



Innovative Natural Fibre Reinforced Bio-Composite Granules for Cradle-to-Cradle Solutions – China in our hands?

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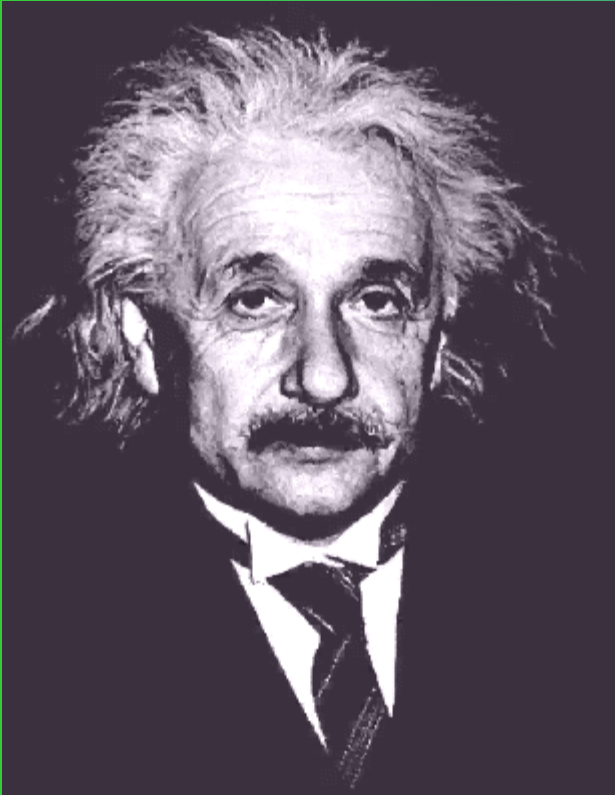
Introduction

Our world in the 21st century fundamentally differs from the 20th century:

- Economically due to credit crunch
- Ecologically due to climate change
- Geo-politically due to rising energy needs



Paradigm shift needed



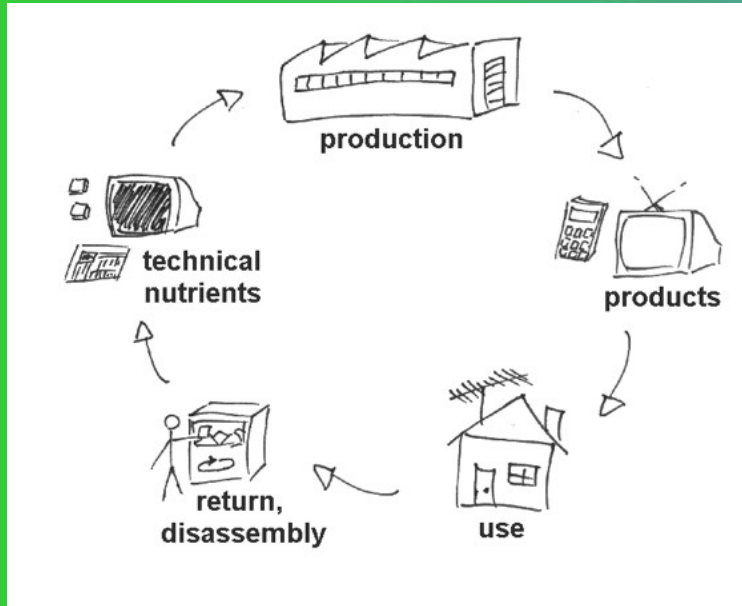
“The world will not evolve past its current state of crisis by using the same thinking that created the situation.”

A new way of thinking: Cradle-to-Cradle

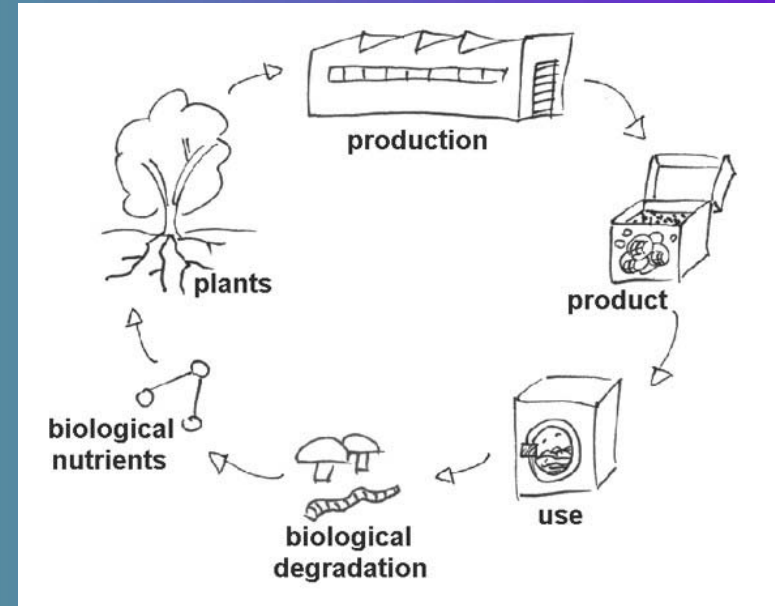


Michael Braungart & William McDonough

Two interdependent metabolisms



Technical nutrients
=
technical recycling



Biological nutrients
=
biological recycling

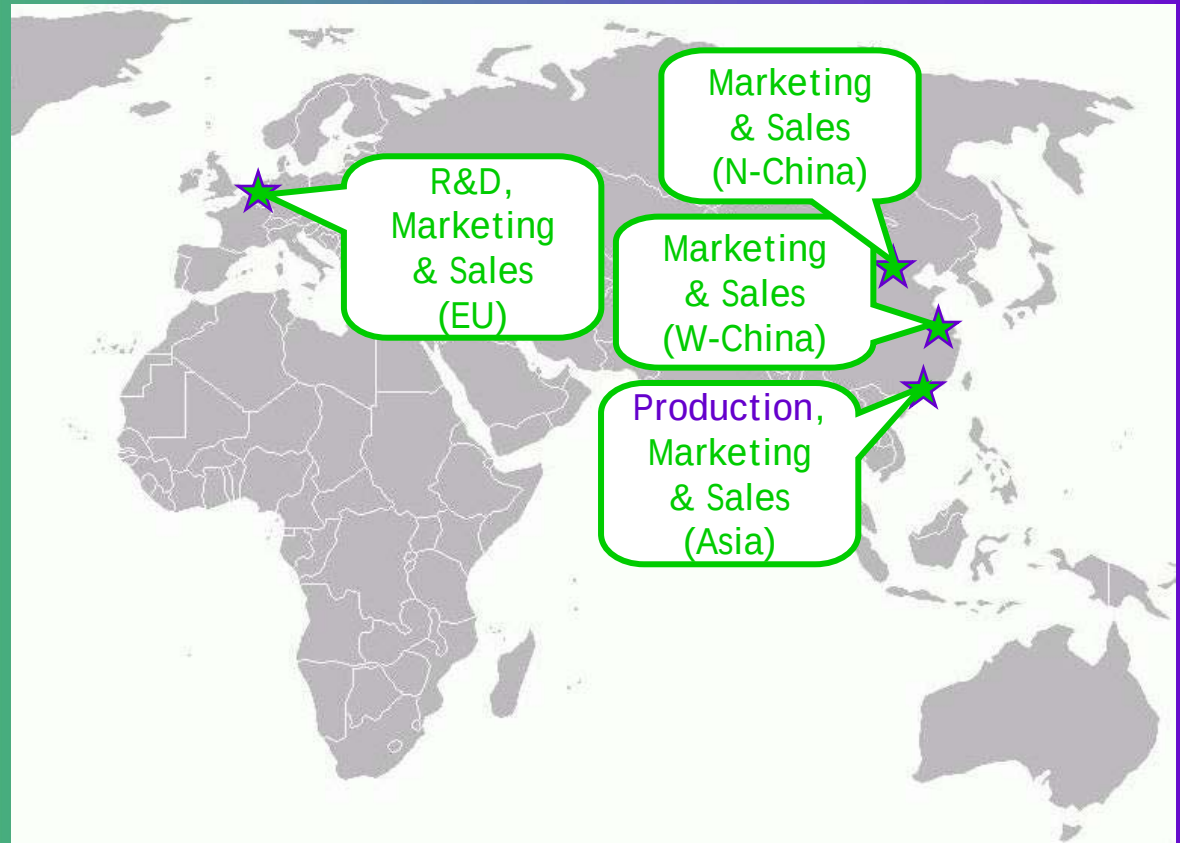
What is GreenGran?

- Production and sales natural fibre bio-composite granules for injection-moulding applications
- Agency for bio-degradable C2C plastic granules for film-, foil-, foam- and glue applications
- Consulting customers on injection moulding and on smart product/market applications

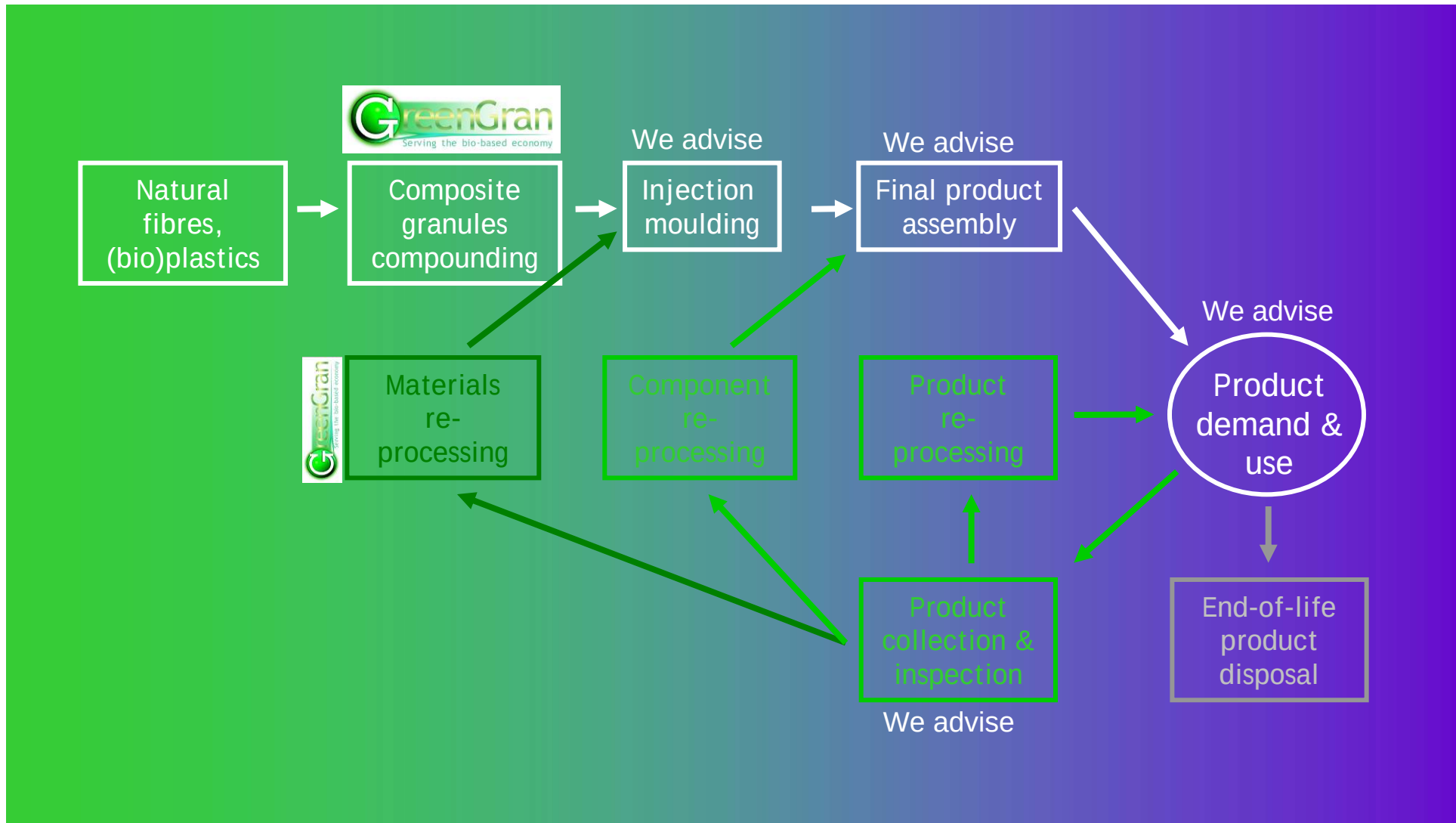


What and where

- Fibres used: hemp, flax, kenaf, jute, rami
- Plastics used: PP, PLA, PHB
- Both standard- and tailor-made compositions
- Master batches

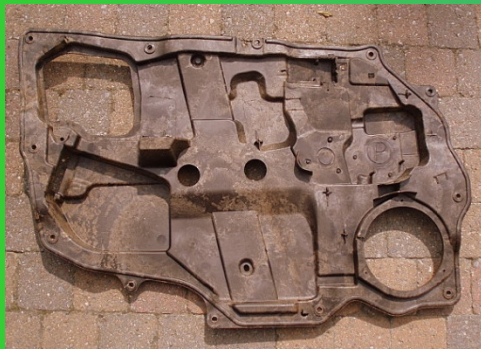


Sustainable NF/(bio)plastic granules → technical recycling



Highlighting GreenGran's product quality

Our granules compete with engineering plastics:



- lighter, stiffer, equally strong
- Economic competitive



- Flame retardant, using halogen-free additives
- From small to large objects
- Recycle-able or bio-degradable (C2C)

Properties comparison chart

Granule type/ Property	ABS V0	PBT V0	PP-GF	GreenGran PPNF
Fibre content [wt.%]	0	0	30	50
Density [kg/m ³]	1,18	1.45	1,14	1,08-1.10
Flexural modulus [MPa]	-	-	4,300	4,900
Flexural strength [MPa]	-	-	102	89
Tensile Modulus [MPa]	2,300	2.500	4,600	5,420
Tensile strength [MPa]	-	-	68	62
Elongation at break [%]	12	4.5	3	3
Charpy Impact strength, notched [KJ/m ²]	-	4	9	5
Rockwell [R-scale]	95	-	-	109
Water Absorption [%]	1.5	0.5	<0.1	0.9
HDT A [°C]	-	-	-	132
HDT B [°C]	92	-	145	156
Melting point [°C]	100	225	175	175

Bio-composite degradability (PLA-NF)

Fibre-reinforced green composites

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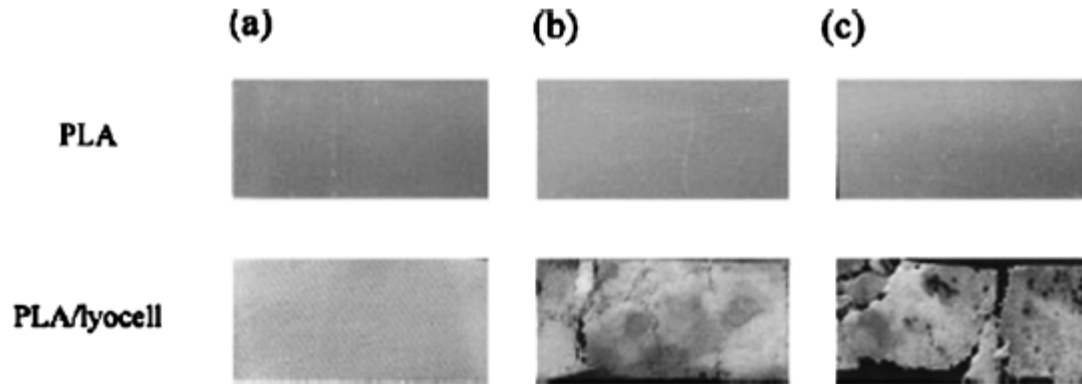


Figure 5. Photographs of PLA (top) and PLA/lyocell composite (bottom) after the soil burial test: (a) before test, (b) at 60 days, and (c) at 120 days.

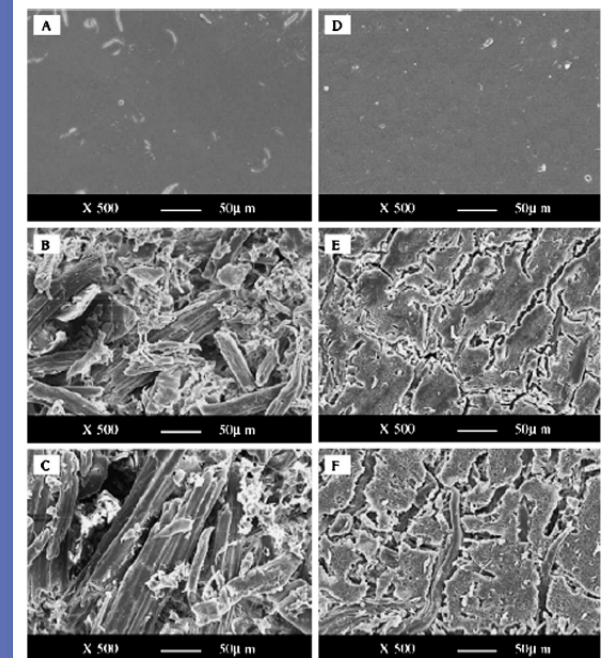
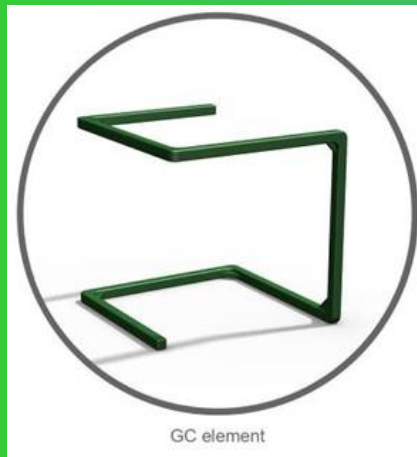


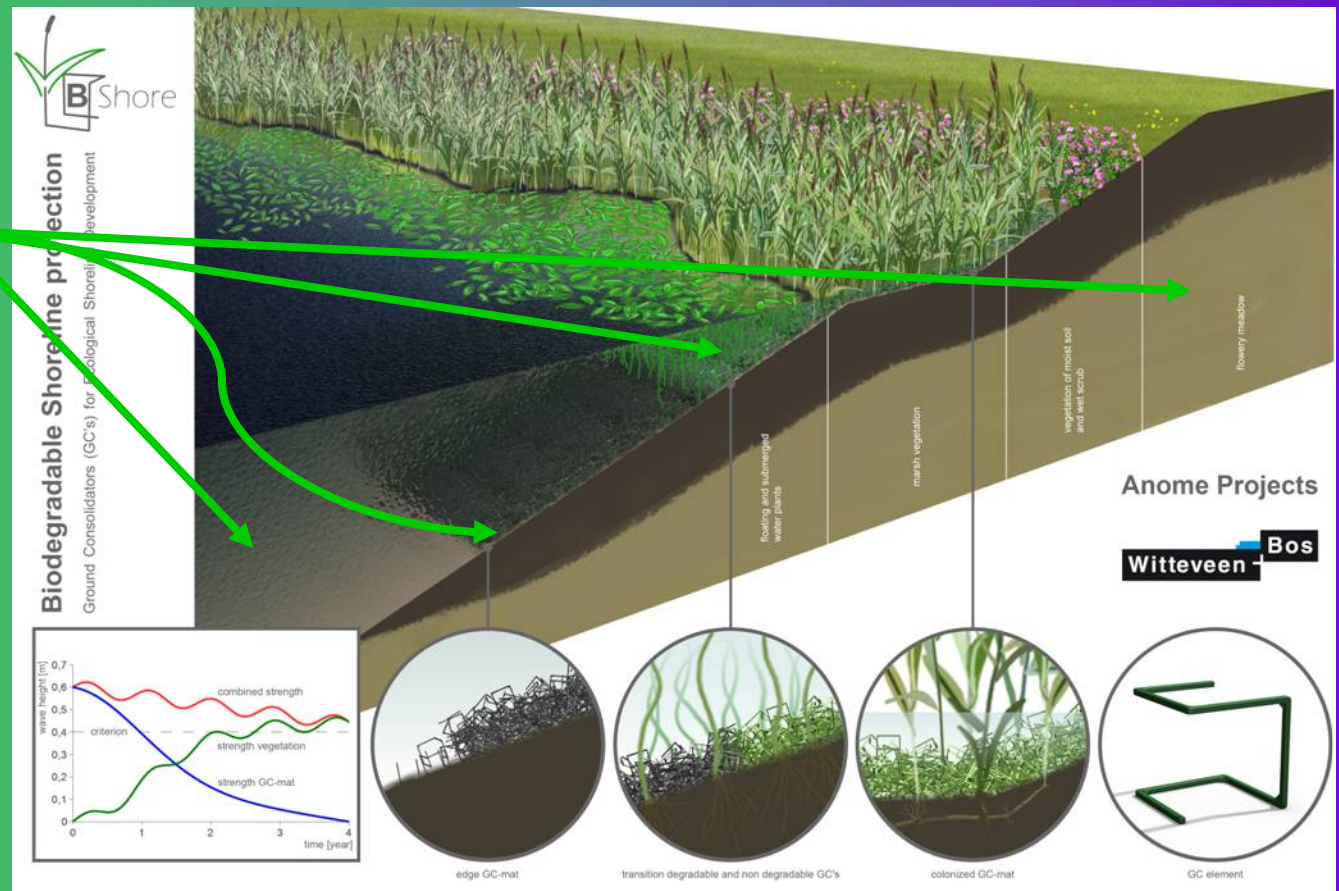
Figure 3. SEM micrographs of PLA or PBS/BF composites with LDI (NCO content, 0.65%) after different enzymatic degradation time. (a) control of PLA/BF composite, (b) after 7 days, (c) 9 days, (d) control of PBS/BF composite, (e) after 2 days, (f) 4 days.

Composition	Flexural modulus (MPa)	Flexural strength (MPa)	Charpy Impact (kJ/m ²)
PLA + 50% natural fibre	7,270	115	10
PLA + bio-elastomer + 30% natural fibre	3,980	76	33

Examples in product development: Waterworks



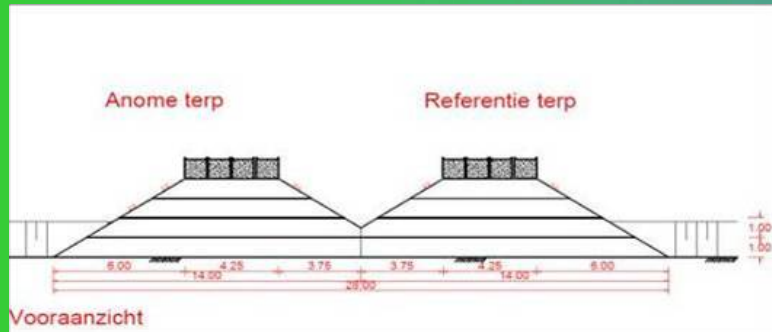
- Riverbank erosion blockage
- Dyke reinforcement
- Artificial reef
- Fundament for coral- and mangrove growth



Examples in product development: Waterworks



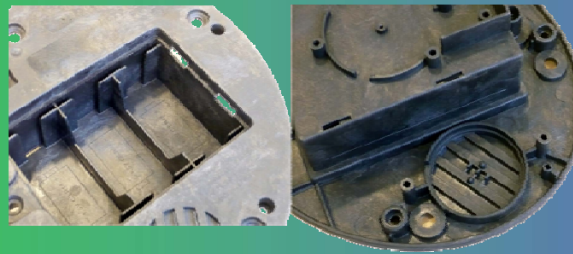
Examples in product development: Waterworks



Examples in product development: E&E housing

Housings of electrical appliances:

- GSM charger
- GPS
- Battery tray
- Computer housing



- Replacement of FR-ABS
- Halogen-free FR additives
- UL94 from HB up till V0/5VB



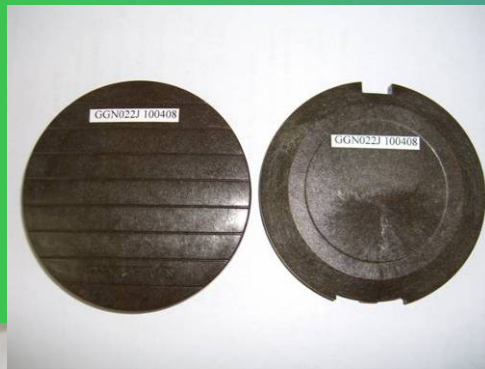
Win-Win-Win for E&E housing

The BioCharger is threefold eco:

- Oil-based housing is replaced by bio-based materials
- Bromine-based FR additive is replaced by halogen-free alternative
- Automatic charging-stop after 3 hrs → no needless energy consumption



Examples in product development: Consumer goods



Cosmetic containers



chairs

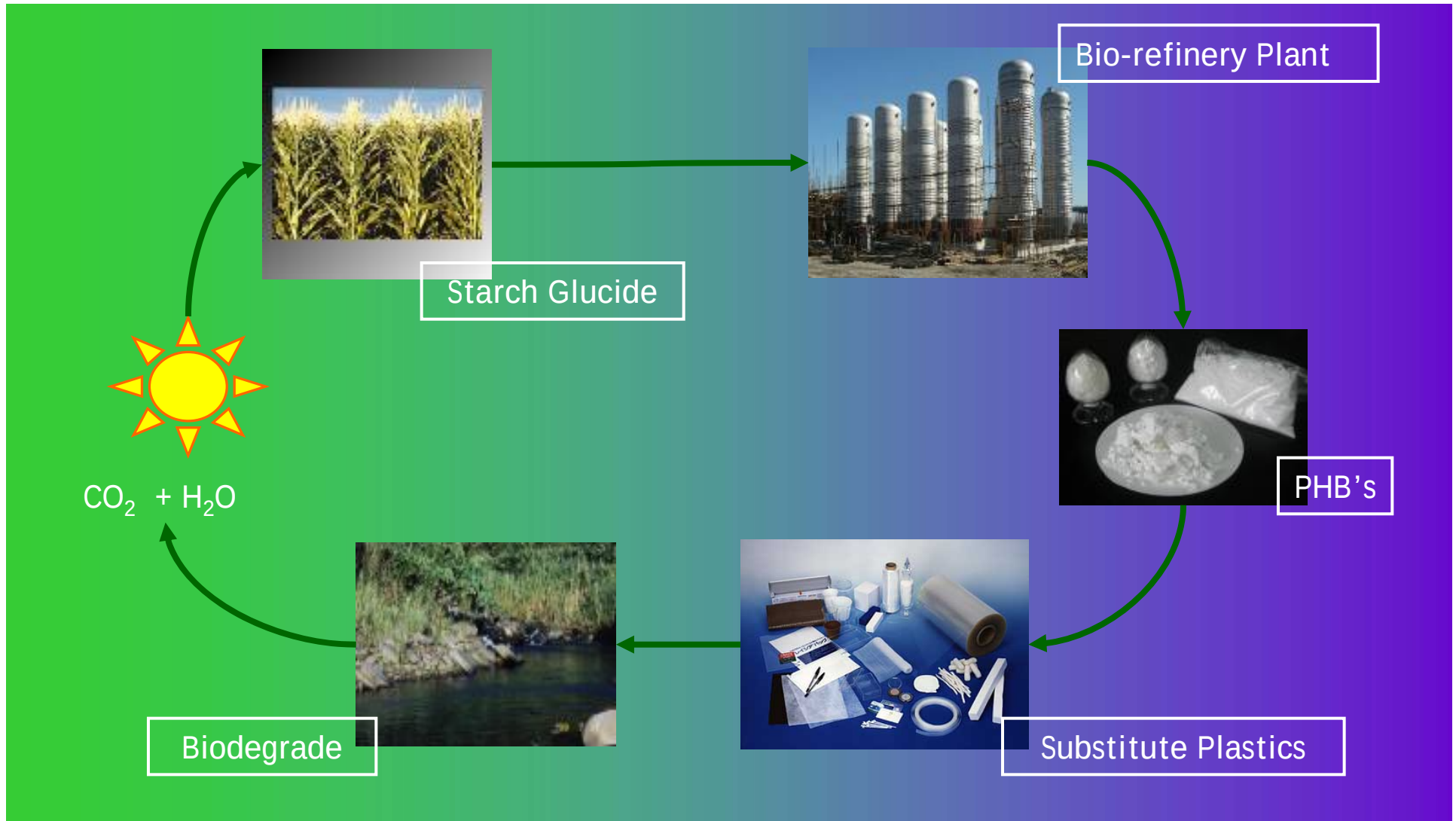


Toys

Pro's and cons

- Technical competition unfilled- vs filled- vs reinforced plastic:
 - Mechanical properties following 20-30% glassfibre (GF) reinforced, impact properties lower than most unfilled plastics
 - Lower melt flow = lower throughput , unless nozzle is widened
 - For economic competition with:
 - Unfilled plastic: only by reducing weight or by following C2C economics, or to market it as bio-based product
 - Chalk, carbon, etc filled plastics: idem
- (Glass fibre reinforced) engineering plastics: OK

Biodegradable PLA/PHB granules → biological recycling

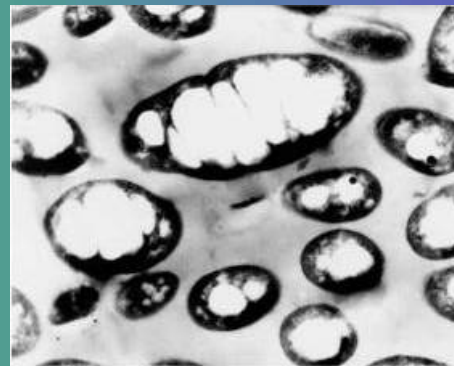


PHA Advantages for disposable applications

Source	Renewable	Polyester obtained from sugars' fermentation
Mechanical	Good	Adjustable
Thermal	Good	High HDT
Processability	Good	Processable in existing production machines
Durability	Good	No degradation during usage
Bio-degradability	Good	3-6 months for fully bio-degraded into water & CO ₂
Green Aspect	Good	Zero carbon emission.

PHA Family

PHBV	P(3HB-co-3HV)	ICI: Biopol, TianAn
PHBHx	P(3HB-co-3HHx)	Kaneka, TsingHua Uni.
PHBO	P(3HB-co-3HO)	P&G: Nodax (stopped)
P3HB	P(3HB)	Biomer
PHB	P(3HB-co-4HB)	SoGreen Metabolix



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Production in
Tianjin, China



Performance Advantage of SoGreen's PHB

Capability of producing varieties of copolymers, or compositions, by adjusting polymerization ratios, thus having broad application potential

Our PHB granules can be used for making:

- films
- foils
- foams
- adhesives
- rubber additives



Concluding ...

For sustainable applications, to replace traditional engineering plastics by bio-based alternatives → use 'GreenGran' NF/PP, NF/PLA/PHB



For disposable applications, to replace traditional oil-based plastics by bio-degradable alternatives → use 'SoGreen' PHB



End of presentation

- Thank you for your attention!
- For more info:
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