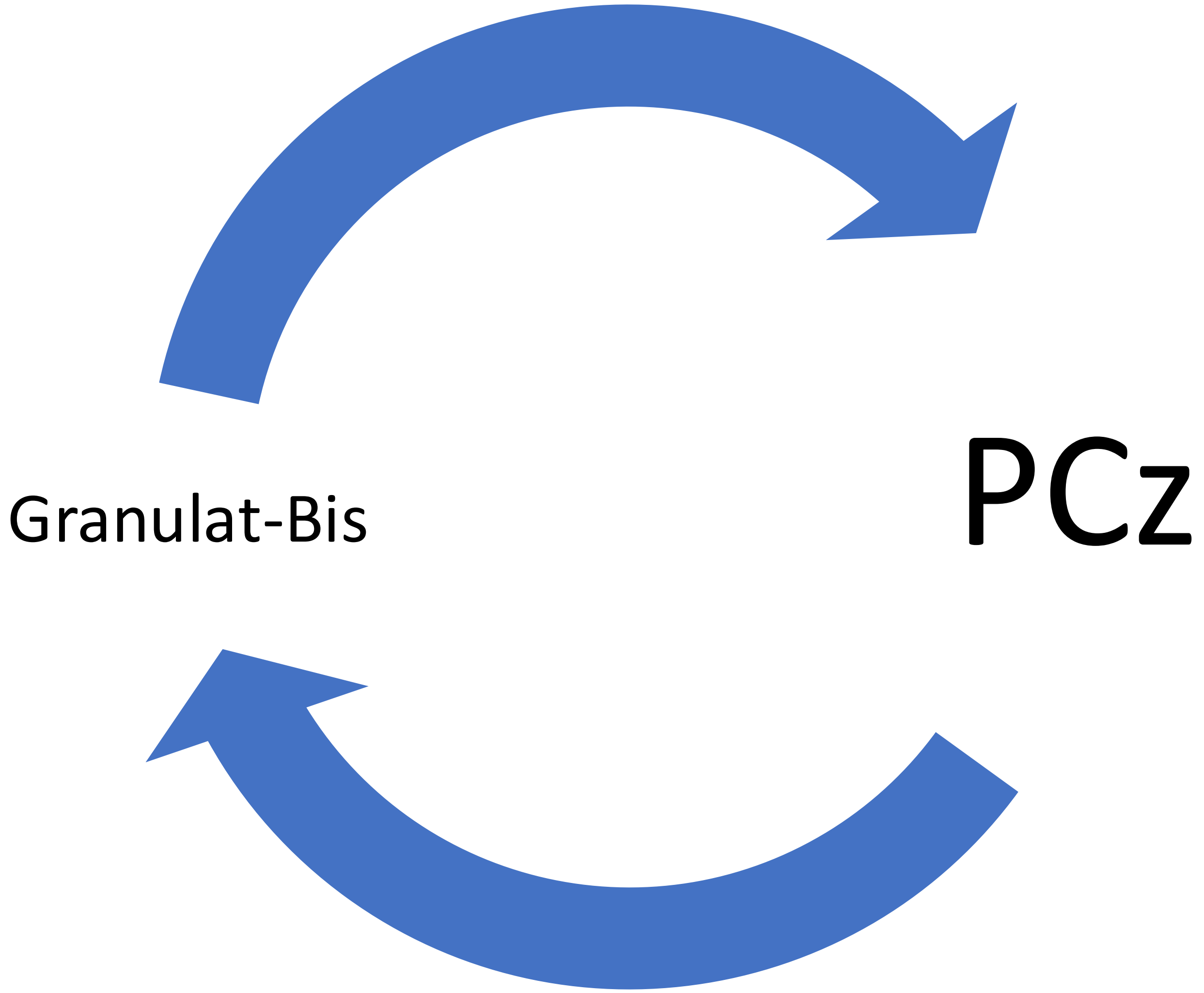


Complex viscosity and (b) MFI of LDPE after extrusion cycles.
(Jin et al, Reproduced with permission of Elsevier



Scheme of PET super-clean recycling processes based on pellets. (Welle) Reproduced with permission of Elsevier.)

Recykling mechaniczny fakty i mity



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Recykling mechaniczny fakty i mity

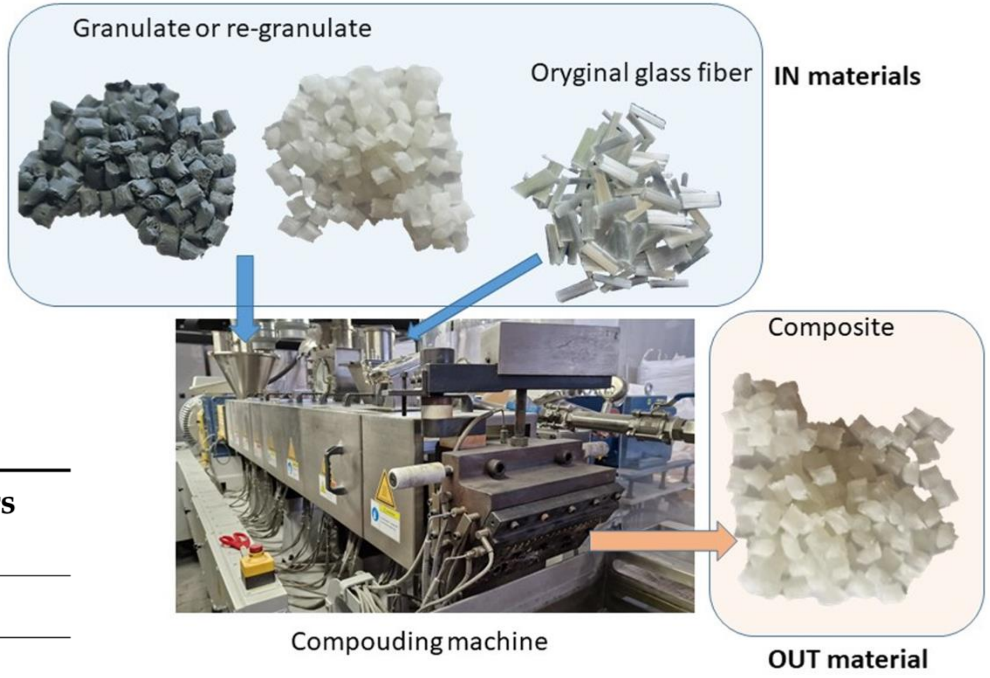


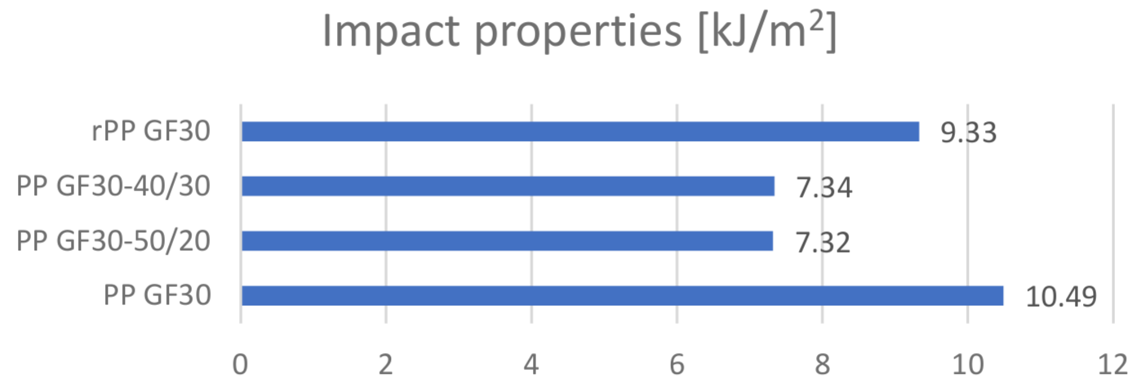
Table 1. Formulations of polypropylene/recycled polypropylene/glass fibers.

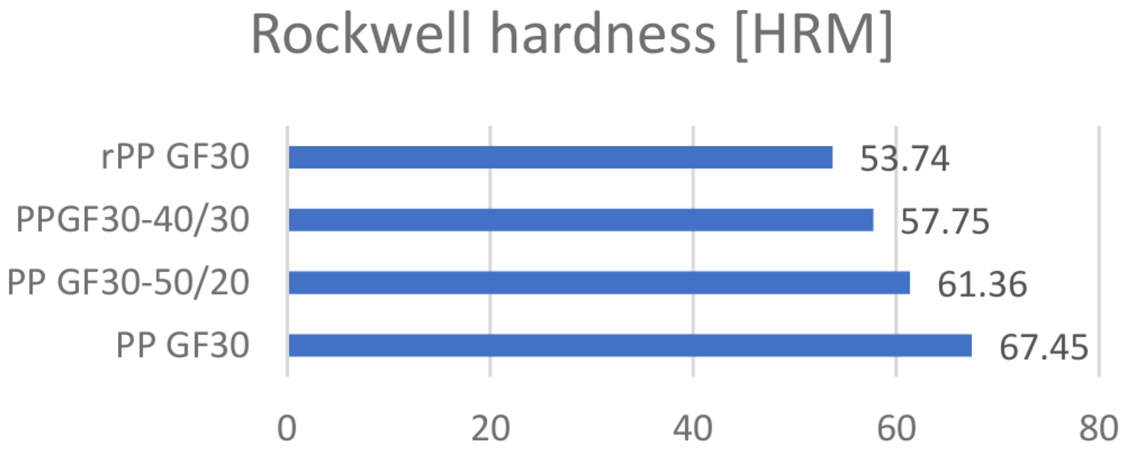
S./No.	Material Code	PP (Virgin) [wt.%]	rPP [wt.%]	Glass Fibers [wt.%]
1.	PPGF30	70	0	30
2.	PPGF30-50/20	50	20	30
3.	PPGF30-40/30	40	30	30
4.	rPPGF30	0	70	30

Źródło : Analysis of Selected Properties of Polymer Mixtures Derived from Virgin and Re-Granulated PP with Glass Fibers

Table 2. Tested materials—specific compositions and mass shares of individual substrates.

PP GF30 Composite			
No.	MFR [g/10 min]	Mass [kg]	Amount [wt.%]
PP	12	700	70
rPP	—	0	0
Glass fibers	—	300	30
Output MFR	5 [g/10 min]		
Color	Natural		
PP GF30-50/20			
No.	MFR [g/10 min]	Mass [kg]	Amount [wt.%]
PP	12	500	50
rPP	6	200	20
Glass fibers	—	300	30
Output MFR	4.043 [g/10 min]		
Color	Gray		
PP GF30-40/30			
No.	MFI [g/10 min]	Mass [kg]	Amount [wt.%]
PP	12	400	40
rPP	6	300	30
Glass fibers	—	300	30
Output MFR	4.1 [g/10 min]		
Color	Dark gray		
rPP GF30			
No.	MFI [g/10 min]	Mass [kg]	Amount [wt.%]
PP	—	0	0
rPP	6	700	70
Glass fibers	—	300	30
Output MFR	2.5 [g/10 min]		
Color	Black		





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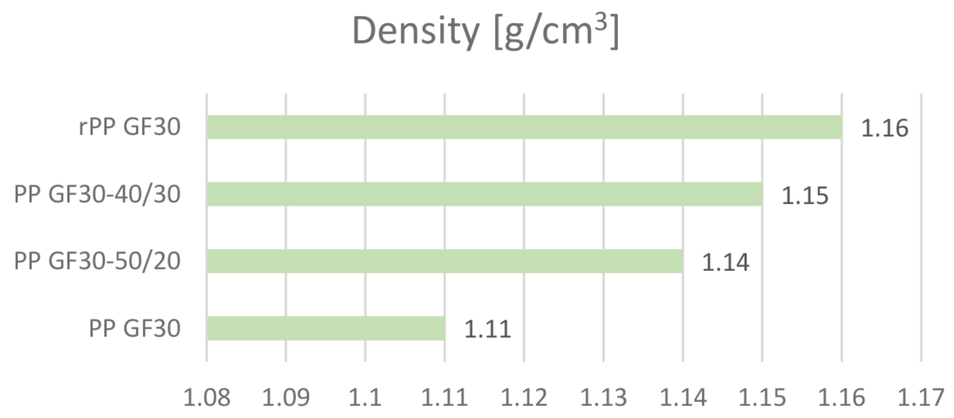
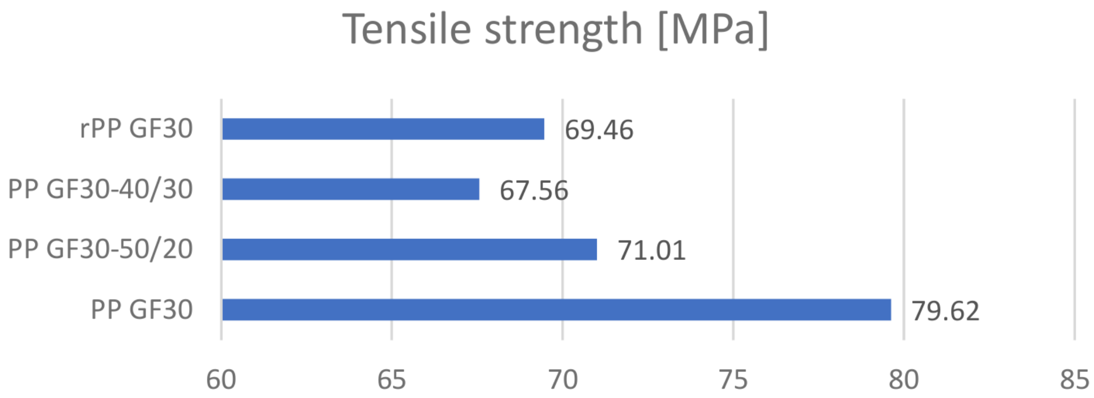
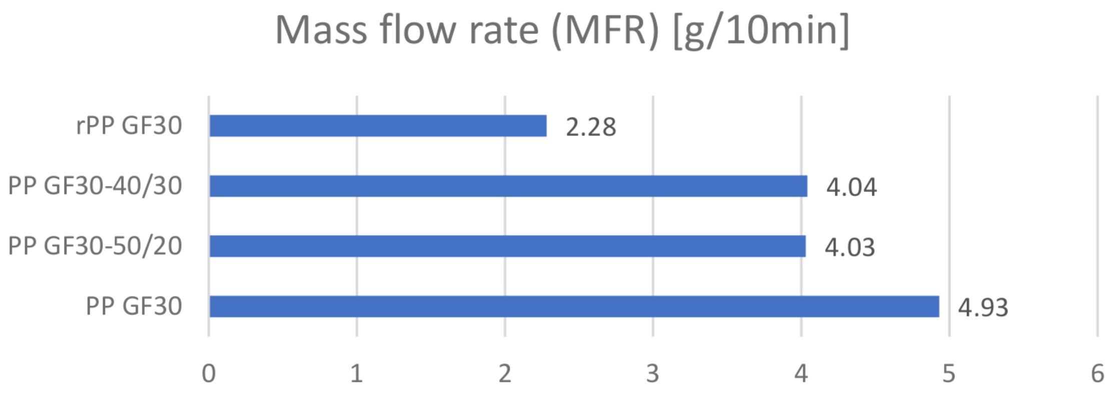


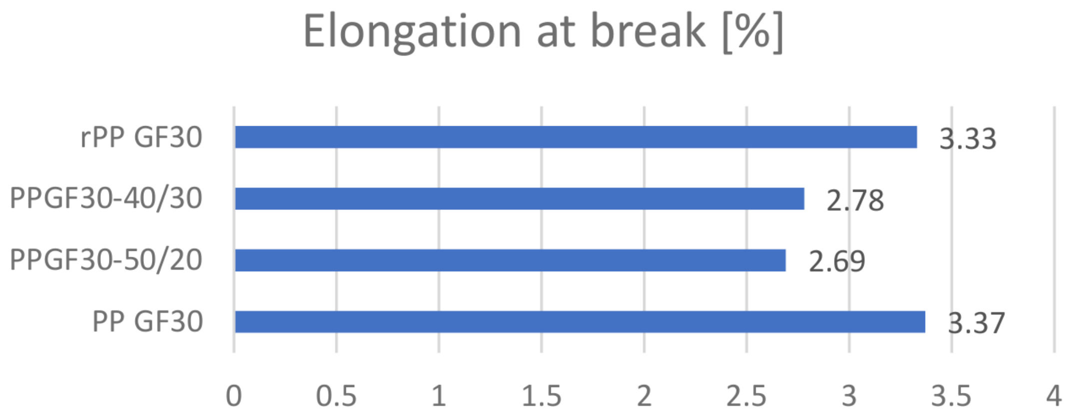
Comparison of the obtained density values.



Comparison of the mechanical properties obtained in the static tensile strength test.



Comparison of the melt mass flow rates of the tested granulates.



Comparison of elongations at break of obtained composites.

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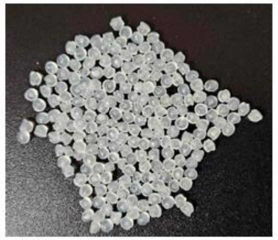
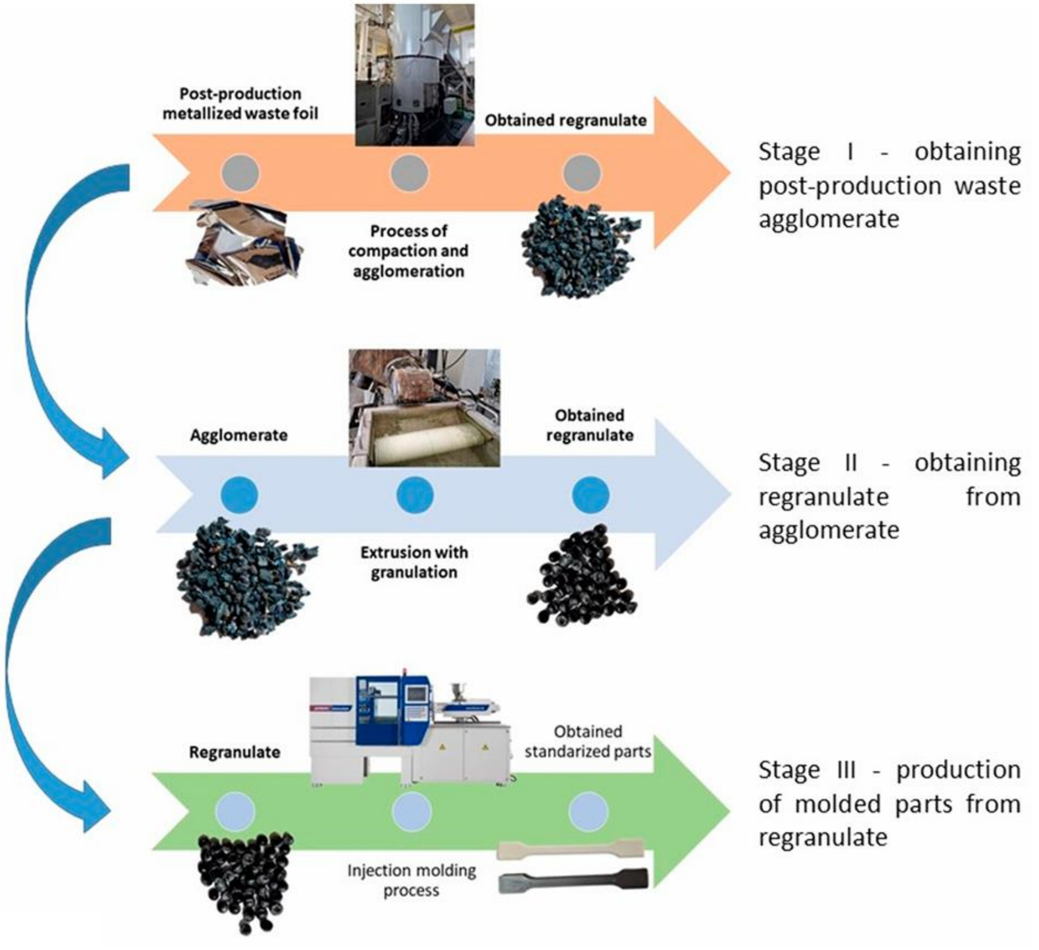
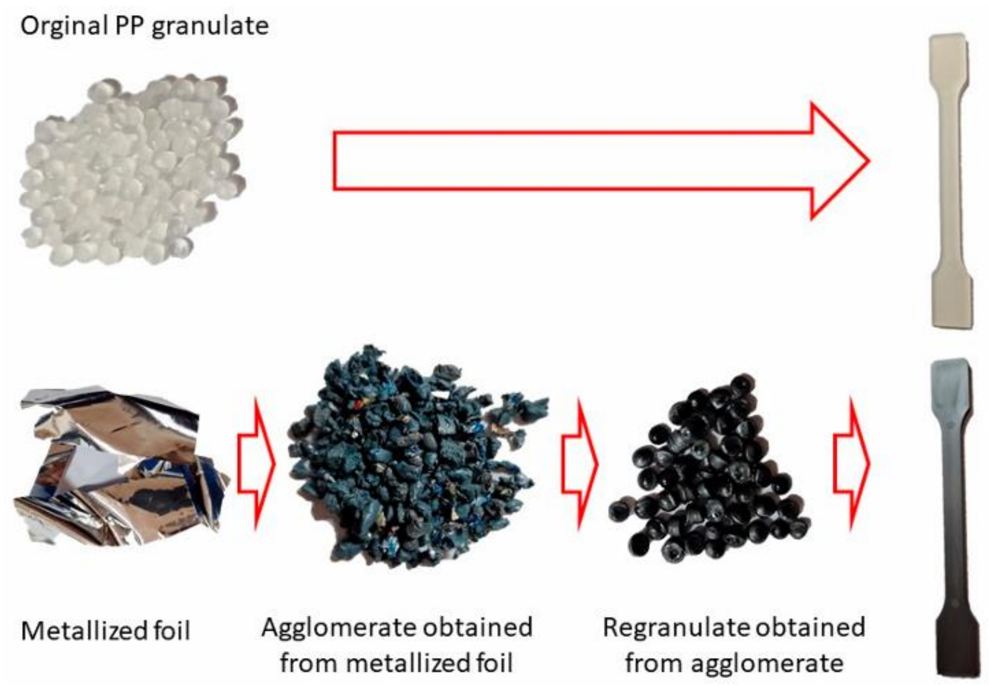
Table 1. Description of all materials tested during the research.

Tested Materials		
Sample Name	**Properties Description**	**View of the Sample**
1 PP_cast reference sample	The primary PP granulate is used to produce food wrap films using the casting method. Due to business confidentiality, the trade name of the material may not be disclosed.	
2_1 Metallized film	Processed waste from metallized and overprinted film constituting the input research material	
2_2 Agglomerate	Agglomerate of waste metallized film as a semi-finished product for the production of re-granulate	
2_3 rPP_metallized	PP re-granulate (rPP) obtained from metallized and overprinted film	

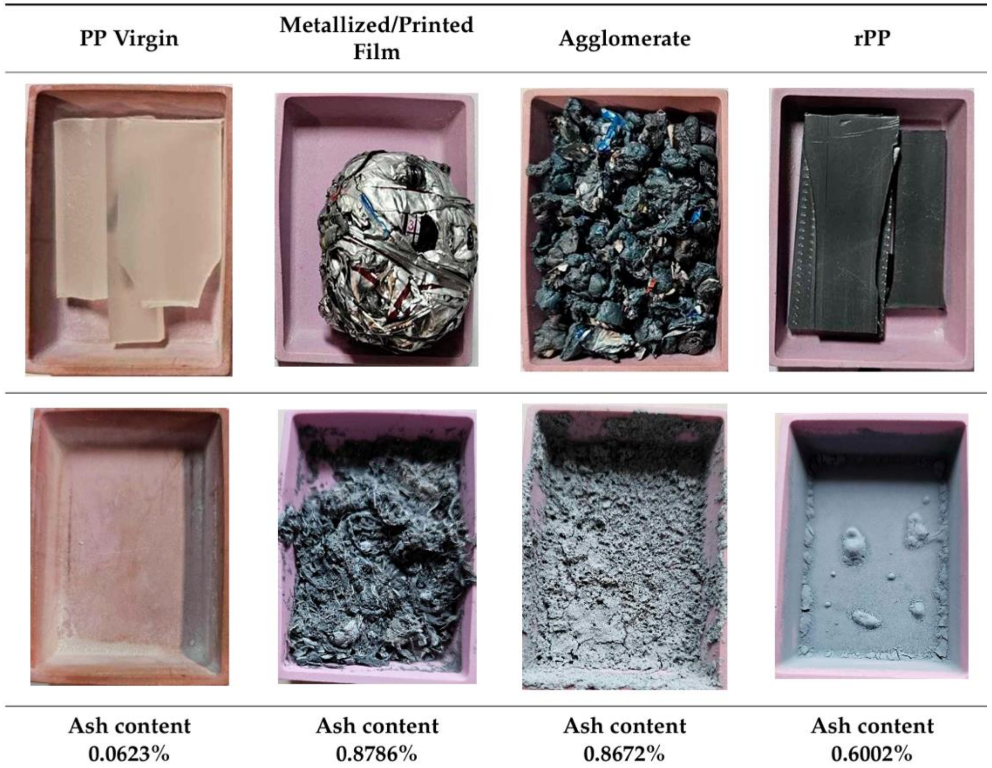


The scheme of producing agglomerate, re-granulate and standardized test samples.



The process of standardized sample preparation.

Ash content analysis results for granulate, agglomerate and re-granulate.



Basic properties of the compared polymer materials.

Parameter	PP_Cast	rPP_Metallized
Density	0.901 g/cm^3	0.908 g/cm^3
Density	agglomerate—0.771 g/cm^3	
Bulk density	0.525 g/cm^3	0.492 g/cm^3
Bulk density	agglomerate—0.310 g/cm^3	
Mass flow rate (MFR) (230 °C/2.16 kg)	14.55 g/10 min.	9.27 g/10 min.
Melting temperature	169.7 °C	168.6 °C
Crystallization temperature	118.2 °C	115.1 °C
Moisture content	less than 0.1% weight	

Summary of mechanical properties for compared samples.

	PP_Cast	rPP_Metallized
Tensile strength, MPa	31.78	32.93
Standard deviation	0.39	0.14
Strain, %	402	116
Standard deviation	45.63	79.37
Modulus of elasticity, MPa	1305.77	1462.15
Standard deviation	35.6	12.49

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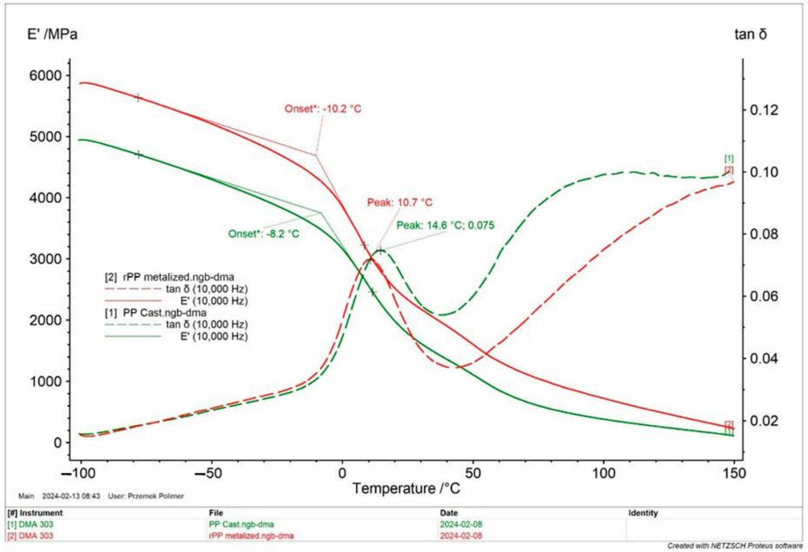
Statistical data of impact strength of the comparison samples.

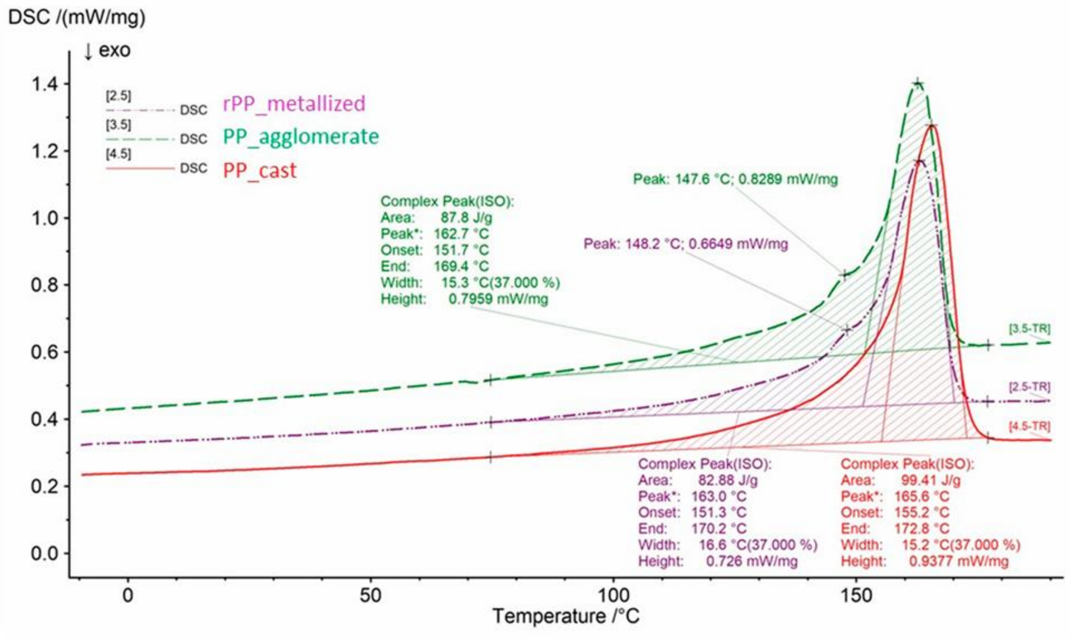
Impact Strength, kJ/m^2		
	PP_Cast	rPP_Metallized
Average value	3.08	2.91
Standard deviation	0.08	0.09

Statistical data of Rockwell hardness [HRM].

Rockwell Hardness, HRM		
	PP_Cast	rPP_Metallized
Average value	79.44	89.8
Standard deviation	0.61	2.37



DMA thermograms (E′ storage modulus and tan δ tangent delta) at a frequency of 10 Hz, for both tested samples.



DSC thermograms of the tested samples during second heating.

Summary of thermal properties of the analyzed materials—second heating.

	Melting Temp., °C	Melting Enthalpy, J/g *	Onset Temp., °C
PP_cast	165.6	99.41	155.2
Agglomerate from PP film	(147.6) 162.7	87.80	151.7
rPP_metallized	(148.2) 163.0	82.88	151.3

* The value obtained comes from the second heating cycle and was read from the heating curve.

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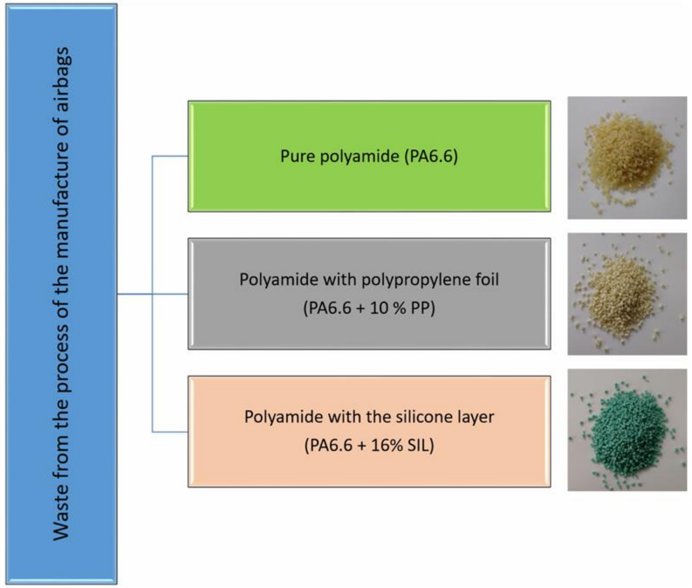
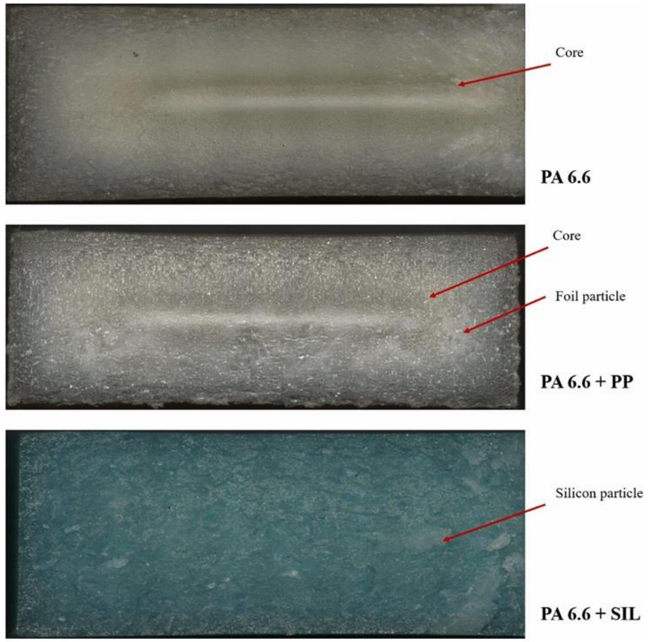
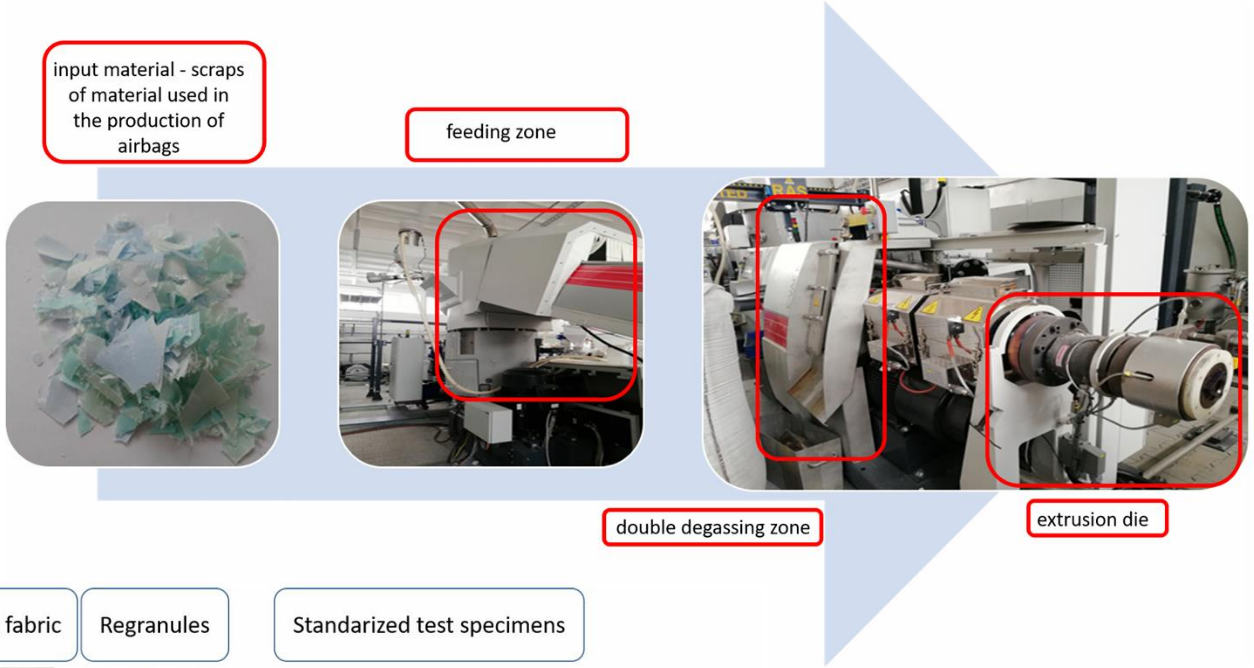




The cross-sections of standardized test specimens



Standardized test specimens obtained in accordance with ISO 294

Źródło : Impact of ImpurItles of polypropylene and sIlIcone InclusIons on the propertIes of polyamIde 6.6 regranulates derIved from the re-processIng of aIrbags

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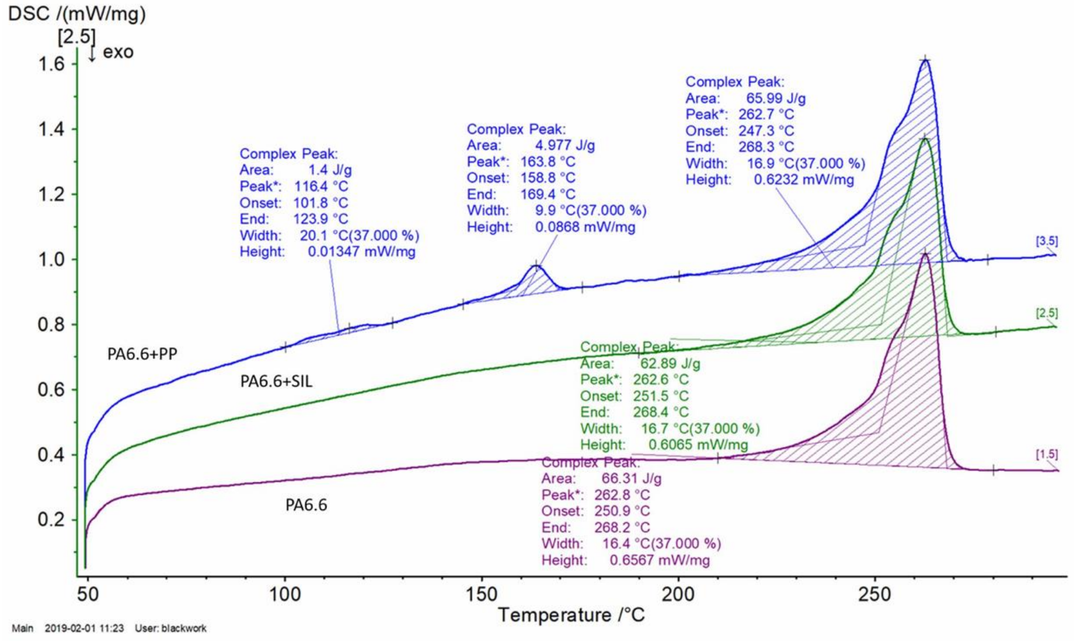
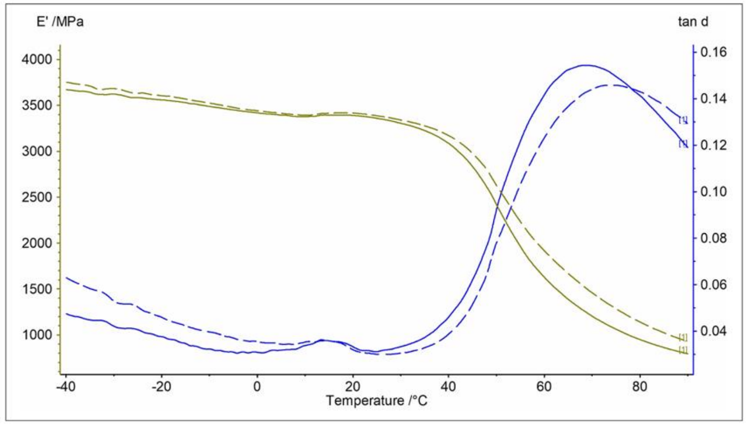
Results of mass and volume flow rate measurement

Polymer tested	MFR [g/10 min]	MVR [cm^3/10 min]
	Avarage	Avarage
PA6.6	96,64	91,20
PA6.6 + PP	115,80	110,15
Pa6.6 + SIL	46,87	44,60

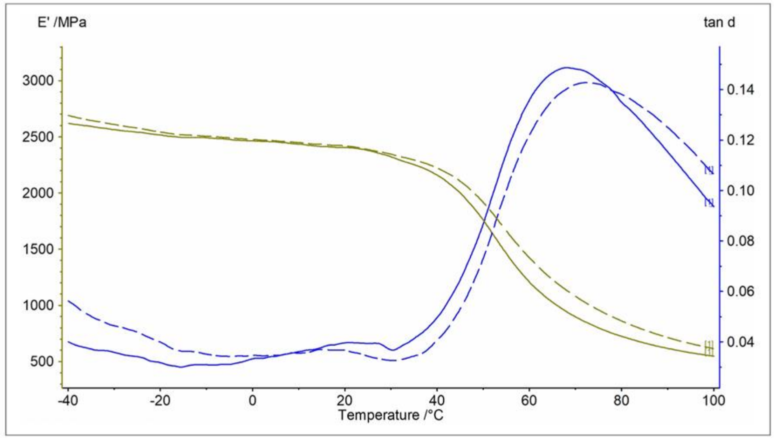


DSC thermograms for test specimens PA6.6, PA6.6 + PP and PA6.6 + SIL, heating curves

DMA curves obtained for pa6.6 (pure polyamide)



DMA curves obtained for PA6.6 + sil (polyamide with a layer of silicone)



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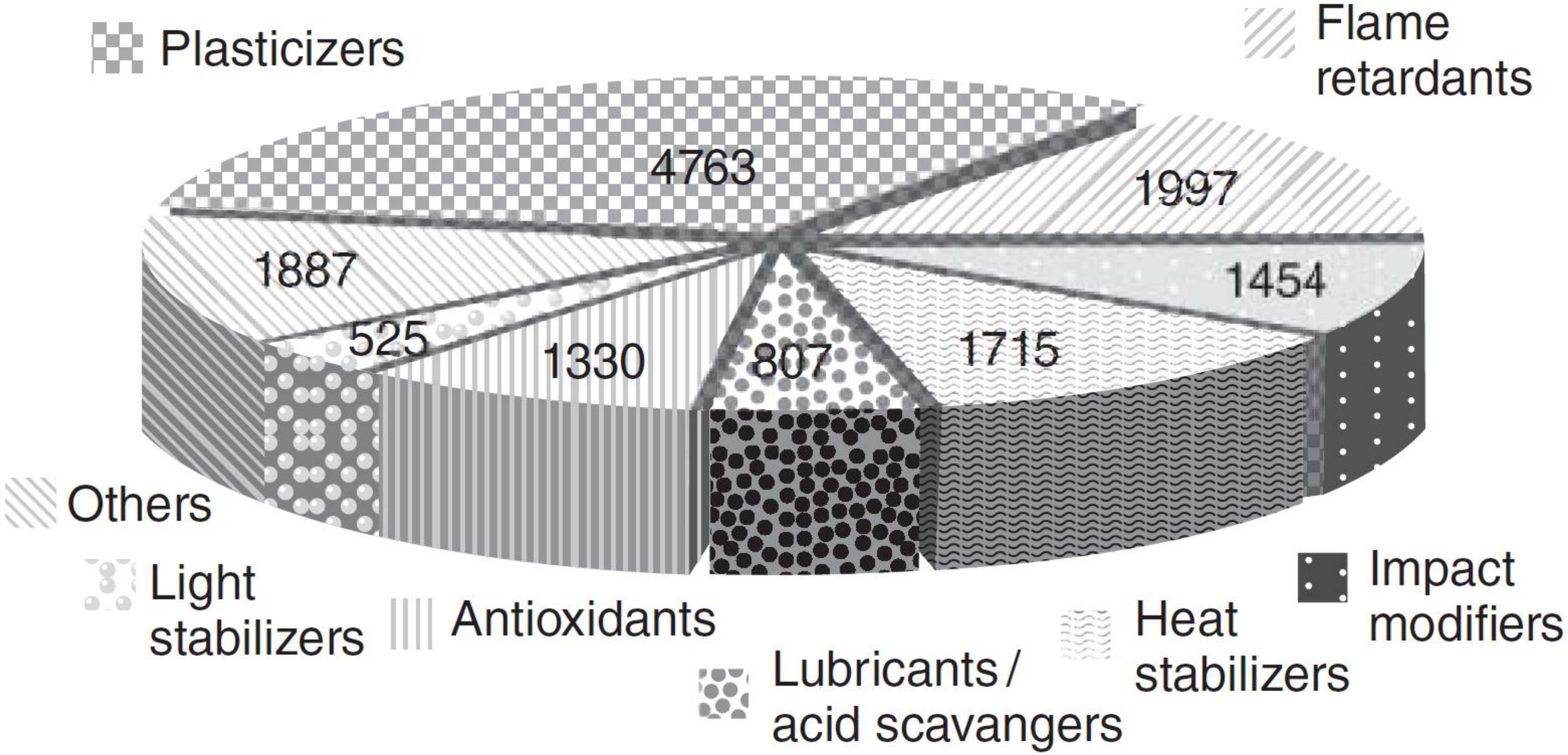
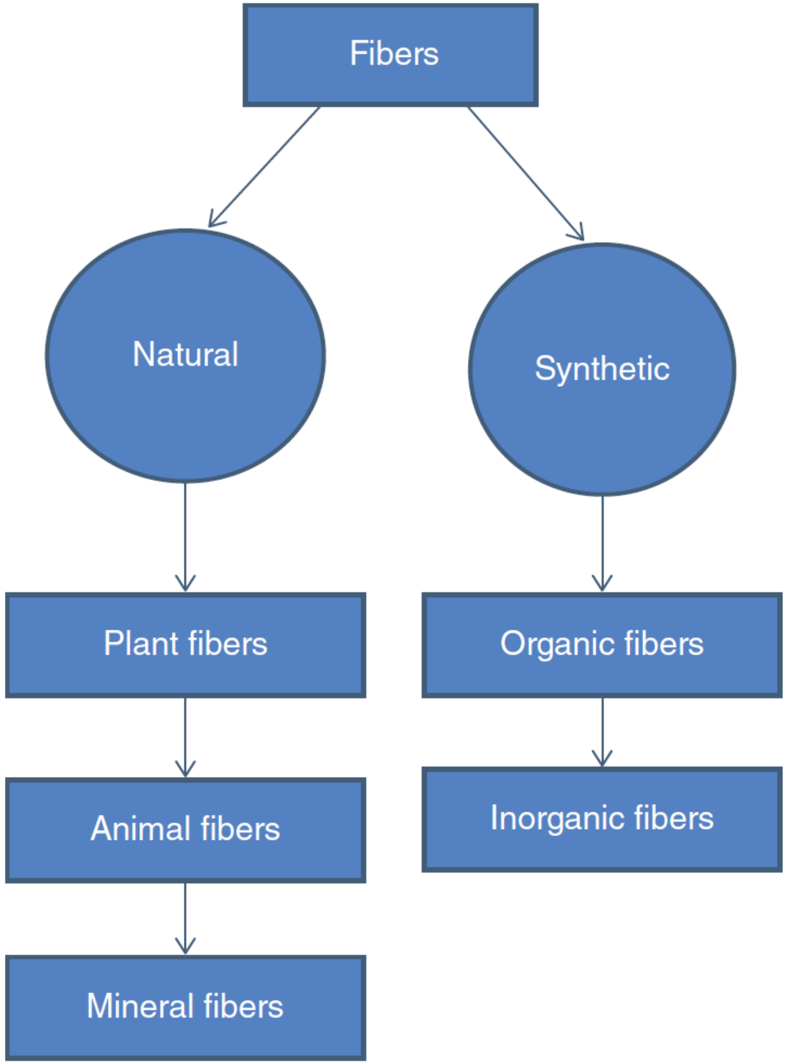
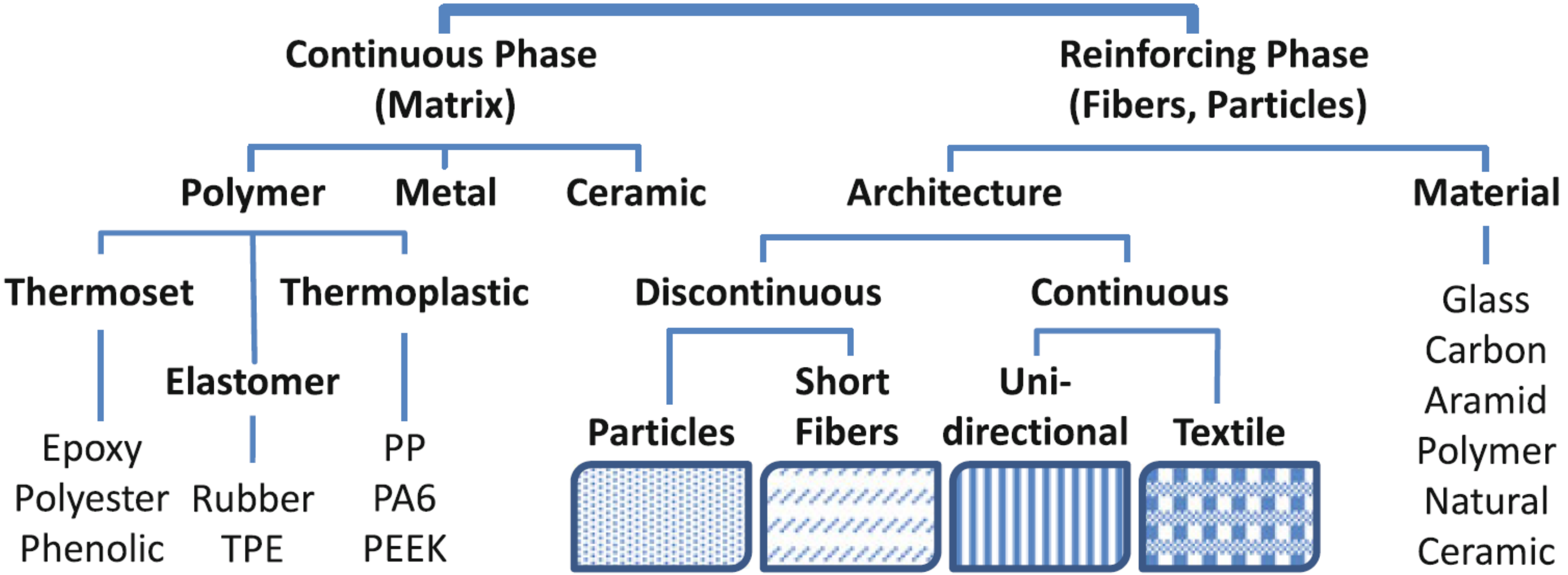
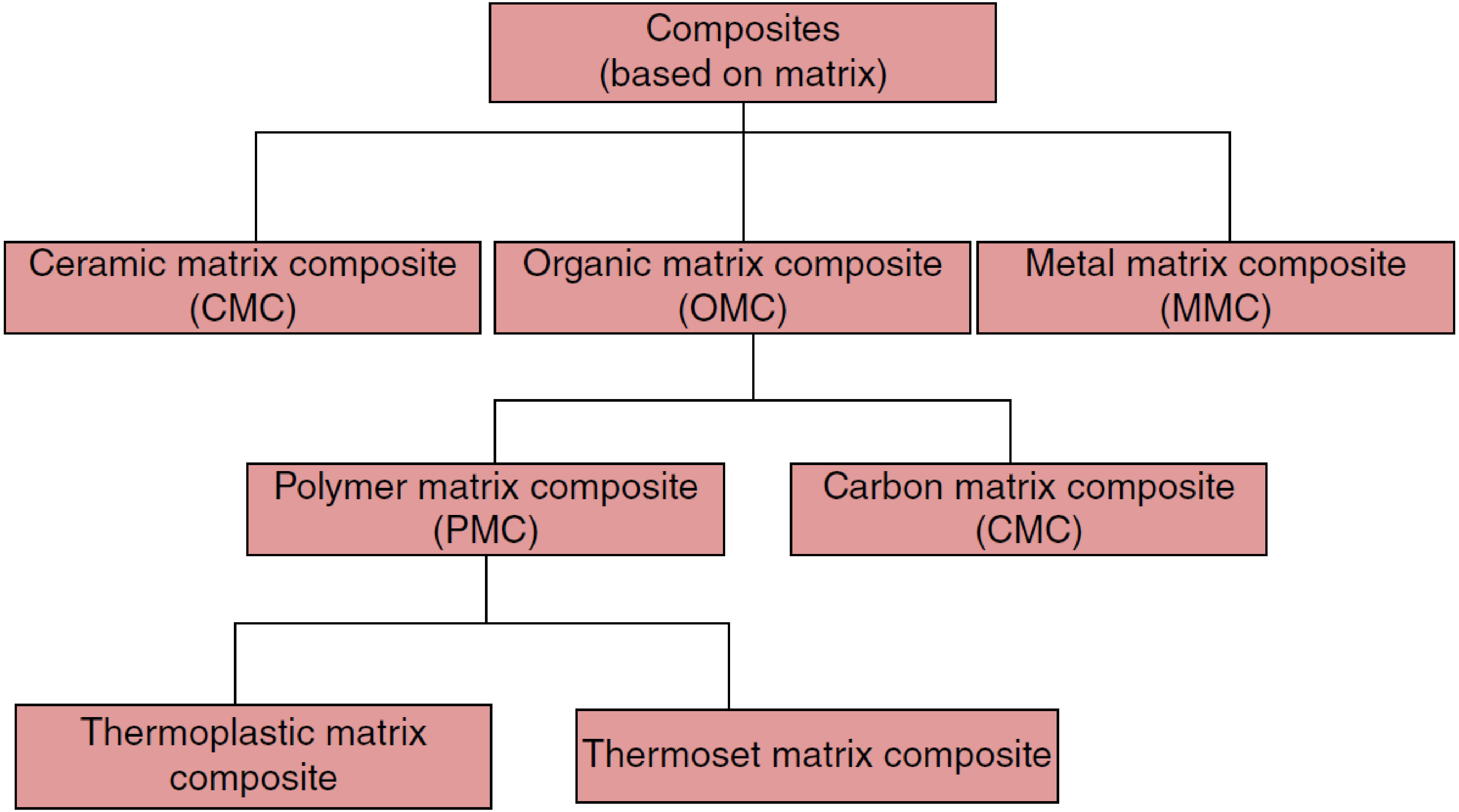
Dlaczego recykling mechaniczny bywa trudny ?

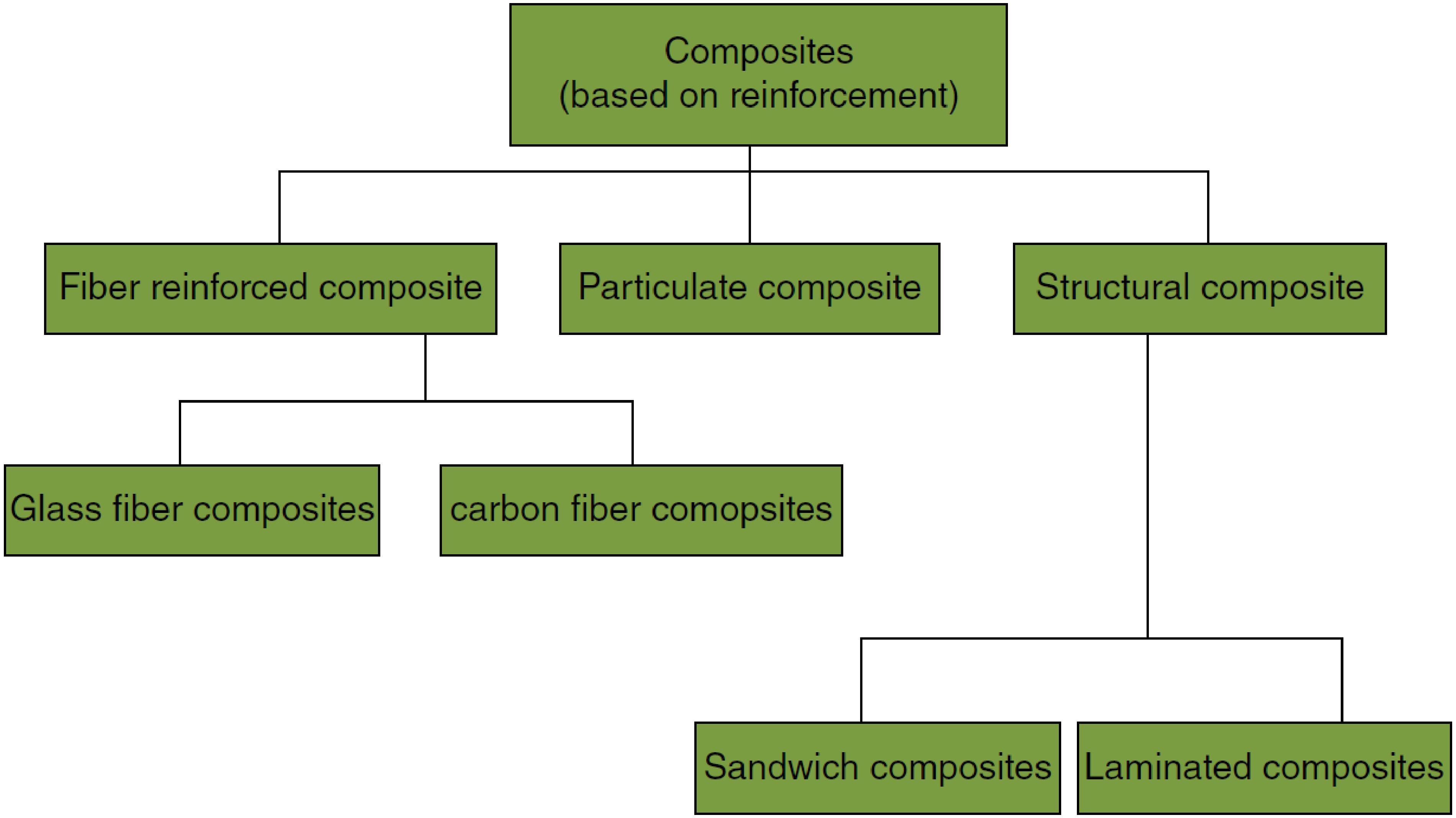



Fibers
Natural
Synthetic
Plant fibers
Animal fibers
Mineral fibers
Organic fibers
Inorganic fibers

Composite Materials




Composites
(based on matrix)
Ceramic matrix composite
(CMC)
Organic matrix composite
(OMC)
Metal matrix composite
(MMC)
Polymer matrix composite
(PMC)
Carbon matrix composite
(CMC)
Thermoplastic matrix
composite
Thermoset matrix composite


Composites
(based on reinforcement)
Fiber reinforced composite
Particulate composite
Structural composite
Glass fiber composites
carbon fiber comopsites
Sandwich composites
Laminated composites

Wyzwania w recyklingu tworzyw sztucznych post-konsumenckich

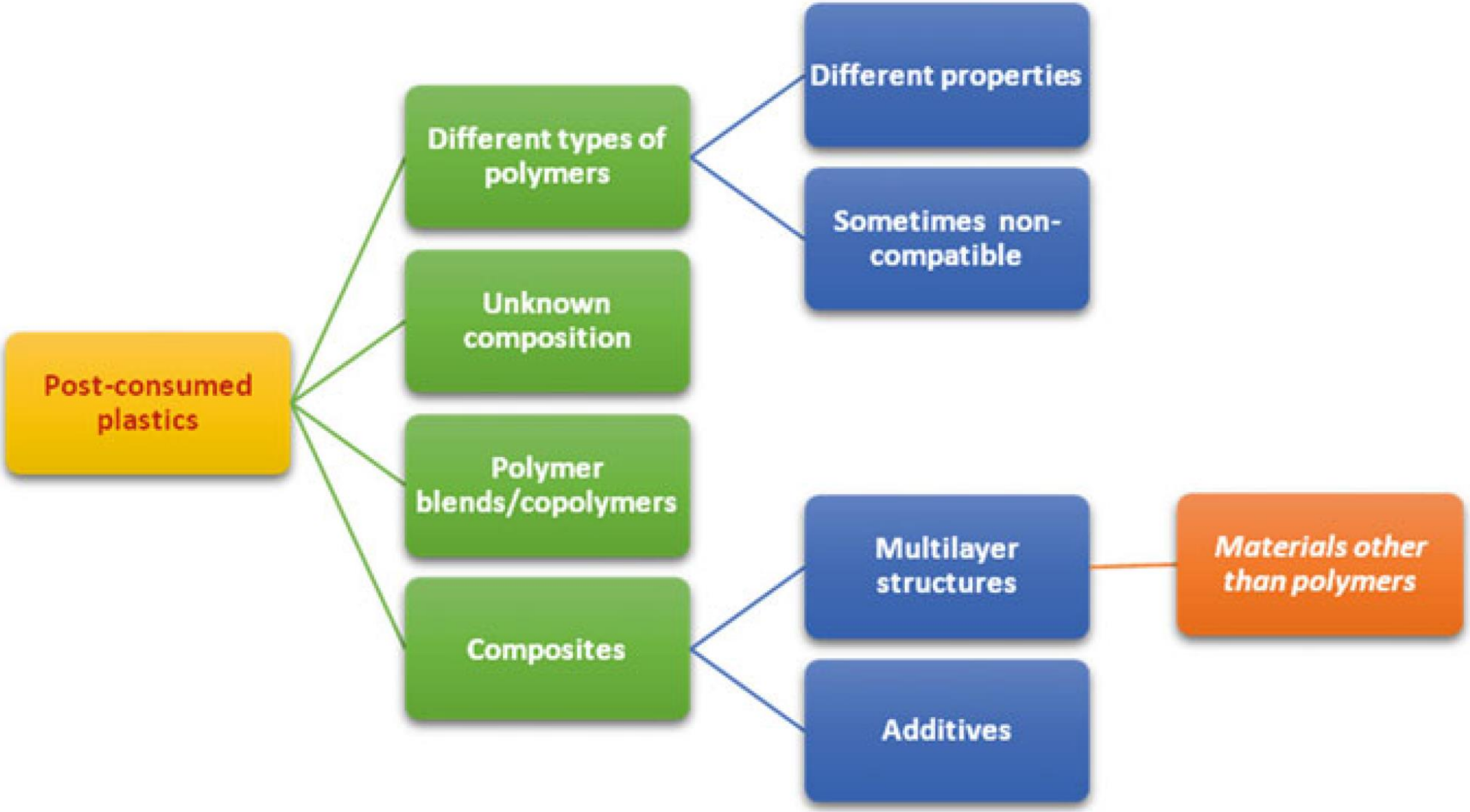
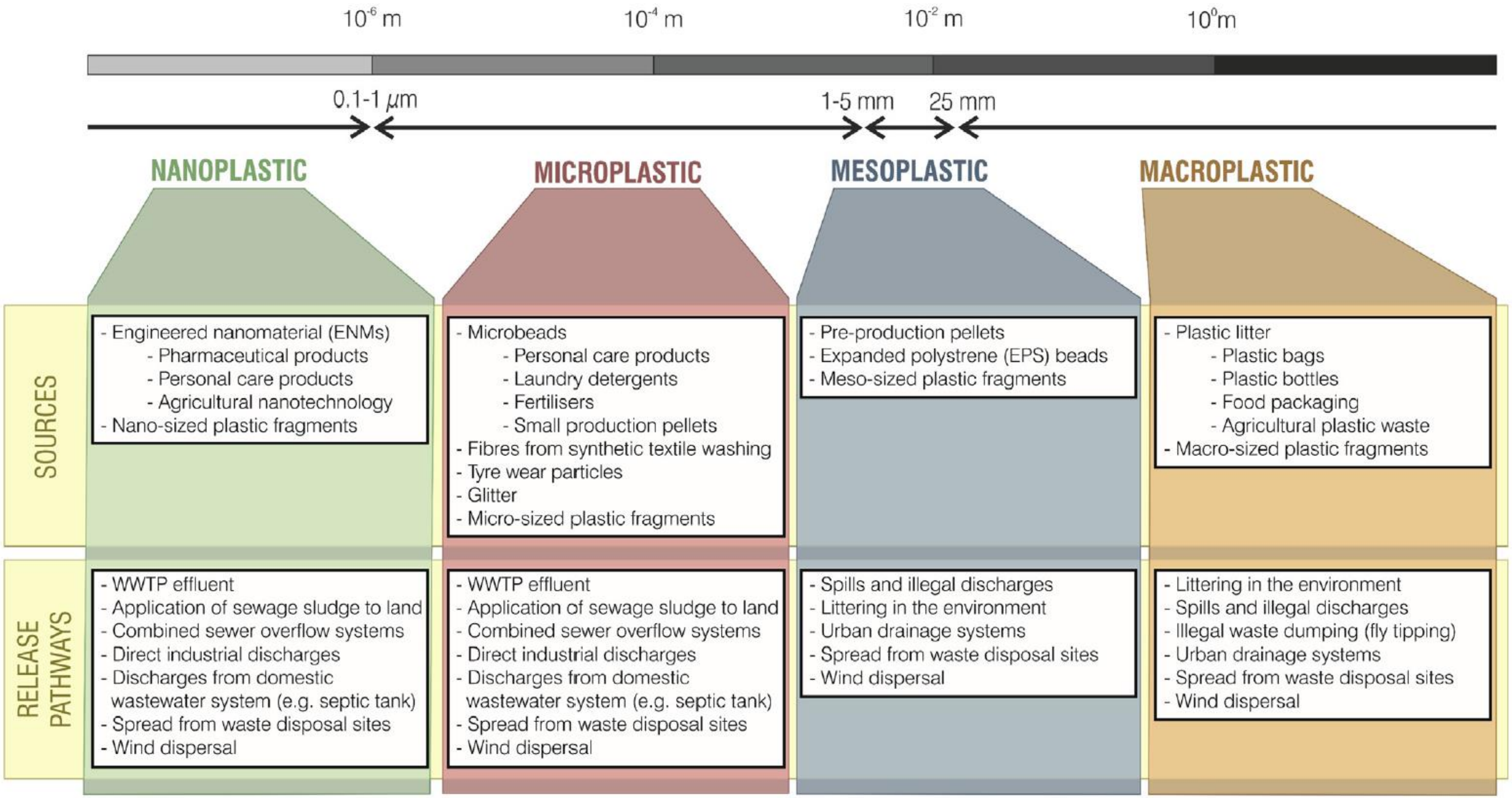


Table 1 Mechanical property of recycled LDPE

Types of PE	Mechanical property	Before recycling	After recycling	References
LDPE	Tensile strength (MPa)	16	12	Pedroso and Rosa (2005)
	Young's modulus (GPa)	191	221.25	
	Elongation at break (%)	393.4	285.8	
HDPE	Tensile strength (MPa)	33.7	34.2	Pattanakul et al. (1991)
	Modulus (MPa)	596	640	
	Elongation %	69.7	36.9	
	Impact strength (ft.lb/in)	2.522	2.201	

Table 2 Mechanical property of recycled PP

Mechanical property	Before recycling	After recycling	References
Tensile strength (MPa)	34.7 ± 0.22	36.3 ± 0.17	Aurrekoetxea et al. (2001a)
	–	~34.7 1 × Re ~35.2 3 × Re ~36.1 5 × Re	Aurrekoetxea et al. (2001b)
Tensile modulus (MPa)	1704 ± 39	1993 ± 49	Aurrekoetxea et al. (2001a)
	–	~1708 1 × Re ~1804 3 × Re ~1948 5 × Re	Aurrekoetxea et al. (2001b)
Elongation at break (%)	66.37 ± 5.38	51.55 ± 2.2	Aurrekoetxea et al. (2001a)


10^-6 m
10^-4 m
10^-2 m
10^0 m
0.1-1 µm
1-5 mm
25 mm
NANOPLASTIC
MICROPLASTIC
MESOPLASTIC
MACROPLASTIC
SOURCES
- Engineered nanomaterial (ENMs)
- Pharmaceutical products
- Personal care products
- Agricultural nanotechnology
- Nano-sized plastic fragments
- Microbeads
- Personal care products
- Laundry detergents
- Fertilisers
- Small production pellets
- Fibres from synthetic textile washing
- Tyre wear particles
- Glitter
- Micro-sized plastic fragments
- Pre-production pellets
- Expanded polystrene (EPS) beads
- Meso-sized plastic fragments
- Plastic litter
- Plastic bags
- Plastic bottles
- Food packaging
- Agricultural plastic waste
- Macro-sized plastic fragments
RELEASE PATHWAYS
- WWTP effluent
- Application of sewage sludge to land
- Combined sewer overflow systems
- Direct industrial discharges
- Discharges from domestic wastewater system (e.g. septic tank)
- Spread from waste disposal sites
- Wind dispersal
- WWTP effluent
- Application of sewage sludge to land
- Combined sewer overflow systems
- Direct industrial discharges
- Discharges from domestic wastewater system (e.g. septic tank)
- Spread from waste disposal sites
- Wind dispersal
- Spills and illegal discharges
- Littering in the environment
- Urban drainage systems
- Spread from waste disposal sites
- Wind dispersal
- Littering in the environment
- Spills and illegal discharges
- Illegal waste dumping (fly tipping)
- Urban drainage systems
- Spread from waste disposal sites
- Wind dispersal

PLASTIGO

Wydział Inżynierii Mechanicznej

Dziękuję za uwagę!