

Executive summary and spec-sheets of facilities for circularity by design

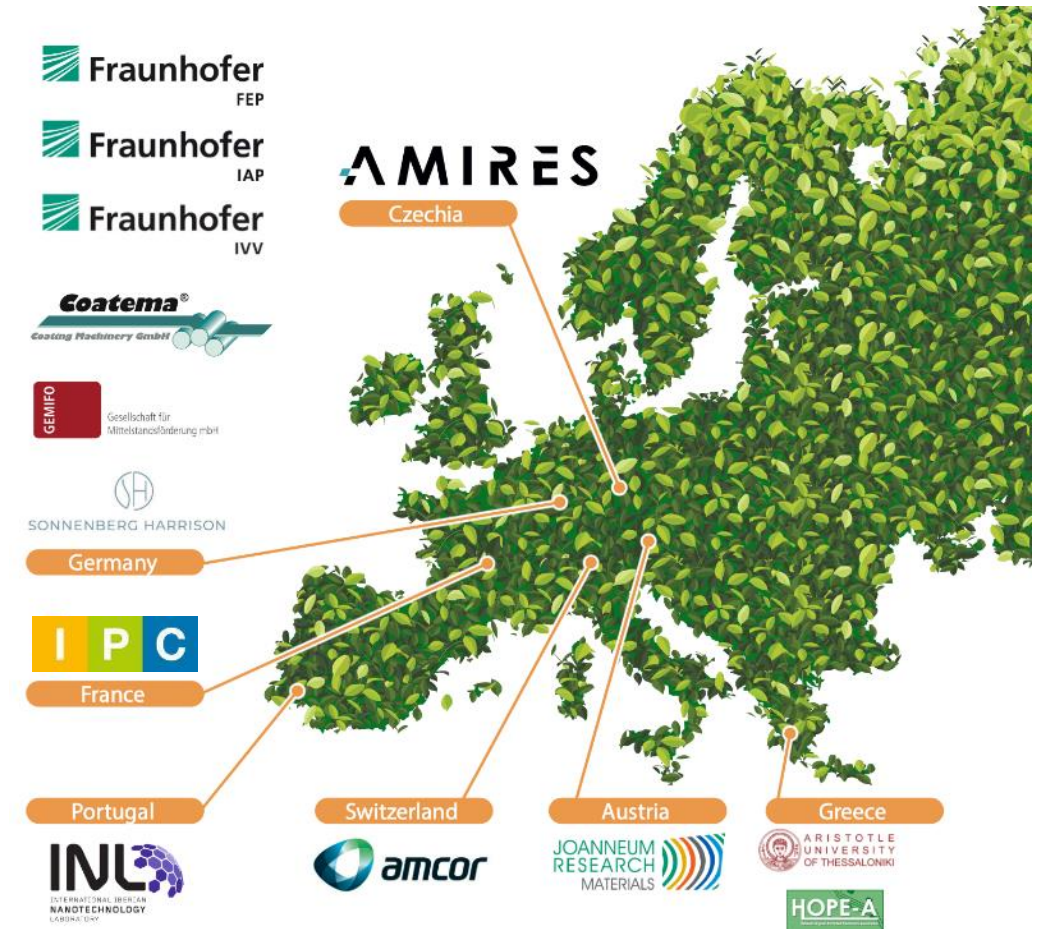


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The facilities at a glance

- Use Cases of the FlexFunction2Sustain project (p. 3)
- “Circularity by design” concept (p.4)
- Eco-design services (p.5)
- Processing facility for formulation & converting (p.7)
- Recyclability evaluation (p.10)
- Biodegradability evaluation (p.17)
- Interconnection between all the OITB services (p.22)

Service Providers in FlexFunction2Sustain



Use Cases of the FlexFunction2Sustain project

FlexFunction2Sustain’s technical facilities and the performances of novel nano-functionalised surfaces will be demonstrated and validated by Europe’s leading companies within six industrial application scenarios. Application examples for the services related to the Use Cases are labelled with a code specific for each one (UC#)

Industrial Validation in 6 Use Cases

UC1



Biobased
Optical Films
for Labelling of
Consumer Goods
and Surface
Design

UC2



Marine
degradable
shampoo sachets

UC3



Selective and
switchable
water filter
membranes

UC4



Multifunctional
scratch resistant
surfaces in
automotive

UC5



Recyclable
mono-polymer
drink pouches

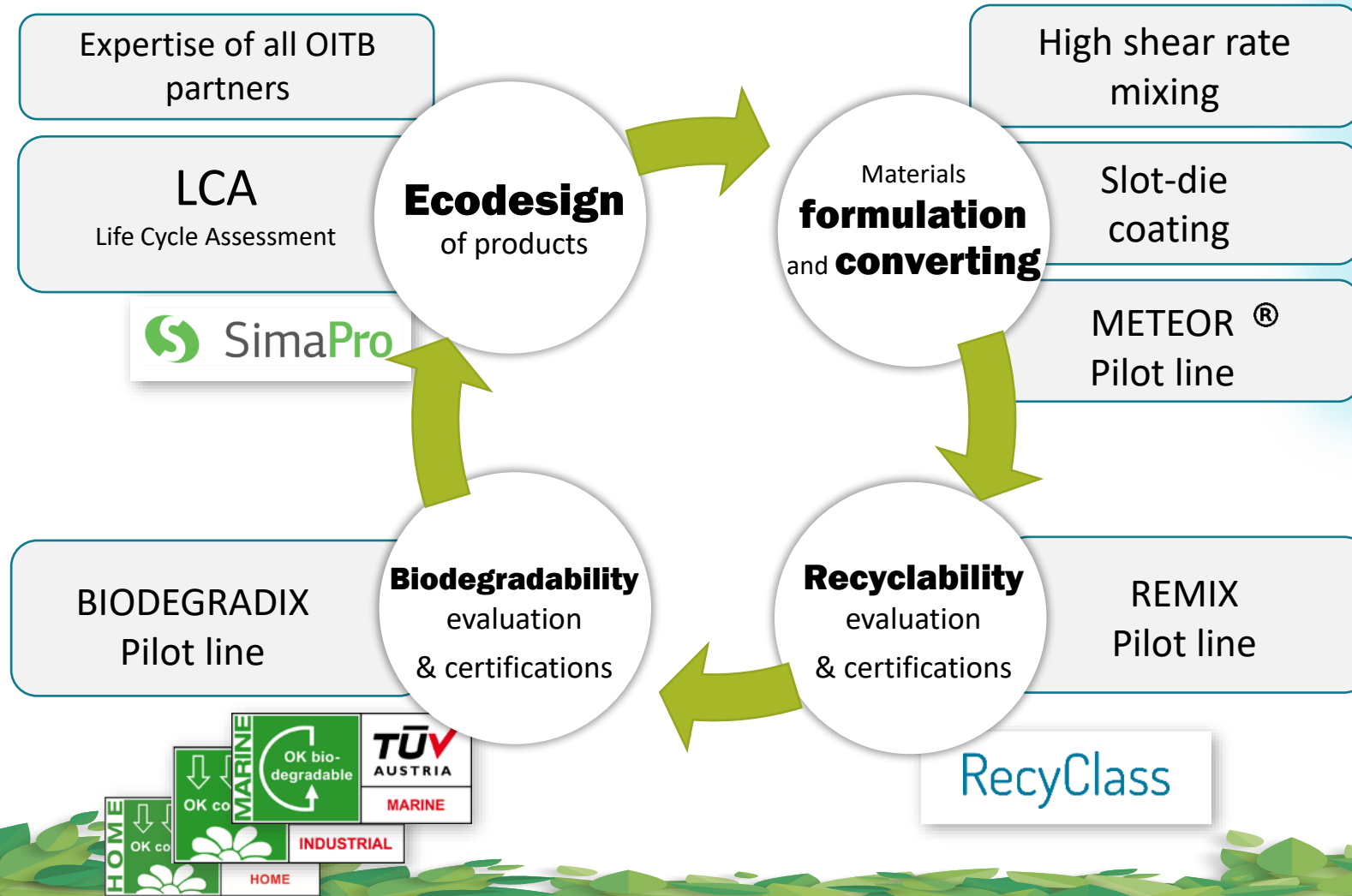
UC6



Sustainable
paper-based
food packaging

A full description of the six Use Cases can be found in the FlexFunction2Sustain Project Handbook, available at <https://flexfunction2sustain.eu>

“Circularity by design” concept & link with other FF2S services



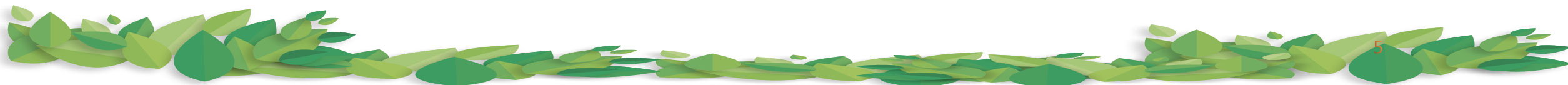
+ Functionalisation
(Lab-2-Fab facilities within the OITB)

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Eco-design supported by expertise

Expertise		
Functionalities	Technical specifications	Application examples
Design for Recycling flexible plastic and paper surfaces and membranes	<ul style="list-style-type: none"> - Expertise in food and pharma packaging, membrane-based filter systems, printed electronics, and more - Supporting customers at early development stages to minimize the risk of innovation in Eco-design - Design according to legislation and internationally recognized recycling protocols 	<p>Capri-Sun Use Case (UC5): Design of novel recyclable packaging materials for drink pouches</p> <p>P&G Use Case (UC2): Design of marine degradable shampoo sachets</p>

Application examples:
 Top: Capri-Sun drink pouch
 Bottom: P&G Marine degradable shampoo sachets



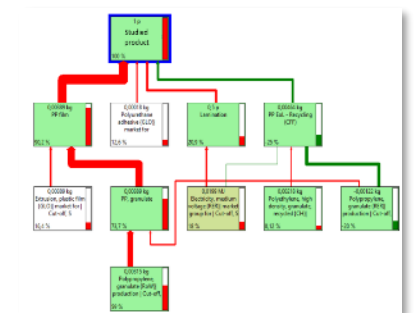
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Eco-design supported by Life Cycle Assessment

Life Cycle Assessment

Functionalities	Tools	Technical specifications	Application examples
Identification of environmental impacts	Life Cycle Inventory Sheets SimaPro Software Ecoinvent 3.0 database Product Environmental Footprint (PEF) GulPlug energy consumption measurement equipment	Cradle-to-gate studies Cradle-to-grave studies Cradle-to-cradle studies Screening LCA Continuous energy consumption measurements of up to 6 machines simultaneously	Comparative LCA between non-recyclable, recyclable, and biodegradable structures (UC1) Comparative LCA to identify the best End of Life scenario for an innovative product (UC3) Comparative LCA between commercial reference and 3 monomaterial structures to identify which replacement solution is the more environmentally friendly (UC5)

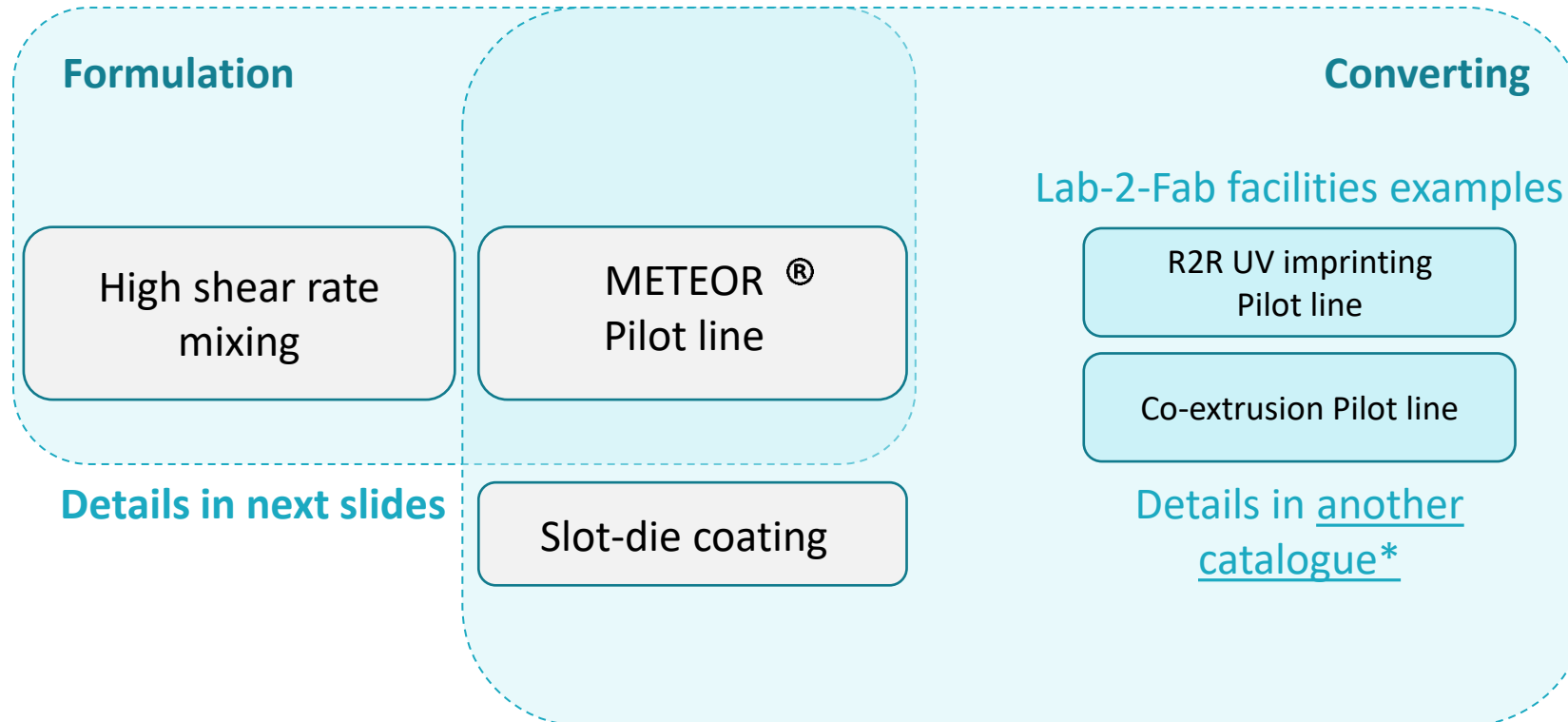
Lifecycle overview* from SimaPro Software



* Image available in a better resolution in the [Executive Summary](#) associated to this catalogue (link to be updated upon publication)

Executive summary and spec-sheets of facilities for circularity by design

Materials formulation and converting



*Link to be updated upon publication of the corresponding catalogue

Executive summary and spec-sheets of facilities for circularity by design

Processing facility for formulation & converting

Upgraded lines for coating preparation & processing

Functionalities	Equipment	Technical specifications	Application examples
High shear rate mixing	Planetary ball mill	Homogeneous dispersion formulations through high shear rate mixing for the development of high-barrier coating materials	Gas barrier layer development for the mono-material based laminate production for drink pouches (UC5) More details in the public deliverable D3.1
Slot die coating process	Roll-to-roll Coating and Lamination line	Pumping with a syringe pump or extender-screw pump. Pre-heating and degassing possibility in a pressure tank Coating Width: 300 mm	Gas barrier coating application for the mono-material based laminate production for drink pouches (UC5) More details in the public deliverable D3.1

Upgraded lines @IVV:
Top: High Shear Rate Mixing
Bottom: Slot die coating



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Processing facility for formulation & converting

Upgraded METEOR pilot line

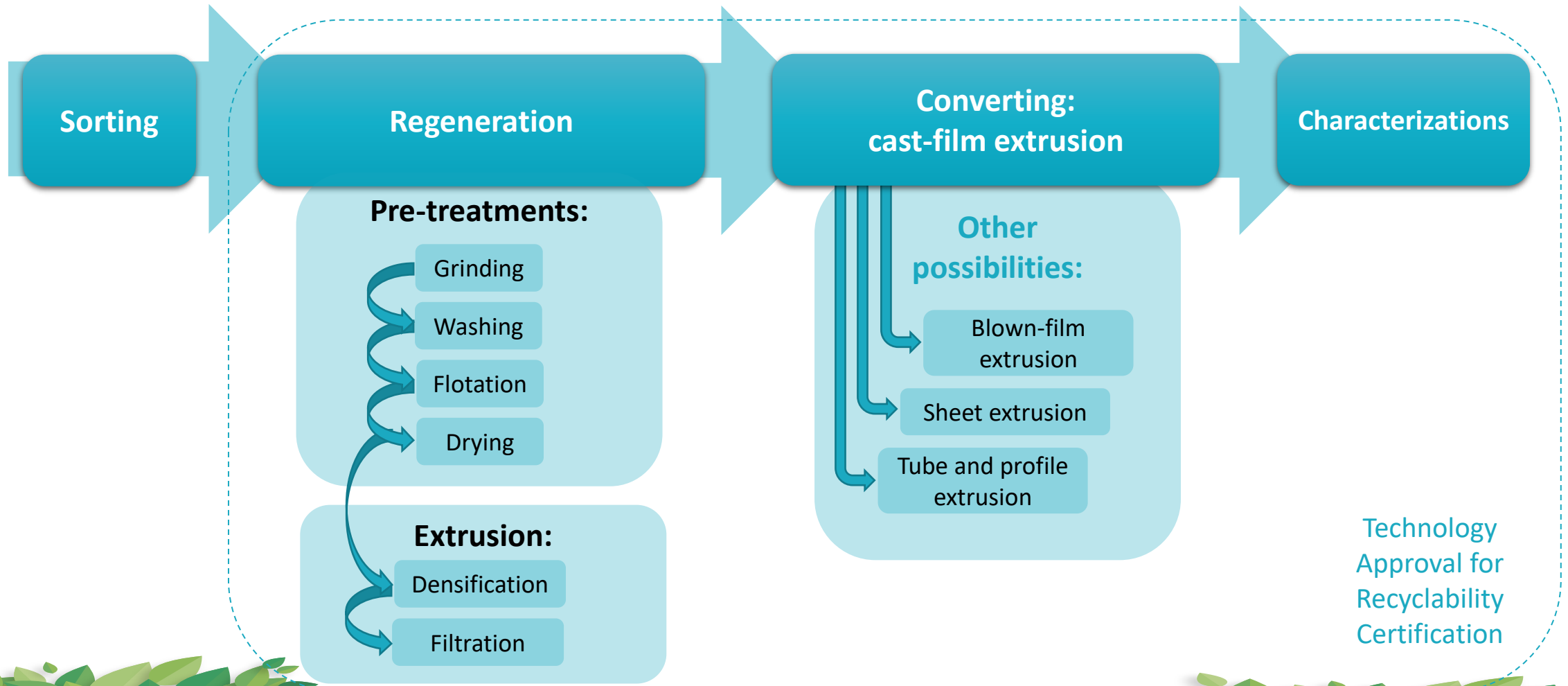
Functionalities	Equipment	Technical specifications	Application examples
Compounding & converting in one step	<p>METEOR® pilot line (patented)</p> <p>On-line rheometer</p> <p>Flat die</p> <p>Scamex cast line with take-off station</p>	<p>Compounding and specific material formulations development with an efficient dispersion of additives while reducing the thermo-mechanical degradation of the material</p> <ul style="list-style-type: none"> - Film coextrusion - High temperatures, up to 300°C, - Compounding process throughput range: from just a few kg/h up to 100 kg/h - Line speed: 0 to 35 m/min - Films thickness range: 25 to 250 µm - Films width: 300 to 330 mm 	<p>Compounding PLA with crosslinking additives in order to improve its thermal stability (UC1)</p>

METEOR equipped with the cast line @IPC



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Recyclability evaluation – REMIX pilot line



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Recyclability evaluation – REMIX pilot line

Upgraded sorting evaluation

Functionalities	Equipment	Technical specifications	Application examples
Optical sorting	Mistral+ Connect DVI 1200 - Pellenc ST equipped with a high-resolution sorting bar	Near Infra-Red and visible spectra detection Assessment of sortability with static and dynamic tests - Samples: films or rigid materials, 20mm to 350mm, max 10kg/m ² - Maximal flow rate: 1 to 3t/h, depending on samples area density	Verification of compatibility with existing sorting technologies for recyclable innovative packaging (UC5)

Mistral+ Connect DVI 1200 sorting machine (Pellenc ST) @ IPC



Executive summary and spec-sheets of facilities for circularity by design

Recyclability evaluation – REMIX pilot line

Pre-treatments			
Functionalities	Equipment	Technical specifications	Application examples
Grinding	Shredder Alterval MR17-40	Size reduction, especially for films - 3 grid sizes: 10, 20 and 30 mm - Maximum flow rate: 150 kg/h	Recyclability evaluation with existing technologies for innovative packaging (UC5)
Washing	Sorema washing pilot line	- Tank capacity: 20 L - Vibrating sieve & cyclone drying	
Sink-float separation	Auger dynamic flotation pilot line	Sinking and floating fractions recovery - Vibrating feeding - Tank capacity: 4.4 m ³ - 5 successive mixing rollers	

Pre-treatment equipment:

Top: shredder

Middle: washing pilot line

Bottom: flotation pilot line



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Recyclability evaluation – REMIX pilot line

Extrusion & Converting

Functionalities	Equipment	Technical specifications	Application examples
Thermomodensification	Wanner thermogranulator	Transforms ground films into pellets to enable their processing through further standard techniques - Max temperature: 400 °C - Max flow rate: 20 kg/h	Recyclability evaluation with existing technologies for innovative packaging (UC5)
Extrusion - Filtration	Clextral extruder EVOLUM 32 HT Filtering system Maag HSC-050	- Max temperature: 400 °C - Max screw rotation speed: 800 rpm - Max flow rate: 100kg/h - Filtration area \varnothing 50 mm - Filters fineness: 105 μ m, 150 μ m, 300 μ m, 500 μ m (other sizes on demand)	
Converting: cast-film extrusion	Flat die Scamex cast line with take-off station	- Max temperature: 300 °C - Line speed: 0 to 35 m/min - Films thickness range: 25 to 250 μ m - Films width: 300 to 330 mm	

Extrusion equipment:
Top: Thermogranulator
Bottom: Filtering system



Executive summary and spec-sheets of facilities for circularity by design

Recyclability evaluation – REMIX pilot line

Characterisations of recycled pellets

Analysis	Equipment	Technical specifications	Application examples
Bulk Density	- Apparatus for the determination of bulk density - 2000 ml.	According to ISO 15344	Evaluation of the recyclates quality to support their recyclability evaluation with existing technologies for innovative packaging (UC5)
Density	- Precision scale METTLER TOLEDO AE240 ; - Accessories for density measurement.	According to ISO 1183-1	
Melt Index	- Melt Flow Indexer GOTTFERT Mi-40 ; - Capillary die, length 8 mm and diameter \approx 2.1 mm ; - Precision scale METTLER TOLEDO AE200 ; - Ventilated oven HERAEUS UT 6060.	According to ISO 1133	
Ash content	- Muffle furnace NABERTHERM ; - Precision scale METTLER TOLEDO AE200	According to ISO 3451-1	
Differential Scanning Calorimetry	- DSC calorimeter Q100 TA Instruments ; - Indium reference standard ; - Plomb reference standard ; - Precision scale METTLER TOLEDO AE240.	According to ISO 11357-3	

Differential scanning calorimetry (DSC) @IPC



Executive summary and spec-sheets of facilities for circularity by design

Recyclability evaluation – REMIX pilot line

Characterisations of recycled pellets & films

Analysis	Equipment	Technical specifications	Application examples
Volatiles	<ul style="list-style-type: none"> - Ventilated oven HERAEUS UT 6060 ; - Precision scale METTLER TOLEDO AE200 ; - Timer NOVO 82110. 		Evaluation of the recyclates quality to support their recyclability evaluation with existing technologies for innovative packaging (UC5)
Colorimetry	<ul style="list-style-type: none"> - Spectro guide BYK Gardner. 	L*,a*,b* measures	
Thickness	<ul style="list-style-type: none"> - Heidenhain thickness gauge. 	According to ISO 4593	
Tear Strength	<ul style="list-style-type: none"> - Zwick/Roell BT2-FR005TH.A50 	According to EN ISO 6383-1	
Tensile properties	<ul style="list-style-type: none"> - Dynamometer ZWICK 1.0 ; - 1 kN sensor ; - Thermo-hygrometer TESTO TERM 6010 ; - Digital micrometer 25 mm; 	According to ISO 527-3	
Dart Impact	<ul style="list-style-type: none"> - Dart Tester 	According to ISO 7765-1	
Gels and Specks	<ul style="list-style-type: none"> - Microscope VHX-7100 KEYENCE. 		

Dart Tester @IPC



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Recyclability evaluation – REMIX pilot line

Certification possibilities (Recyclclass)

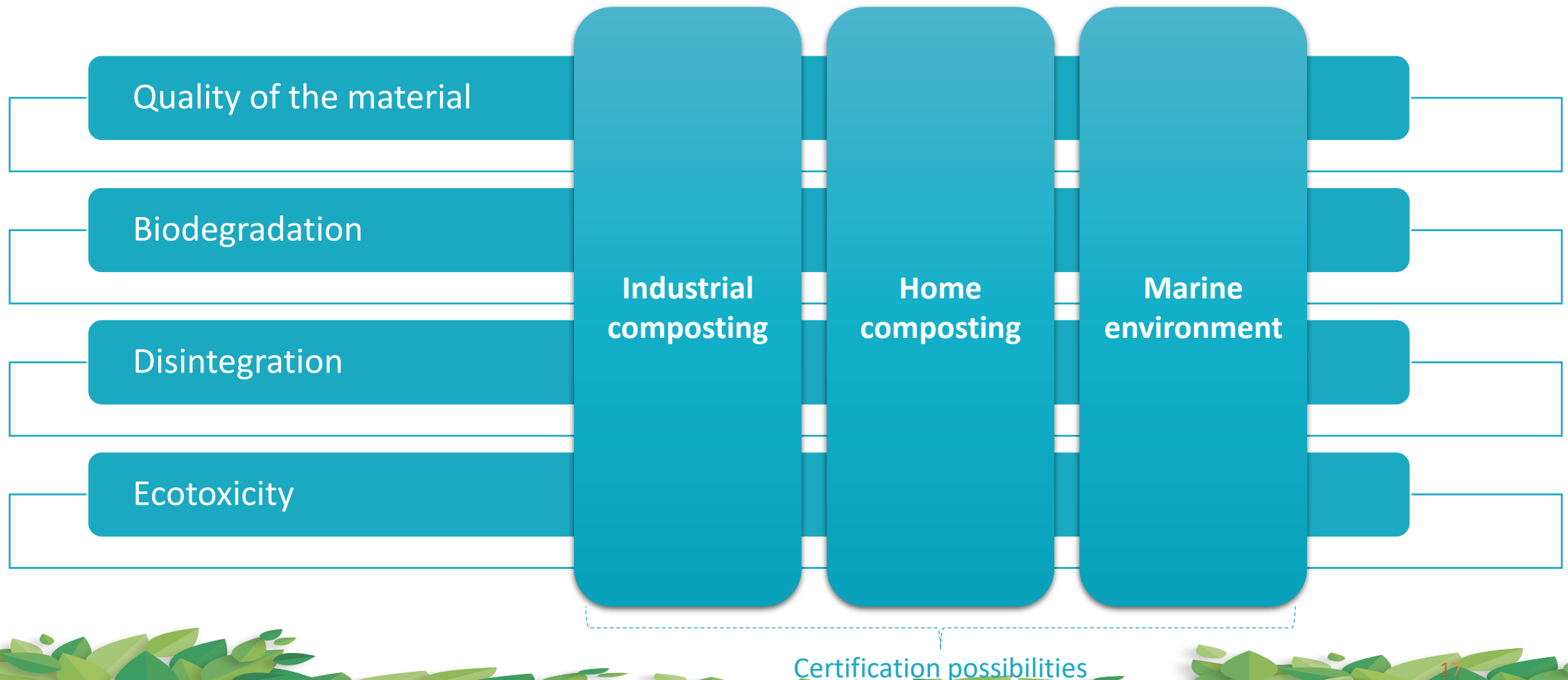
Name	Technical specifications
Technology Approval	<ul style="list-style-type: none"> - Packaging not entirely covered by Recyclclass' Design for Recycling guidelines - The packaging will follow the Recyclability Evaluation Protocol for PP Films (also available for PE) - Input: 10 kg of innovative packaging & 25 kg of control film
Design for Recycling Certification	<ul style="list-style-type: none"> - Packaging entirely covered by Recyclclass' Design for Recycling guidelines - The technical recyclability of the packaging will be audited for the EU market, based on the existence of a recycling stream and the packaging's structure.
Recyclability Rate Certification	<ul style="list-style-type: none"> - Packaging entirely covered by Recyclclass' Design for Recycling guidelines - The effective recyclability of the packaging will be audited for the specific geographical area of the certification body, based on the existence of a recycling stream and the packaging's structure.
Letter of Compatibility	<ul style="list-style-type: none"> - Semi-finished packaging - The semi-finished packaging will be audited, based on the existence of a recycling stream and the packaging's structure.

Example of Recyclclass logo for a recyclable packaging



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Biodegradability evaluation – BIODEGRADIX pilot line



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Biodegradability evaluation – BIODEGRADIX pilot line

Biodegradation monitoring

Functionalities	Equipment	Technical specifications	Application examples
Biodegradability evaluation in industrial compost conditions	36 channels ECHO Respiriometer	Samples: 3x 100 g (powder) Temperature: 58 °C Duration: up to 6 months	Biodegradation of samples: screening for the selection of a formulation (UC1)
Biodegradability evaluation in home compost conditions	12 channels ECHO Respiriometer	Samples: 3x 100 g (powder) Temperature: 25 °C Duration: up to 12 months	Biodegradation evaluation of the raw material (UC6)
Biodegradability evaluation in marine environment	12 channels ECHO Respiriometer	Samples: 3x ≈200 mg (depends on the carbon content) (powder) Temperature: 30 °C Duration: up to 6 months	Biodegradation of samples (UC2)

12-channel respirometers
Left: for home compost
Right: for marine conditions



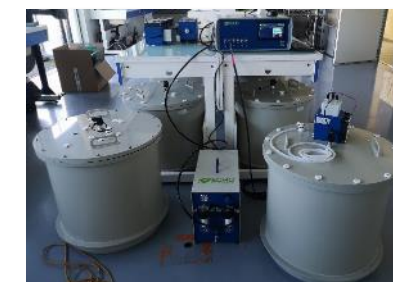
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Biodegradability evaluation – BIODEGRADIX pilot line

Disintegration evaluation

Functionalities	Equipment	Technical specifications	Application examples
Lab-scale disintegration evaluation in industrial compost conditions	Heat chamber Reversal film frames Incubators	Samples: 700 cm ² (2-3 A4 sheets)(film) Temperature: 58 °C for 90 days, then 25 °C Duration: up to 6 months	Disintegration of samples: study of the impact of crosslinking on PLA disintegration (UC1)
Lab-scale disintegration evaluation in home compost conditions	Heat chamber Reversal film frames Incubators	Samples: 700 cm ² (2-3 A4 sheets)(film) Temperature: between 20 °C and 30 °C Duration: up to 6 months	Disintegration of samples: identification of the impact of a coating on a paper (UC6)
Pilot-scale disintegration evaluation in composting conditions (valid for both industrial and home compost)	6 thermally insulated tanks	Samples: 10 kg (final form) Self-heating Duration: 3 to 6 months	Disintegration of samples: evaluation of their behaviour upon self-heating composting process
Disintegration evaluation in marine environment	Heat chamber	Samples 3x 2x2 cm (and at least 3 g) Temperature: 30 °C Duration: up to 84 days	Disintegration of samples: screening for the selection of a formulation (UC2)

Thermally insulated tanks for pilot-scale disintegration in composting conditions



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Biodegradability evaluation – BIODEGRADIX pilot line

Ecotoxicity evaluation			
Functionalities	Equipment	Technical specifications	Application examples
Ecotoxicity evaluation in compost conditions (valid for both industrial and home compost)	Heat chamber Lights	Samples from pilot-scale disintegration (see previous slide) Duration: 21 days after 50% of seedling emergence	Ecotoxicity evaluation of samples' degradation products
Ecotoxicity evaluation in fresh water environment (as used in marine environment certification)	<i>Daphnia Magna</i> (planktonic crustacean)	Samples 3x 2x2 cm (and at least 3 g) Duration: 3 to 6 months incubation + 48 h	Ecotoxicity evaluation of samples's degradation products in the aquatic environment, screening for the selection of a formulation (UC2)

Organisms studied for the ecotoxicity tests:
Top: wheat plants,
Bottom: *Daphnia Magna*



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Biodegradability evaluation – BIODEGRADIX pilot line

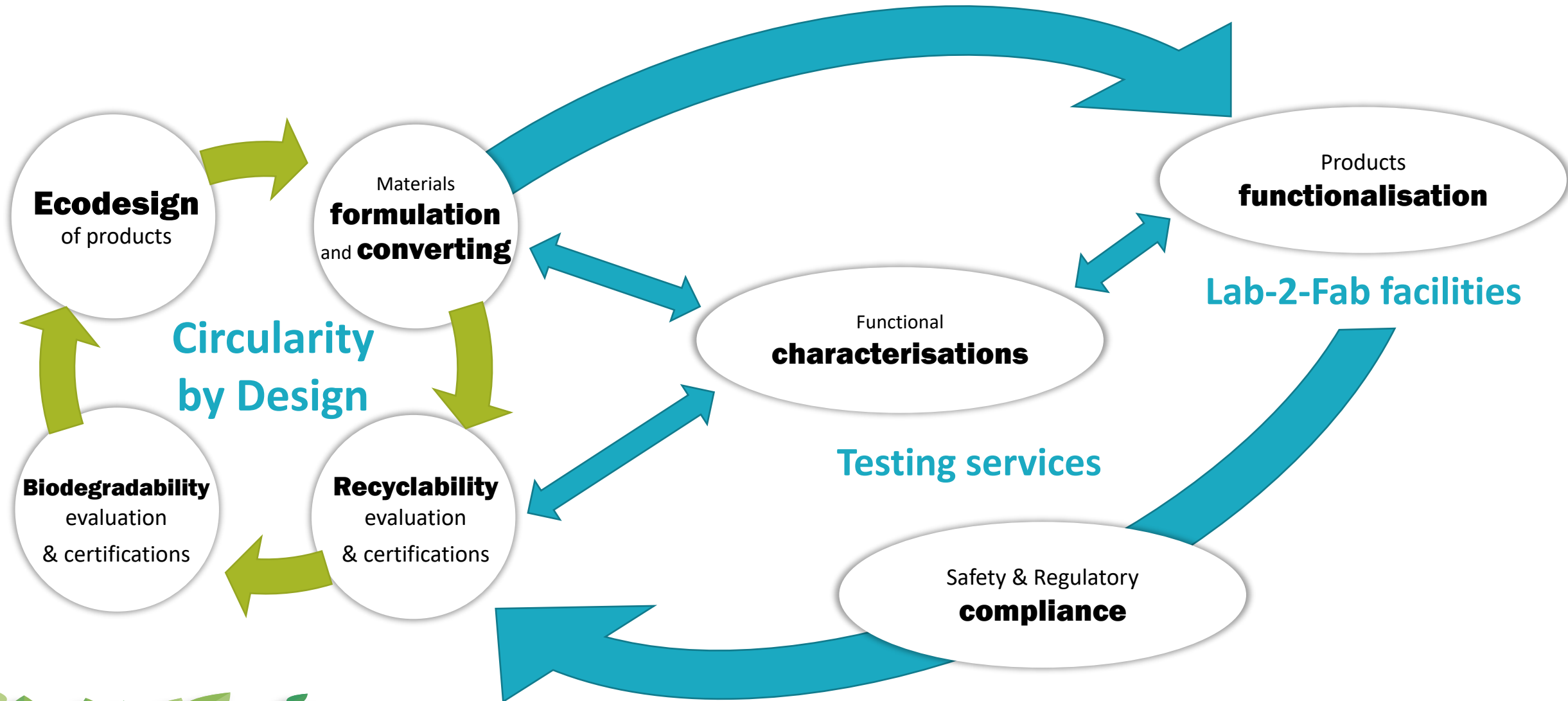
Certification possibilities

Name & Standard	Requirements
OK compost INDUSTRIAL (EN 13432)	<ul style="list-style-type: none"> - Heavy metals: nontoxic and non-included in REACH's list - Infra-red analysis, total organic carbon analysis - Biodegradation: 90% in 6 months - Disintegration: 90% in 6 months - Ecotoxicity: non-toxic on 2 plant species
OK compost HOME (NF-T 51800)	<ul style="list-style-type: none"> - Heavy metals: nontoxic and non-included in REACH's list - Infra-red analysis, total organic carbon analysis - Biodegradation: 90% in 12 months - Disintegration: 90% in 6 months - Ecotoxicity: non-toxic on 2 plant species
OK biodegradable MARINE (ASTM D6691)	<ul style="list-style-type: none"> - Heavy metals: nontoxic and non-included in REACH's list - Infra-red analysis, total organic carbon analysis - Biodegradation: 90% in 6 months - Disintegration: 90% in 6 months - Ecotoxicity: 90% of survival of <i>Daphnia magna</i>

Logos of TÜV Austria for the aimed certifications



Interconnection between all the OITB services



Interconnection between all the OITB services

Link with the other FlexFunction2Sustain services		
Lines	Technical specifications	References to other catalogues
Lab-2-Fab facilities for nanofunctionalisation plastic and paper surfaces and membranes	<ul style="list-style-type: none"> - Vacuum coating processes for nano-surface modification - Atmospheric pressure processes for film extrusion, coatings and lamination - Nano-structuring of surfaces - Smart functionality: printed electronics 	See Executive summary and full list of collected facility specifications*
Functional characterisations	<ul style="list-style-type: none"> - Gas barrier testing - Testing of electrochemical properties - Assessment of mechanical properties, integrity, and durability - Optical properties characterisation - Surface and microstructure analysis - Thermal and rheological properties - Test specimen preparation 	See Catalogue of physiochemical and functional characterisation services
Food compliance test facilities and health safety testing facilities	<ul style="list-style-type: none"> - Migration testing and safety assessment - Microbiological safety assessment - Off-Flavours testing - Analysis of Volatile Organic Compounds (VOCs) - Nano-material safety and risk assessment - Advice on Regulatory Compliance 	See Catalogue for services for safety and regulatory compliance testing*

*Links to be updated upon publication of the corresponding catalogues

An example customer project

Do you want a recyclable food packaging? Here's how to:



• Definition of product specifications (SEP, INL, FHG-IVV, customer)

• Film Extrusion (FHG-IVV or IPC)

• Gas Barrier Coating Tests (FHG-FEP | FHG-IVV | AMCOR)

• Lamination (FHG-IVV | AMCOR)

• Food contact verification (INL)

• Recyclability test (IPC)

• Piloting | Yield and quality verification | cost assessment (AMCOR & Co.)