



Plastic from e-waste: The end of the line

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Goals

- .. Have a basic understanding of what plastic is.
- .. Know the most common plastic types in e-waste. Learn & try out simple methods to recognise them.
- .. Get to know a few common e-waste plastics. Learn & try out methods to identify / separate some of them.
- .. Depollutions «musts» and «shoulds». Disposal and limited re-use options.
- .. Know of the possibilities of local and international pre- and post-processing solutions.
- .. Exchange local experiences for profitable & safe processing of plastics.

Plastic under the microscope

Thermoplastic:
Softens when heated

Thermoset:
Is irreversibly cured, does not soften.



Polymer Chains:
Structure, mechanical strength

Pigments

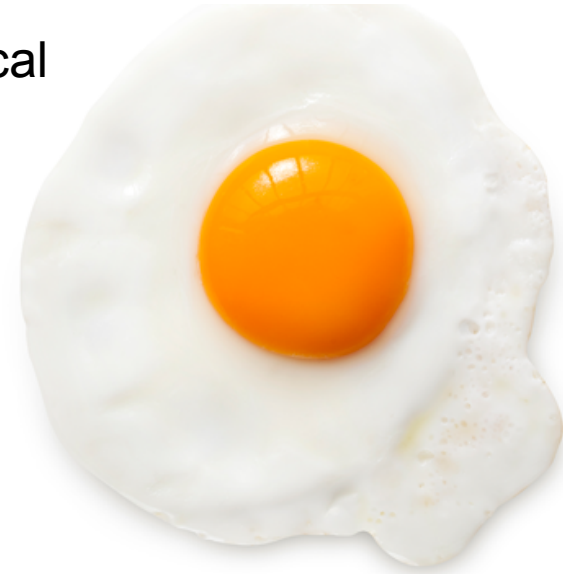
«Spices»:

Stabilizers

Flame Retardants

Plasticisers

...



Recycleable as separate streams

Most housings, but problems:

- Fillers & fibers
- Hazardous substances

Non-recycleable, may be reginded and used as a «filler».

PWBs: Metal of higher priority

Degradation of plastic

- Plastics rarely degrade at the speed we like:
 - During (re)use: Too fast
 - In the environment: Too slow
- Degradation:
 - Polymer chains become shorter -> plastic gets softer.
 - Additives often lose their function:
 - Pigments lose their color, stabilisers get used up
 - Hazardous additives: Persistent organics or inorganic are released and may be transformed into worse compounds.
- Oxygen, light and heat promote the degradation
- There is a limit to recycling, but it is not an issue yet

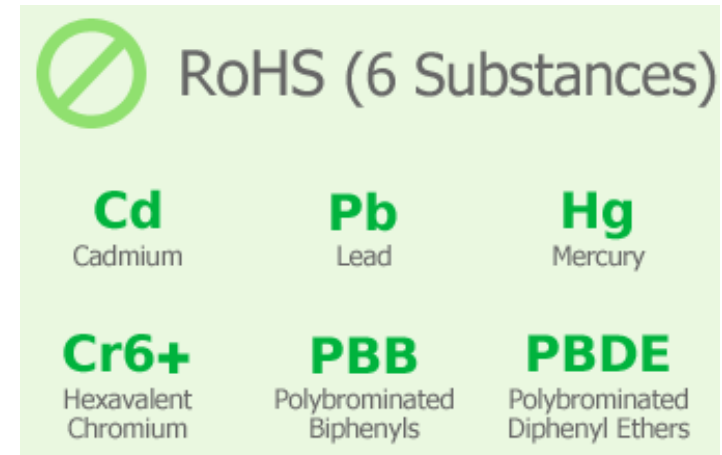
Plastics in e-waste

- Overall, ~29% of e-waste is plastic by weight.
- Different polymers used for different applications
- Main polymers used: ABS, HIPS, PC(+ABS), PP.

Fraction	Plastic content	Major plastics	Minor Plastic
Cooling appliances	High	PS (>70%)	ABS, PP
CRT PC Monitor	28%	ABS (70%)	PC+ABS
CRT TV	23%	PS, HIPS,	ABS
PC/Server	6%	ABS, PC+ABS	HIPS
Office printer	33%	PC+ABS, ABS	PS, HIPS
Consumer electronics	33%	ABS, PP	PS, ABS
Cables	<10%	PVC, PP	Cross-linked (XL)PP
PS from cooling appl.		ABS / HIPS, various categories	PVC (soft, cables)

Regulations on hazardous additives - 1

- Restriction of Hazardous Substances (RoHS) in new electronic equipment and automobiles.
- Same limits usually enforced in e-waste recycling.



PBBs & PBDEs	Pb	Hg	Cr(VI)	Cd
1000 ppm (mg/kg)				100 ppm

- Stockholm convention (POP) lists some Brominated flame retardants
 - Manufacture and use of Penta, Octa-BDE, (HBCD, HBB), banned globally. PBDE-Waste needs to be adequately disposed.
 - POP BFR-Waste need to be adequately managed, i.e. disposed.
 - Recycling permitted on an intermediary basis if:
 - PBDEs are not extracted.
 - Reprocessing and use do not pose a risk

Regulations on hazardous additives - 2

	HBCD(D)	PBDEs	PBBs	TBBPA	Heavy Metals
RoHS		All	All		Pb, Hg, Cr(VI), Cd
POPs		Penta, octa	Hexa		

No practicable way to detect good/bad single BFRs in recycling context. Very high stream knowledge necessary

- RoHS compliant: To be recycled.
- RoHS non-compliant:
 - BFR: needs to be disposed
 - Heavy Metals: strongly limited re-use possible, advised as last option
- Good practice of plastic recycling: Recycled materials not to be used in critical applications (i.e. prolonged contact with food / body).

Two additional regulations to watch out for are:

- EU REACH (HBCD): Too complicated to delve in to. If you export for post-processing to EU, the buyer will take care of it.
- Basel convention: contains a catch-all provision for all Halogen-containing waste and as such applies in theory as well. However, it is rarely implemented that stringently.

Know your stream

- Plastic markings are not enough...

- RoHS-compliance

- RoHS substances have changed



- Polymer type

- Only 70% accurate in Europe (with little lowest-cost products)

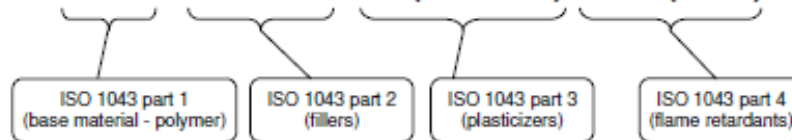
>ABS<

- FR-indication

- Probably trustworthy (?)

>FR< / >FR10<

>PP-GF30-P(ELO)FR(52)<



FR14/15: may be HBCD

FR18-21: RoHS BFRs

ISO 1043 - Marking of Plastics, Rubbers and thermoplastic Elastomers

- ...especially for «old» material.

So what about our streams?

	PS from cooling appl.	ABS / HIPS, various categories	PVC (soft, cables)
Hazardous additives	None, compliant	<ul style="list-style-type: none"> • Brominated flame retardants, 0.1% - 10% depending on category • Hg, Cd, Pb, Cr usually just below RoHS compliance 	<ul style="list-style-type: none"> • Cd, Pb in high concentrations (1-2%). • Rare high voltage: PCBs • Phtalates and other endocrine disruptors
Possible pre-processing	None necessary	BFR-containing parts can be recognized / segregated to improve yield (10-20% remains as high BFR fraction).	None possible

i: Empa-studies on the occurrence of BFRs / HMs in different stream are available

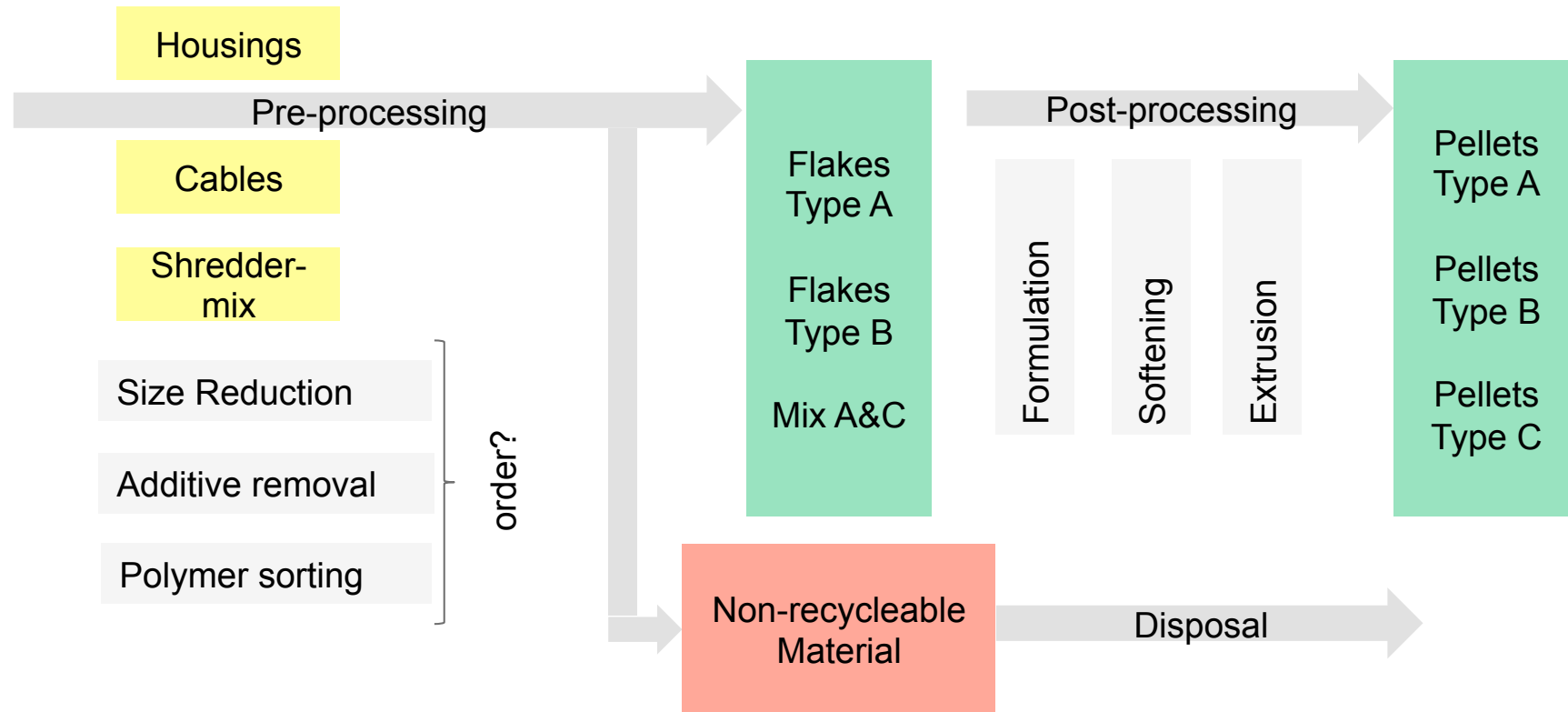
Disposal options

	ABS / HIPS, high BFR	PVC (soft, cables)
Disposal experiences EU	<ul style="list-style-type: none"> • Cement Kiln (positive, but discontinued) • Waste-2-Energy plant (*) (require good process and emission control) 	<ul style="list-style-type: none"> • Landfilling (*) • Waste-2-Energy plant (heavily diluted), (*)
	Ash disposal in high pH environment to trap heavy metals	
Pilot level	Feedstock recycling, HW incineration or other stabilisation	

(*) These options are rarely applicable in the African context:

- Limited recycling may be a viable alternative for PVC
- Local Incineration in Cement Kiln may be something to study for BFR

The e-waste plastic recycling process chain



Plastic never forgets what you did to it: Shredding of whole WEEE can transfer heavy metals into plastic (especially lead), increasing concentrations above RoHS limits.

-> You have to design your own pre-processing strategy, depending on your downstream markets.

Extremes of post-processing

- Local mixed plastic recycler:
 - Buys plastic scrap locally
 - Not interested in quality & hazardous additives
 - Business model: Cheap bulky products for the local market (e.g. fence posts, tiles...)

- MBA polymers – plants in Austria and China.
 - Buys mixed e-waste plastic.
 - Interested in HIPS, ABS, PC, PP. Everything else + BFRs (HIPS/ABS/PC/PP) fractions are safely incinerated.
 - Business model: Buying material, transparent accounting & suggestion on how to improve material quality.