BIOSMART PROJECT

BRUSSELS | **6-7/12/2017**

Bio-based smart packaging for enhanced preservation of food quality.

BIOSMART
BIOMATERIALS FOR SMART FOOD PACKAGING

This project has received funding from European Union´s Horizon 2020 research and innovation programme under grant agreement nº 745762

BIO-BASED INDUSTRIES
Public-Private Partnership

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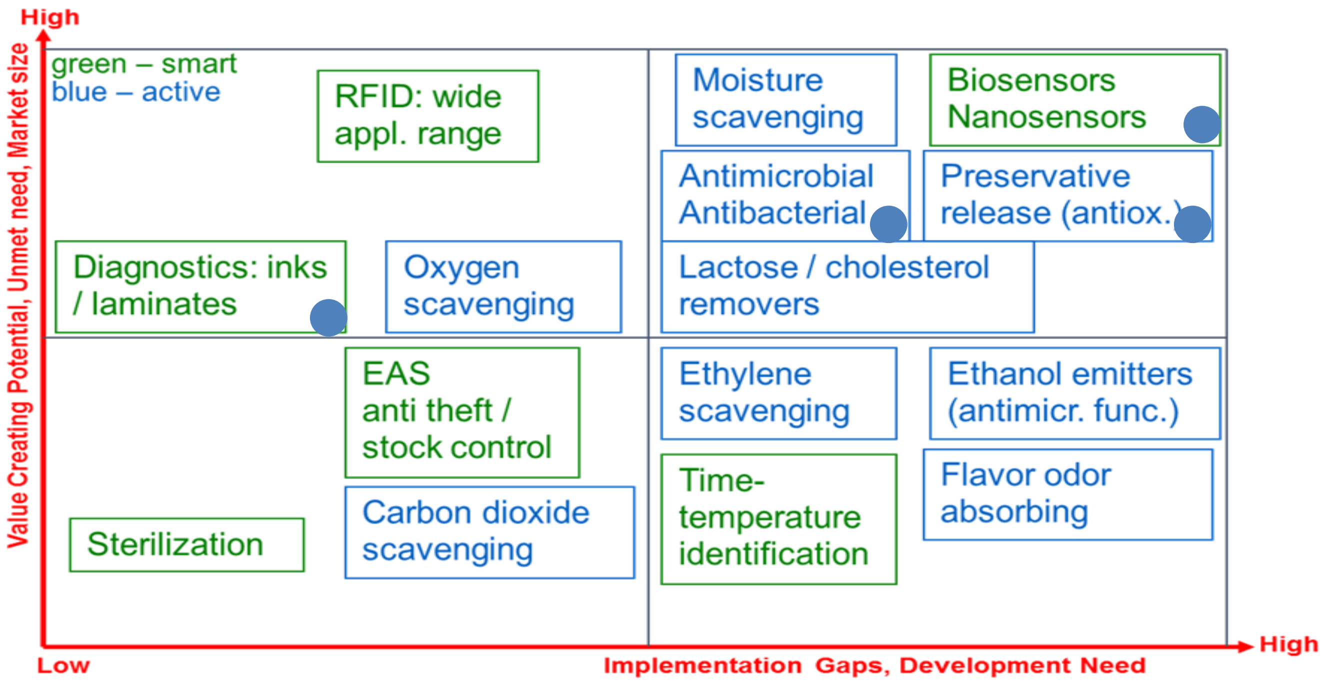
The Packaging Challenges

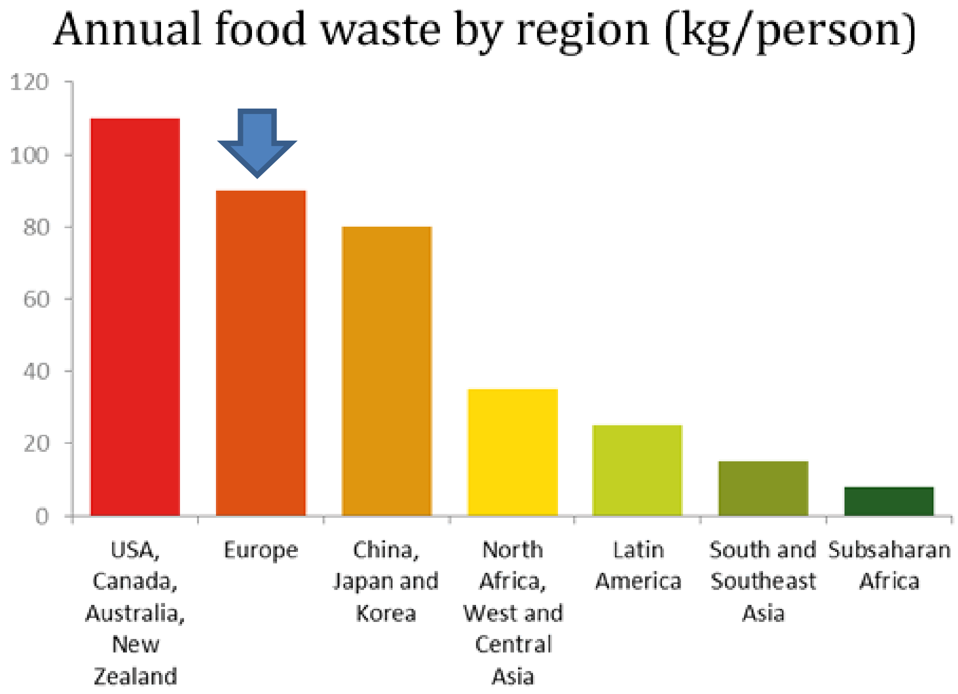
Key Performance Topic	Requirements	Specifics
Food quality	• Enhance **sensory** properties • **Food grade** approved **antimicrobials**	• **Smell,** Color, .. • Avoid **unwanted micro-organism growth** (bacteria, fungi, yeasts) – additional pasteurization and sterilization is possible but adds cost
Manufacturing	• Simple, **economic packaging processing** • Filling compatibility	• Adequate **properties** (sensory, mechanical, barrier) • **Durability** (scratch, ageing, abrasion, impact, tribobioageing) • **Compatibility** with existing machines, run-ability, dimensional stability, sealing- ability.
Logistical	• Ease transportation	• Conform requirements of **bulk packaging & coding**
Marketing	• Point of sale appeal • **Consumer comfort**	• Aesthetically pleasant, conform to customer appeal, **easy handling** and **functionality**
Environmental	• **Human safety** ensured • Minimize resource's use • Facilitate **waste** management	• Food contact **safety,** not causing physical harm • Biodegradability, **non-eco-toxic** • **Positive LCA** (low carbon foot print) • **Recoverable**, re-processable, **compostable**
Legislative	• EU and National **laws**	• Meet all criteria
Financial	• Cost effective	• **Acceptable price** in relation to consumer value

The Funtionality Needs



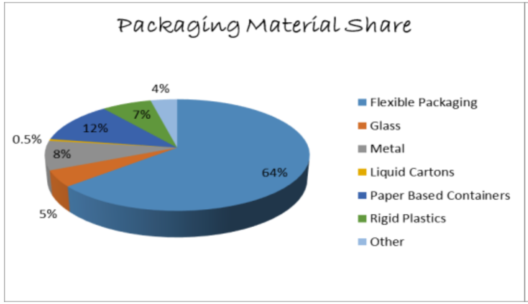
Active and smart functionality needs for food packages in relation to the value creating potential

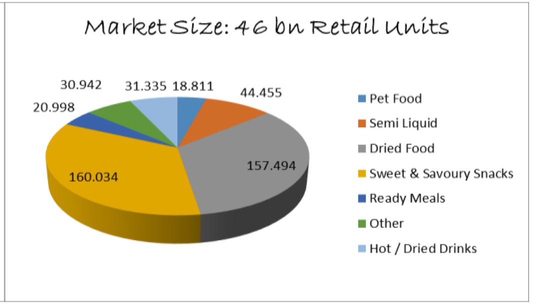
The food waste reduction needs



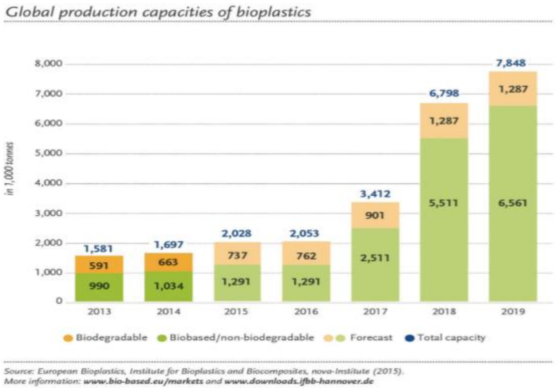
Multiple studies by **various organizations** (e.g. Natural Resources Defence Council, NRDC) indicate that **society is wasting up to 40% of the produced food…**

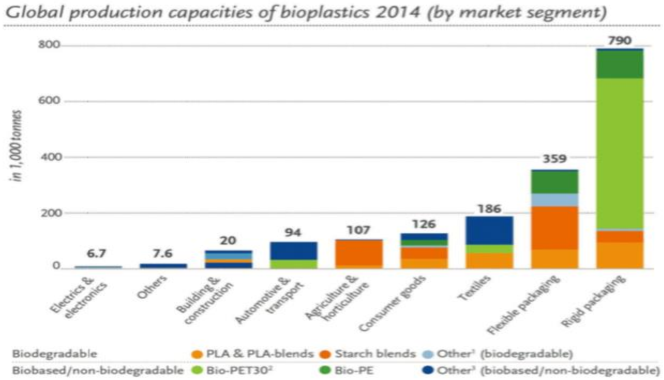
The Market size





*Representative example of the **processed food market** consisting of more than **46 billion retail units** representing **3.1 million tonnes** of plastics use in 2014 (http://www.crugroup.com)*



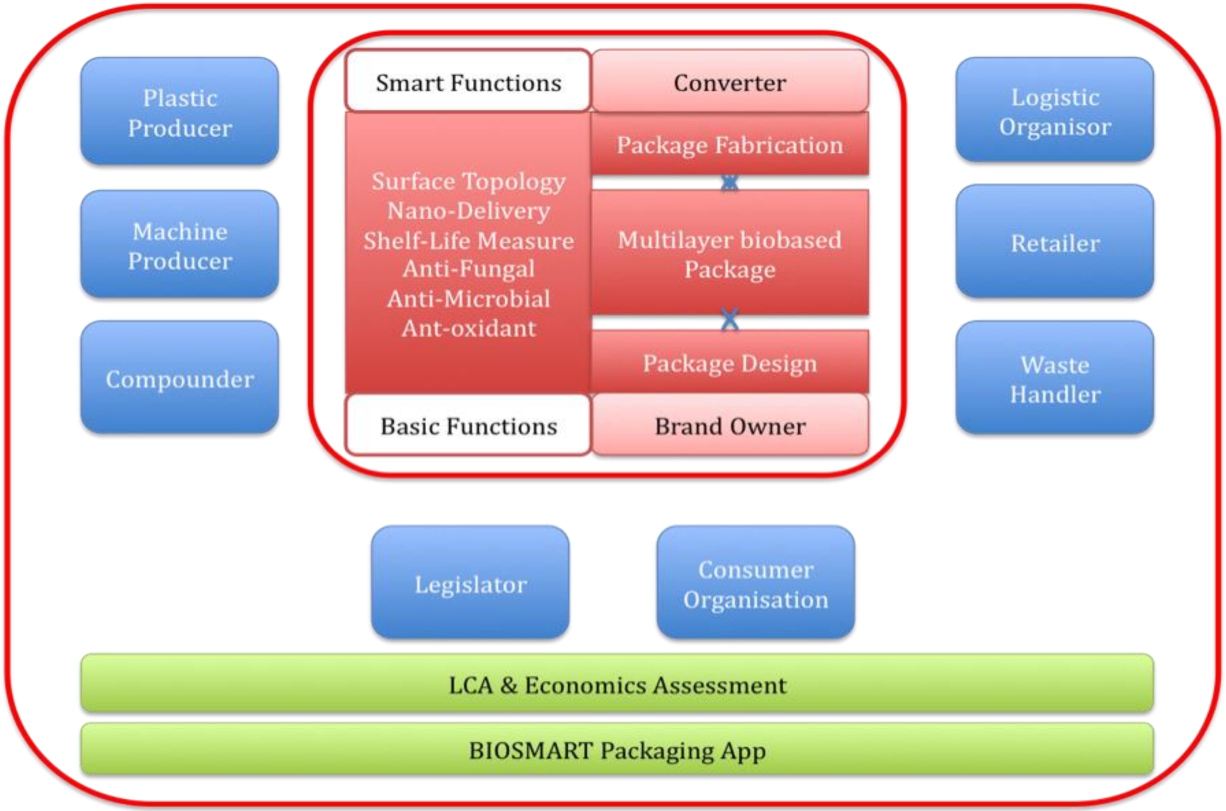


*Global production capacity of **"bioplastics"** by market segments (showing importance of rigid and flexible packaging). Data (2014, **1,7MT)** are projected forward with a significant growth capacity (http://bio-based.eu)*

The Concept


Resin Manufacturer
Converter
Extrusion/Lamination/
Slitting/Printing
Recycling or EOL
OEM
Consumer
Brand Owner
Food Production and Packing
Toll Packer
Food Toller
Retail
McCain
Curvers
Fruit Slices

The structure



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The Project partners & roles

Nº	Name	Acronym	Country	Role
10 8 6	WIPAK PROPAGROUP ITENE	WIP PRO ITENE	DE IT ES	**Packaging developers:** Flexible Films (WIPAK, Propagroup), rigid packaging (Propagroup, WIPAK, GEA), Paper (WIPAK, ITENE)
5 6	Haute Ecole Suisse ITENE	FRI ITE	CH ES	**Biobased polymers** composites developers
4	Univ. Lille, Lipofabrik Univ. Reading	LILLE LIPFK UoR	FR FR UK	**Antimicrobial and Antioxidant peptides and lipopeptides** developers. Food grade approval tests. Freshness test to evaluate food durability.
1 6 5	IK4-TEKNIKER ITENE Haute Ecole Suisse	ITE	ES ES CH	Developers of **antimicrobial films by texturing** and packaging with thermoregulation properties, **biobased barrier properties** (O_2, CO_2, H_2O) by copolymers, solgel and plasma fixation of lipopeptides. Testing, mechanical, optical (printability), durability and haptical (feel and handling ease properties)
7	RISE (INNVENTIA, SP)	INN	SE	Define **possible scenarios** to develop and use the optical active and funcional packages, consumer acceptance, food sensory analysis, recyclability vs compostability.
8 11	TECS GEA	TECS	AT	Development of active **sensors with O_2, CO_2 and amines detection and integration**
1 4	IK4-TEKNIKER Haute Ecole Suisse	TEK FRI	ES CH	Coordination. Assess the **environmental and cost acceptability of the added functionality in comparison to current solutions**

The Interest Group

Company/ Function/Country	Expertise and Role in the Interest Group
Eroski/ Retailer (ES)	**Consumer perspective**, logistic, dissemination. Requirements and **definition of the case studies.** Monitoring of **project results**, **Food provision & Validation tests.**
Natureworks /PLA supplier/ (IT)	Assuring communication flow with converters to facilitate market transfer providing documentation and **technical assistance**
General Mills (ES)	Food packaging **Brandowner** of different trademarks
Unilever/Brand Owner (UK)	Food packaging **Brandowner** of different trademarks

The Objectives

- Development and scale up (TRL3-5) of **active and smart functional bio-based (non-fossil fuel) packages:**
  - Multi-layer films with **bio-based barrier coatings** based on **segmented block copolymers and PLA nanoclays** (reduced O_2, CO_2, H_2O permeability), as alternatives for aluminium, glass, polyvinylalcohol and polyamides barriers.
  - **Superhydrophobic and antimicrobial flexible surface** nano-micro topographies through **physical embossing** and/or **sol-gel technologies.**
  - Nano-bio-based active **micro-encapsulation for thermoregulation.**
  - **Bio-based** antioxidant, antifungal and **antimicrobial systems** based on lipopeptides & food derived peptides
  - **Food quality sensors** detection of gases(O_2, CO_2, NH_x) imprinted in the packages **to monitor food shell life** status

- To **improve mechanical properties** of the PLA, developing **nanoclay composites and copolymers analyzing tribobioageing**.
- Implementation of a single or multiple active and smart technologies into **3 food package** demonstrators at acceptable costs
- Reduce the **environmental impact of the value chain** through novel material selection, package designs, recycling methodologies, **extended shelf life** and **controlled product quality.**
- Develop bio-based materials and a **functionality selector App(lication)** for defining an all-bio-based active and smart packaging solutions in relation to the performance and commercial needs.

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Approach

Pre-processed food	Fresh food
Ingredients: Food Approval	
Material Testing: Easy to recycle	**Material Testing: Compostability**
Functionality testing: antimicrobial properties, Barrier properties, sensors, Migration tests	
Package Testing: improved antimicrobial and barrier properties of biobased easy to recycle solutions & **migration tests**	**Package Testing: increase mechanical performance of actual compostable package** solutions. **Packaging Food Approval**
Preprocessed Food Testing: sensory analysis, food freshness (biochemical & microbiology tests), **sensors** applied to ham, tomato	**Fresh Food Testing:** sensory analysis, **food freshness** (biochemical and microbiology tests), **sensors**, applied to fish..
Environmental and cost impact: LCA , App Biosmart	
Packaging: Rigid (thermoformed, injected) and flexible films	Packaging: Rigid (cellulose bags) and Flexible (films)
Outcome: Increase the **food shelf life** measuring the **food freshness, sensory analysis.**	Outcome: To increase fresh **food shelf life**:, **gas monitoring** (CO_2, O_2, NHx), food freshness, sensory analysis.

Converters: Wipak, PRO - Access to the market

Brand owners: Unilever, GENERAL MILLS, Eroski- Application driven market introduction

Eroski Retailer, validating food testing, Consumer demand

Impact on retailer, consumer & society: to avoid food waste, increasing food shelf life, due date, and reduce waste

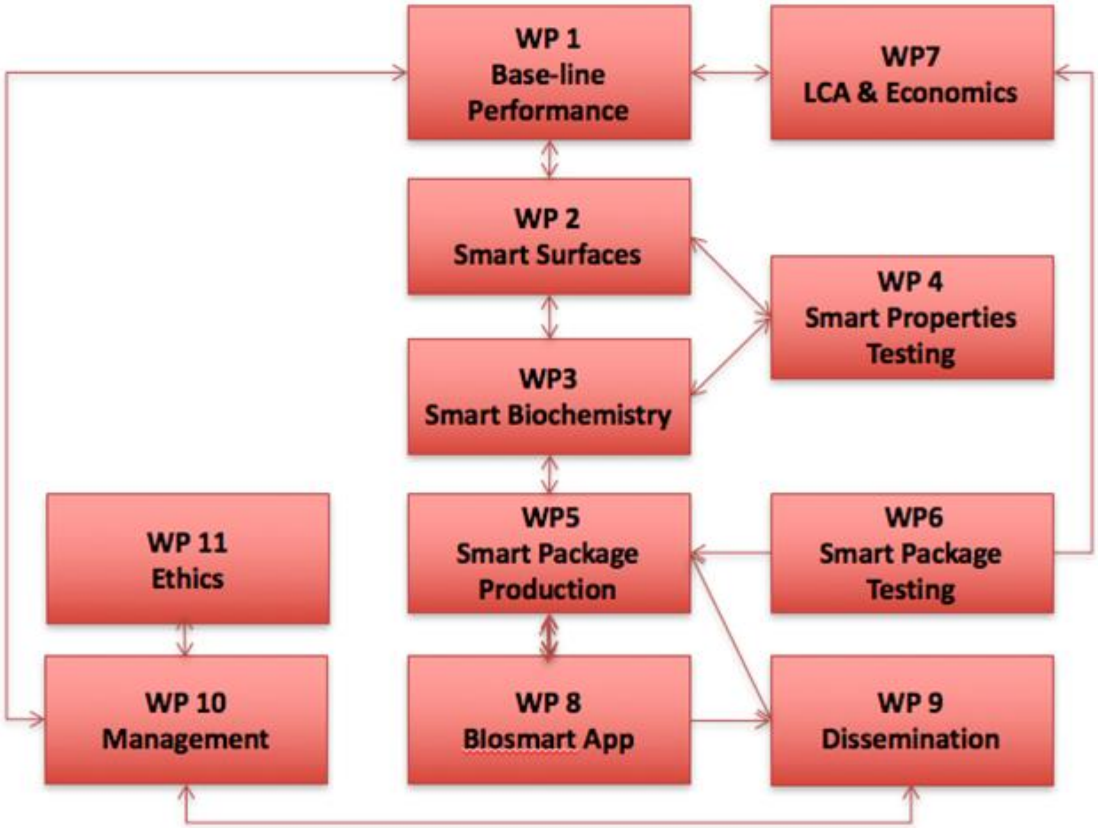
Consumer Acceptance tests : psychological aspects from consumer perspective

Impact to the consumer: The consumer is pleased with better food quality, freshness, sensory test, sensors

Impact for recycling: BioPEF is easy to recycle, similar to current PET. For the short term an acceptable alternative together with actual PET and PP without the need for organizing a separate collection system.

Impact for composting: PLA, PLA composites and Block copolymers are compostable

The Implementation



The BIOSMART Surfaces (WP2)

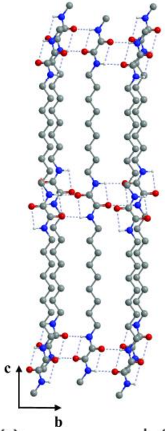
1.- Biobased composite
✓PLA/Polyamide block copolymers and PLA Nanoclays with barrier properties

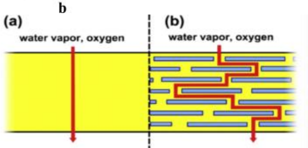
2.- Textured surface
✓R2R transferred Surface topography with antimicrobial properties

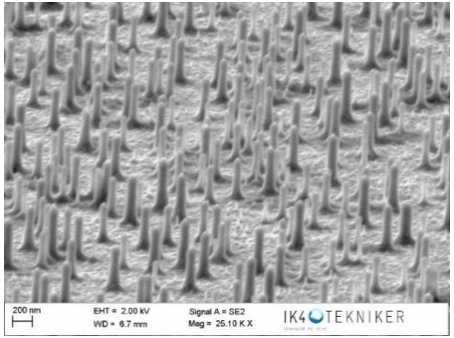
3.-Coating
✓Solgel Superhydrophobic & UV protection barrier coating

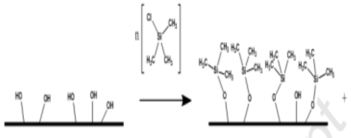
4.-Coating
✓Plasma assisted peptides (functionalization with antimicrobial properties

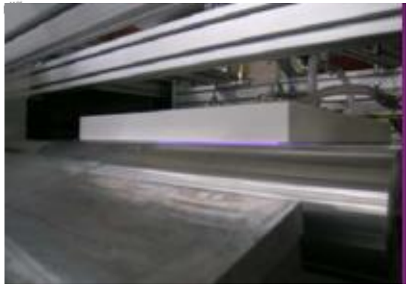
5.-Printed sensors
✓Plasma assisted peptides functionalization with antimicrobial properties

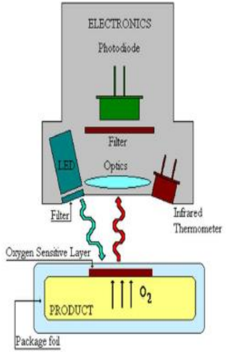


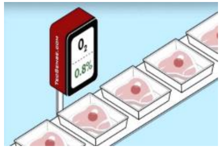












Haute Suisse, ITENE

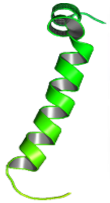
IK4-TEKNIKER

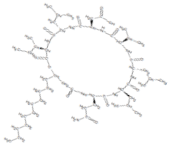
Haute Suisse, LPFB

TECSENSE, GEA

The SMART BIOchemistry (WP3)

A.- Peptides & Lipopetides
✓With antimicrobial and antioxidant properties produced by enzymatic hydrolysis or fermentation

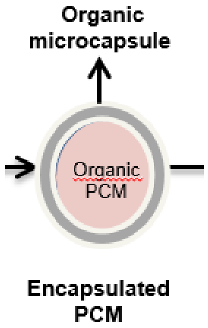




Lille, UoR, LPFB

B.- Encapsulation of biobased (vegetale oils) acting as phase change materials
✓For thermal regulation

Coacervation phase separation process
Precursor ratio
PCM/precursor ratio
pH
Reaction time
Temperature
Capsule size



IK4-TEKNIKER

C.- Biobased masterbatches
✓High durability masterbatches solutions

Composites

Blends, coatings

ITENE

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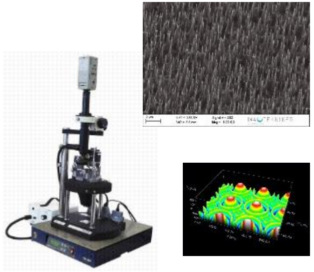
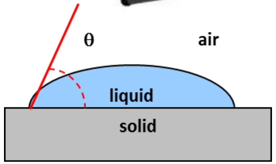
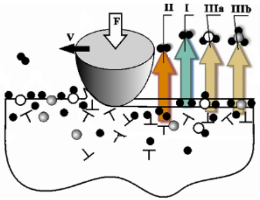
The BIOSMART Testing (WP4)

1.- Surface topography
- ✓Antimicrobial properties ISO 22196:2011





2.- Thermoregulation
- ✓DSC/Thermocalorimetry, outgasing, tribodesorption



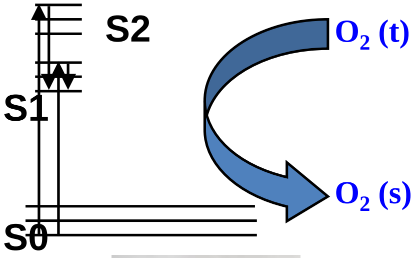
IK4-TEKNIKER

3.- Barrier Properties
- ✓O_2, CO_2, water

ITENE

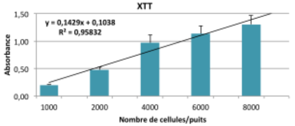
4.- Testing sensors
- ✓O_2, CO_2, volátil amines

Presence of oxygen, amines – fluorescence:



TECSENSE, GEA

5.- Food Approval tests
- ✓Migration tests
- ✓Citotoxicity



LILLE

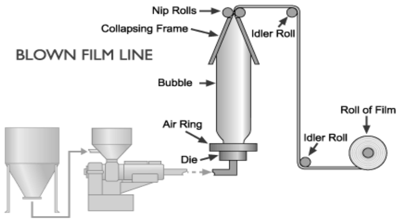
The BIOSMART Packaging (WP5)

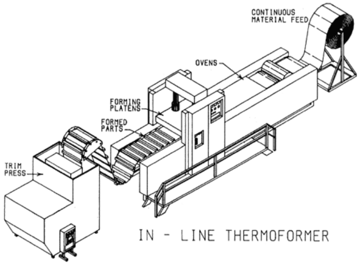
1.- Films
- ✓Blown film line
- ✓Blow extruder

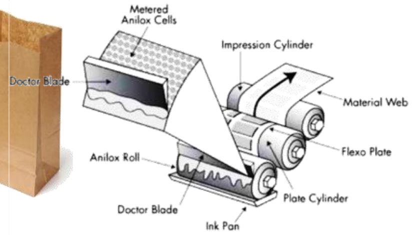
2.- Trays
- ✓Thermoformed packaging

3.- Paper bags
- ✓Paper converting
- ✓Coating machines (Bar, flexo-gravure)

4.- Printing sensor spots O_2, CO_2, volátil amines







PROPAGROUP, WIPAK

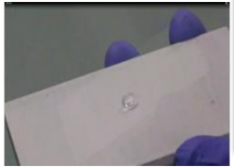
PROPAGROUP, HAUTE Suisse

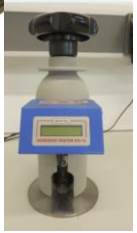
PROPAGROUP, ITENE

TECSENSE, GEA

The BIOSMART Packaging Testing (WP6)

1.- Wettability
- ✓Contact angle
- ✓Surface energy





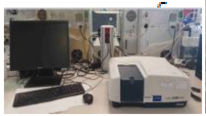
2.- Physico-chemical properties
- ✓Hardness, adherence
- ✓Mechanical properties
- ✓Colour reflectance
- ✓Scratch resistance


3.- Climatic chambers
- ✓TºC, Humidity, UV ageing
- ✓Surface energy
- ✓Tribodesorption
- ✓Friction, outgasing


IK4-TEKNIKER, polymeric base

4.- Permeability and Food grade approval
- ✓Water transmission rate
- ✓Migration tests
- ✓Specific migration tests





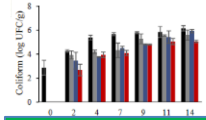
5.- Paper characterization
- ✓Thickness
- ✓Defects
- ✓Light transmission
- ✓Friction
- ✓Cracking
- ✓Tears
- ✓Elongation to break
- ✓Surface smoothess, stifness
- ✓Absortive capacity
- ✓Contact angle
- ✓Food contact regulation



ITENE, paper based

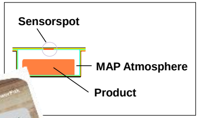
6.- Food fressness
- ✓Tunel technique, DNA degradation
- ✓Lipid oxidation
- ✓Protein markers

Sensory analysis, Panel tests
- ✓Visual appearance
- ✓Smell
- ✓Taste
- ✓Texture

7.- Smart Sensors
- ✓O_2,
- ✓CO_2,
- ✓Volatil amines

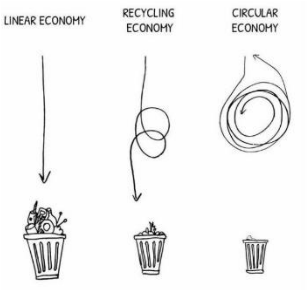
Consumer confidence tests
- ✓Interviews
- ✓Likes, dislikes
- ✓Brand perception,

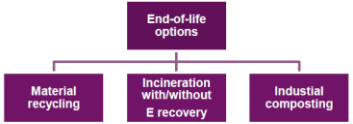



LILLE, RISE, TECSENSE

The ECOBIOSMART Approach (WP7)

1.- The recycling strategy Based on:
- ✓biodegradability,
- ✓ecotoxicity

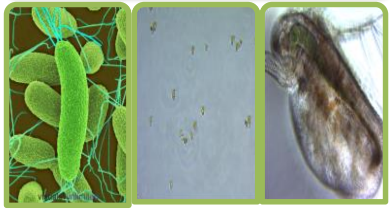




RISE-INNVENTIA-SP

2.- Ecotoxicity
- ✓Bacteria
- ✓Algae
- ✓Daphnia Magna

Aquatic organisms



Vibrio fischeri | Microalgae | *Daphnia magna*

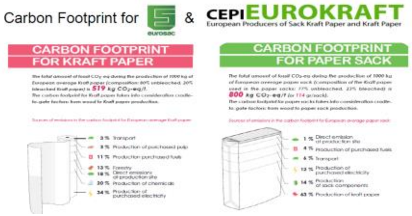
IK4-TEKNIKER

3.- Compostability
- ✓Biodegradability
- ✓Water leaching biodegradability
- ✓Organic recycling
- ✓Recycling of cellulose fibers

UNE-EN 13432
ISO 18606:2013
DIN-Certco and Vinçotte accredited
ISO 14851, ISO 14852
OECD301F

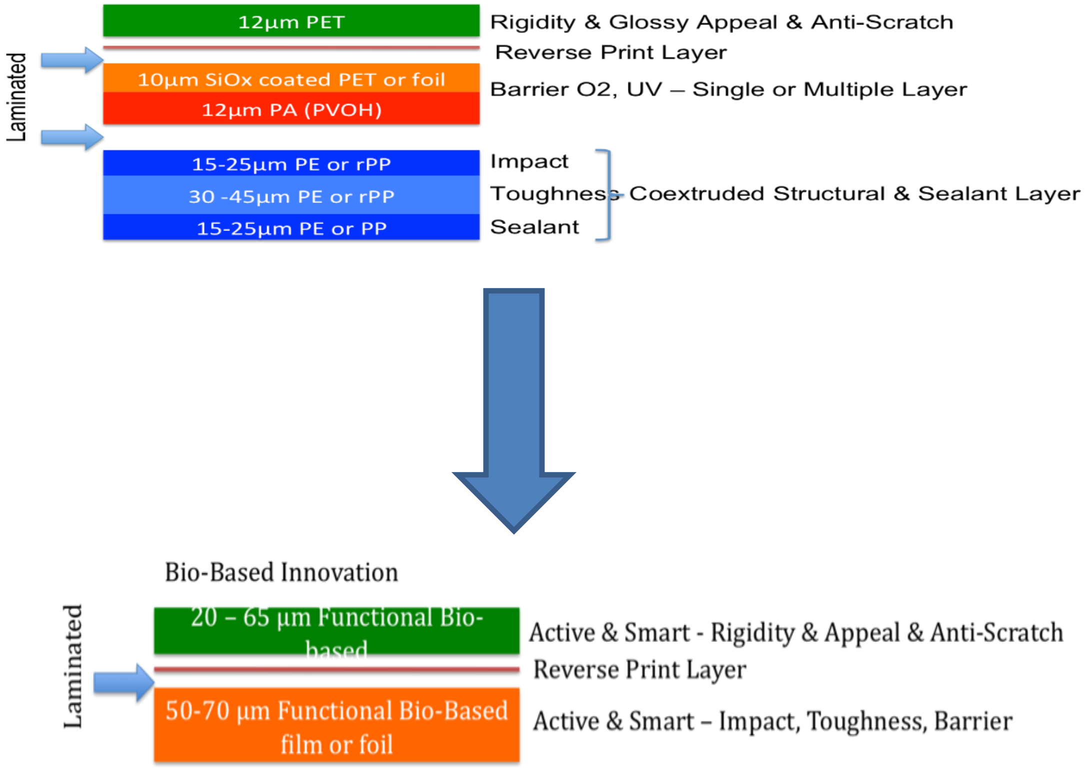
ITENE, RISE

4.- LifeCycle Assessment (LCA)
- ✓ISO 14040/44
- ✓Carbon footprint



IK4-TEKNIKER; RISE

The BIOSMART APP (WP8)



PRESENTLY

Typical multilayer structure **(5-9 layers)** for flexible and rigid food packages. Three prefabricated films laminated together each consisting of multiple layers, with an additional print layer

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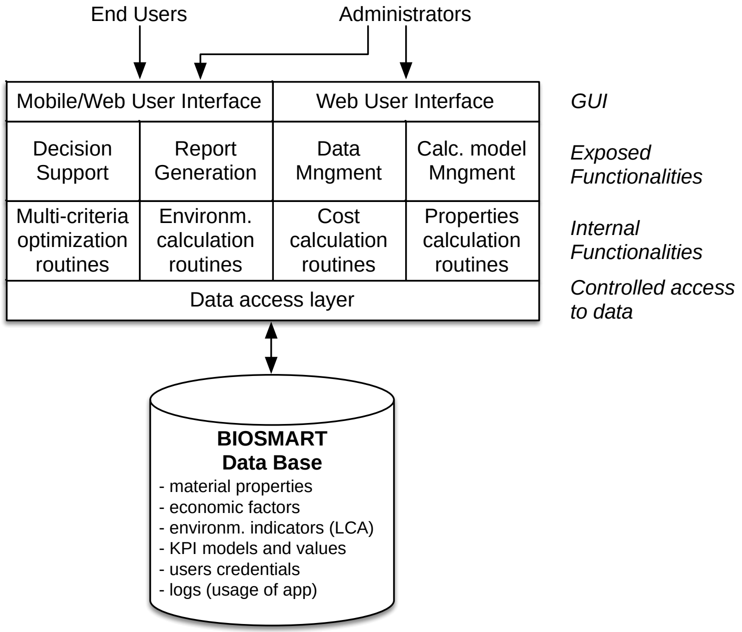
Bio-based plastic simplified multilayer structures (2-3 layers) addressing KPI indicators (barrier, stiffness, printability, antimicrobial properties), by means of combinations of polylactic acid (PLA), copolymer polyesters (e.g. PEF), or modified cellulose.

Fossil-Fuel based	1 sqm film		
Film Structure	Micron	Density(kg/m^3)	Euro cts/sqm
PET	12	1380	2.9
Print	1	1000	0.0
PU Adhesive	3	1400	2.1
PET	10	1380	2.4
PA	12	1140	3.1
PU Adhesive	3	1400	2.1
LDPE	25	923	3.3
rPP	50	905	5.8
LLDPE	25	915	3.1
Total Tickness	141		**24.8**
Conversion cost - 25%			**31.0**

Bio-Based cellulose			
Hemi-Cellulose	10	1500	5.9
Print	1	1000	0.0
Bio Glue (cellulose)	3	1500	1.8
PLA	130	125	11.1
Total Thickness	144		**18.8**
Conversion Cost 35%			**25.4**
Functional Sensor			1
Surface Treatment			1
Active			4
			32.4



Comparison of a fossil-fuel based multilayer 140 µm multilayer film versus a simplified bio-based structure with enhanced active and smart features, standardized for 1 m^2.

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The Impact of the BBI Call

- **KPI 1:** Creation of **new cross-sectorial interconnection** in **bio-based economy clusters** linking to the complete value chain, from bio-based raw material to end-users. The **BIOSMART** brings together **all the value chain stakeholders** as partners developing innovative technology and via **an External Advisory Board** representing key stakeholders affected in product development.

- **KPI 2: at least 1 new bio-based value chain based on the innovative products developed.** The BIOSMART project sets a strategy for implementing **all bio-based packages with additional smart and active functionalities** tailored to the targeted performance needs e.g**. non-sticky surfaces in combination with O_2, CO_2 and the new volatile amine sensors.**

- **KPI 5: New bio-based materials.** A) The BIOSMART introduces **novel bio-based lipopeptide and peptide** additives with **anti-microbial, anti-fungal and/or anti-oxidant** properties **to increment food shelf life.** B) New as **well barrier coatings** (plasma, sol-gel coatings and resin and composites) **with enhanced O_2, CO_2, water and UV barrier properties**. C) **Bio-based bulk materials,** the initial focus is on commercially available bio-based plastics but **PLA will be also reinforced with nanoclays to improve mechanical properties** and also will be explored aliphatics segmented **polyester-co-amides** as workable alternatives and scaled up to enable prototype package developments.

- **KPI 6: New demonstrated consumer products** based on bio-based chemicals and materials. The BIOSMART project focuses on **3 types of packages** (flexible/rigid plastic and cardboard) addressing **consumer needs** including **reduced residual in-package food waste**, and **improved due date** indicator for shelf-life extension and simplified all compostable and/or recyclable package designs. All are new concepts with strong emphasis on **consumer convenience** and **overall value chain value** creation.

THANK YOU

BIOSMART
BIOMATERIALS FOR SMART FOOD PACKAGING

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BIO-BASED INDUSTRIES
Public-Private Partnership

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