Open Day

30 September 2021

Fibrenamics

AutoEcoMat - Development of multifunctional ecological materials for automotive components from the recycling and recovery of industrial waste

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Cofinanciado por:
CVR Centro para a Valorização de Resíduos®
COMPETE 2020 Programa Operacional Competitividade e Internacionalização
PORTUGAL 2020
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

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Intelligence

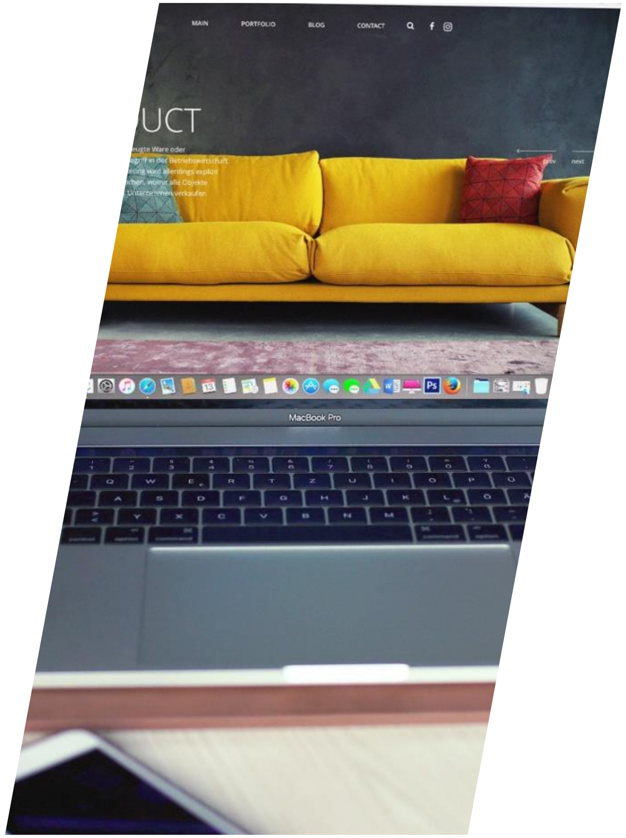
- Identify Opportunities
- Digital Tool

Science

- Generate knowledge
- Generate R&D Projects

Technology

- Transfer Technology
- Generate R&D Projects



Business

- Value chains
- Generate businesses

Fibrenamics

Intelligence

- Identify Opportunities
- Digital Tool

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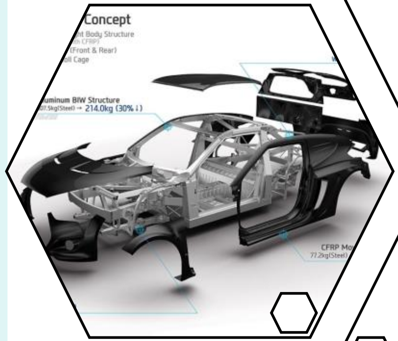
Automotive Industry

Trends



Multifunctionality

Weight reduction

Sustainability

Performance

Competitiveness

Trends

Weight reduction

- 10% reduction in vehicle weight equates to a fuel saving of 5 – 7%.

Sustainability

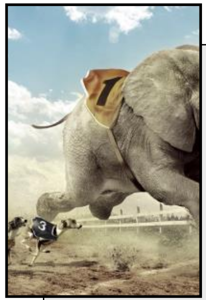
- 40% reduction in gas emissions by 2030.
- **Use of recycled, biodegradable materials** (minimization of waste).

Multifunctionality

- Combination of different types of materials.
- Intelligence, interactivity, autonomy (security).

Performance

- **Mechanical and thermal properties.**
- Corrosion, fatigue (cyclic loads).



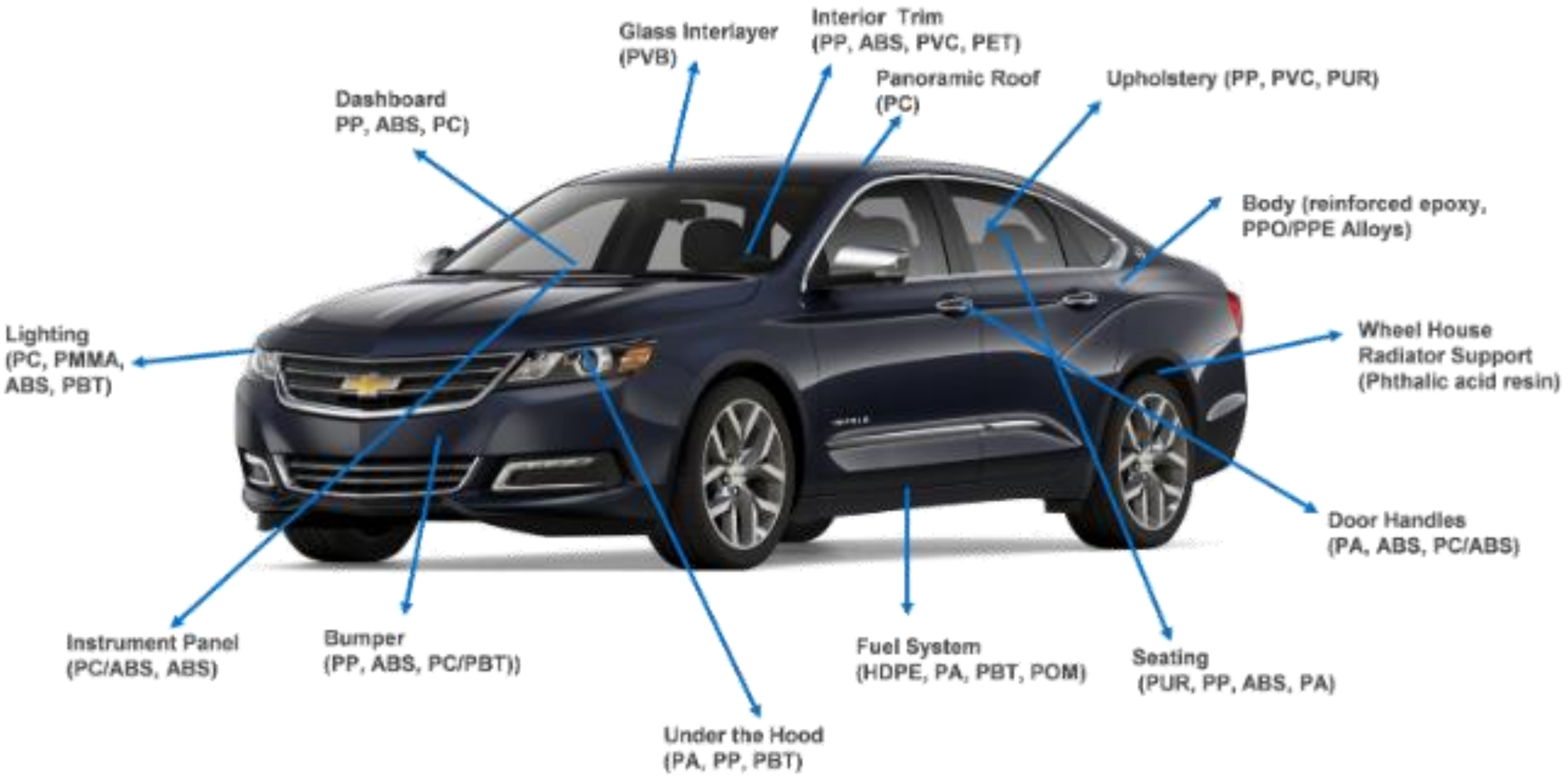
Competitiveness

- Cost, legislation.

Trends

- Diversity of materials inside the cabin
- Use of more ecological and recyclable materials
- Improved energy efficiency
- Weight reduction through components

Polymers in the Automotive Industry



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Market perspectives

- For every 100 kg of polymer used, 200 to 300 kg of conventional materials are replaced.
- **For every kg of vehicle weight reduction, the carbon emission to the atmosphere is reduced by 20 kg.**
- *"**Automotive polymer materials market exceeded $21 billion in 2015 .** By 2022, a compound annual growth rate (CAGR) of 13% is expected."*

Source: Markets and Markets

- **In 2018, close to 80 million passenger cars were produced worldwide.**
- Data from January 2019 projected that automobile production would increase to 117 million vehicles in 2030.

Source: Statista

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Framework

Promoter: Borgstena Textile Portugal, Unipessoal LDA

Name: Development of multifunctional ecological materials for automotive components from the recycling and recovery of industrial waste

Acronym: AutoEcoMat

Duration: 24 + 1 mês

Start: 01-09-2019 **End:** 30-09-2021

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CENTRO PARA A VALORIZAÇÃO DE RESÍDUOS®

Schedule of activities

Atividade	Descrição	2019				2020												2021								
		set	out	nov	dez	jan	fev	mar	abr	mai	jun	jul	ago	set	out	nov	dez	jan	fev	mar	abr	mai	jun	jul	ago	set
1	**ESTUDOS PRELIMINARES**																									
1.1	Caraterização do mercado alvo																									
1.2	Análise das técnicas de reciclagem e transformação de resíduos																									
1.3	Análise das técnicas de valorização de resíduos																									
1.4	Estudo da funcionalização de materiais																									
1.5	Elaboração de caderno de encargos para desenvolvimento de produto																									
2	**RECICLAGEM E TRANSFORMAÇÃO DOS RESÍDUOS**																									
2.1	Estudo dos processos de reciclagem de resíduos																									
2.2	Desenvolvimento do processo de tratamento dos resíduos																									
2.3	Análise dos resíduos obtidos																									
3	**DESENVOLVIMENTO DE MATERIAIS ECOLÓGICOS A PARTIR DE RESÍDUOS**																									
3.1	Estudo das técnicas de valorização de resíduos (extrusão)																									
3.2	Estudo da compatibilidade de matrizes poliméricas com resíduos e respetivas composições																									
3.3	Desenvolvimento de materiais ecológicos com base em resíduos																									
3.4	Estudo e adaptações dos equipamentos																									
4	**DESENVOLVIMENTO DE MATERIAIS COMPÓSITOS RECICLADOS FUNCIONAIS**																									
4.1	Estudo da funcionalização dos materiais compósitos reciclados																									
4.2	Estudo da compatibilidade dos agentes de funcionalização com os materiais poliméricos																									
4.3	Desenvolvimento de materiais compósitos reciclados funcionais e análise de propriedades																									
5	**DESENVOLVIMENTO DE PROTÓTIPOS E AVALIAÇÃO DE PROPRIEDADES**																									
5.1	Desenvolvimento de protótipos																									
5.2	Desenvolvimento de métodos de ensaio de avaliação das propriedades dos protótipos																									
5.3	Avaliação das propriedades estruturais, mecânicas e funcionais																									
6	**INVESTIGAÇÃO DO DESEMPENHO EM CONDIÇÕES REAIS DE UTILIZAÇÃO**																									
6.1	Seleção do modelo de aplicação dos protótipos para prova de conceito																									
6.2	Avaliação do desempenho em condições reais de utilização																									
6.3	Tratamento estatístico dos dados																									
7	**OTIMIZAÇÃO E ENSAIOS**																									
7.1	Reformulação do design dos protótipos																									
7.2	Produção de novos protótipos																									
7.3	Avaliação das propriedades dos protótipos otimizados																									
8	**DIVULGAÇÃO DE RESULTADOS**																									
8.1	Publicações científicas																									
8.2	Open day																									
8.3	Dinamização do website																									
8.4	Participação em feiras e workshops																									

Science

- Generate knowledge
- Generate R&D Projects

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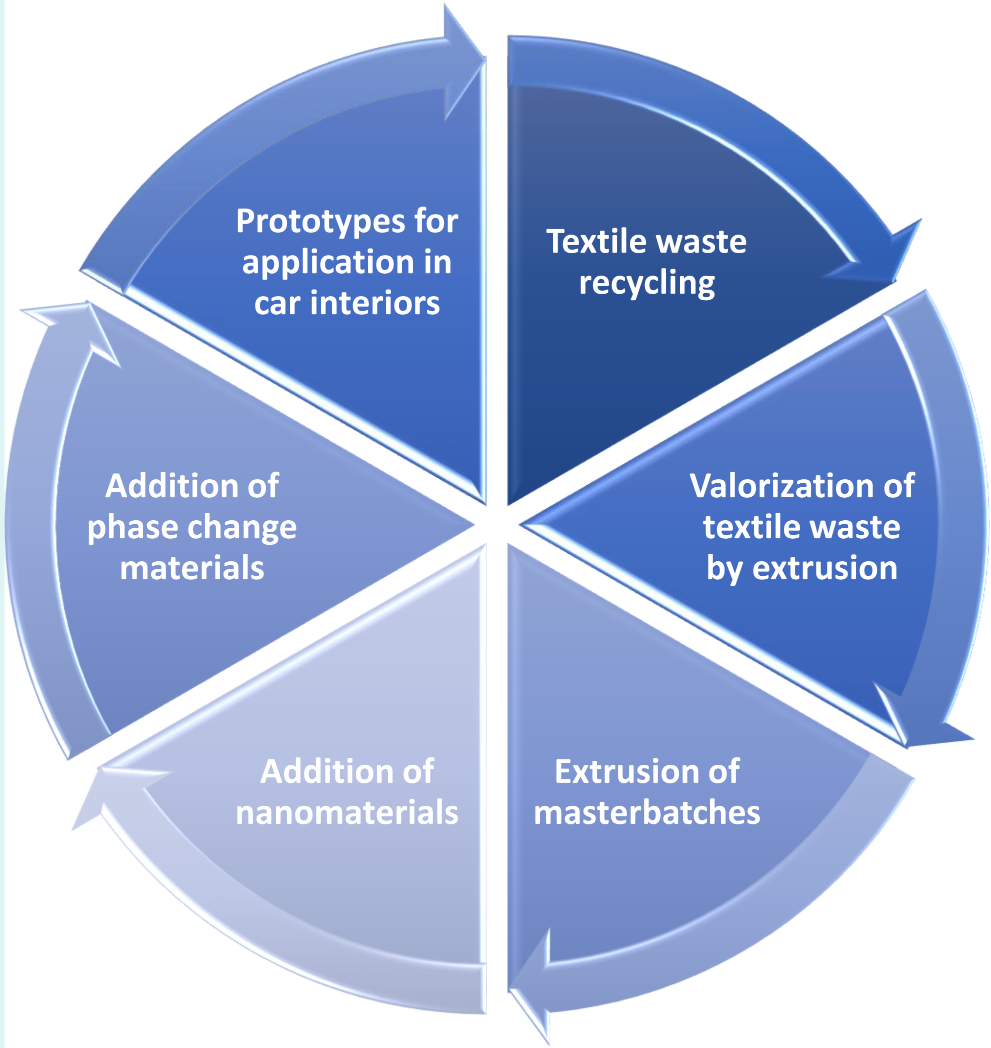
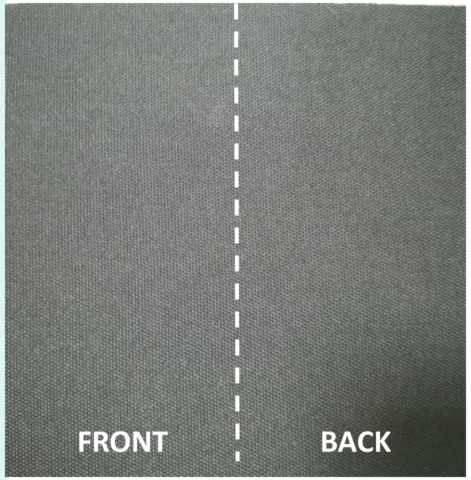
Development strategy

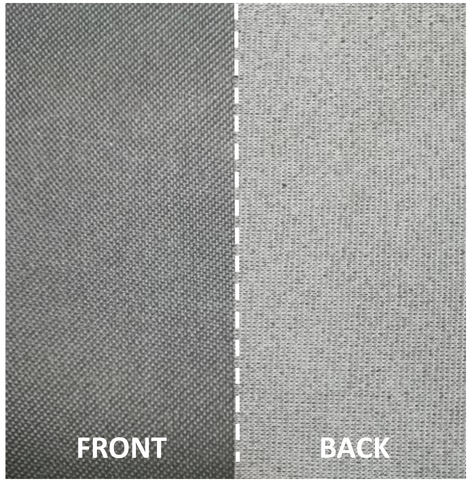


Study of textile waste recycling

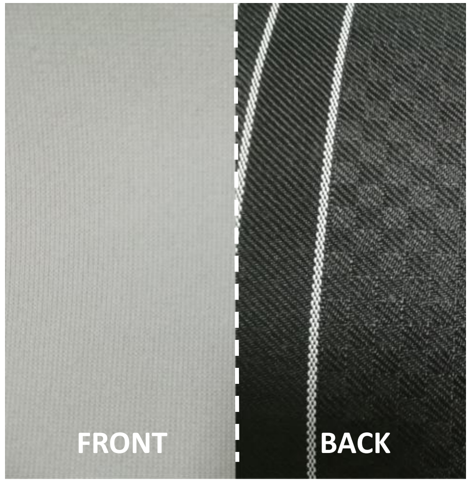
CLIP
Materials: PET



COBRA
Material: PET e PU



VISUAL
Materials: PET e PU



Textile waste of different types

PET, thermoplastic polymer, a characteristic that allows its recycling relatively easily, through the application of pressure and temperature.

PU, thermosetting polymer, a characteristic that makes recycling impossible. The application of high temperature leads to its degradation.

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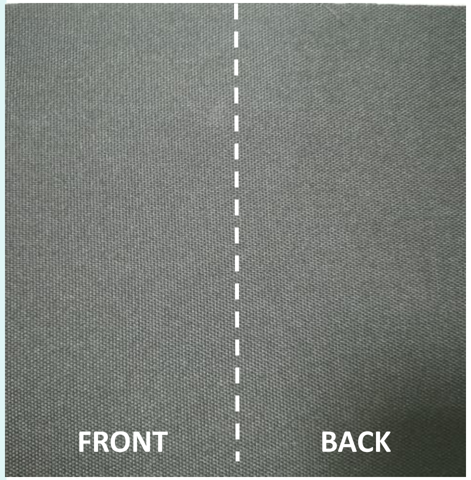
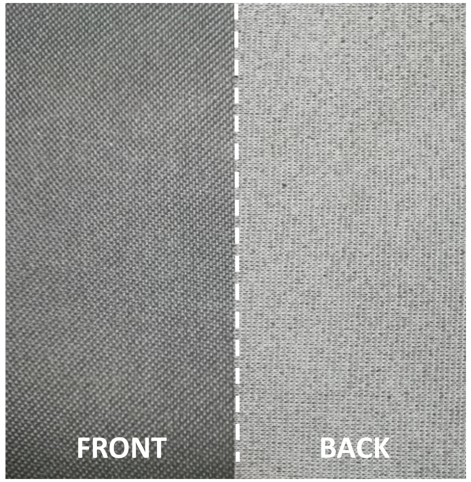
Study of textile waste recycling

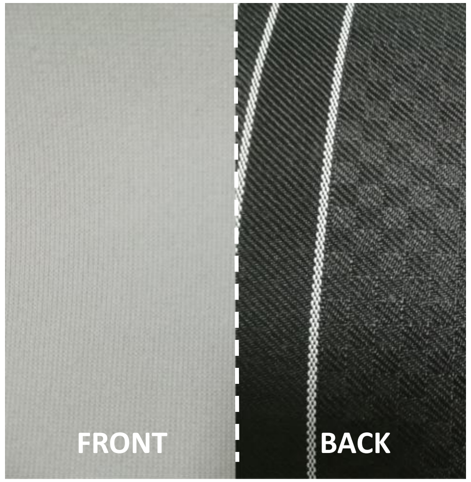
CLIP
Materials: PET



COBRA
Material: PET e PU



VISUAL
Materials: PET e PU



Difficulty in recycling textile waste **due to its high deformation capacity**

Modification of the deformation capacity of waste

(**increase stiffness**)

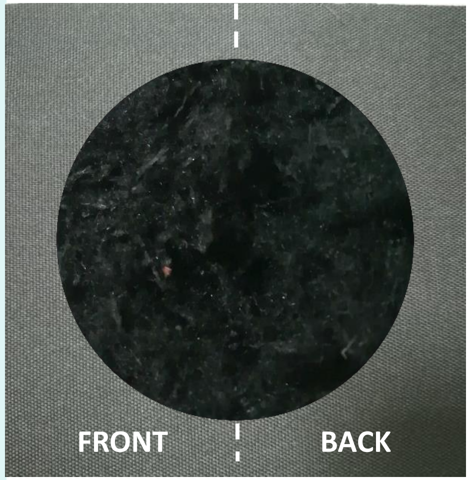
Cryogenic treatment, use of liquid nitrogen to put waste below its T_g

or

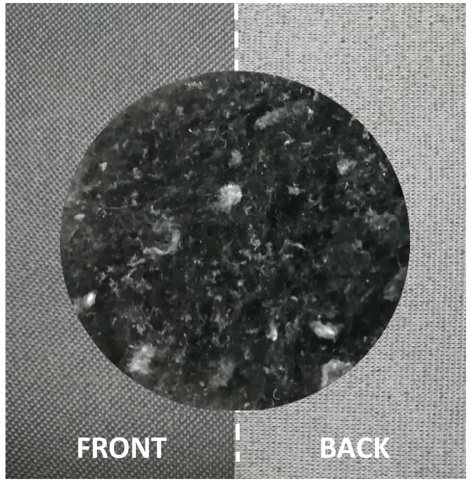
Hot agglomeration, heat treatment above the T_m of waste

Cryogenic treatment

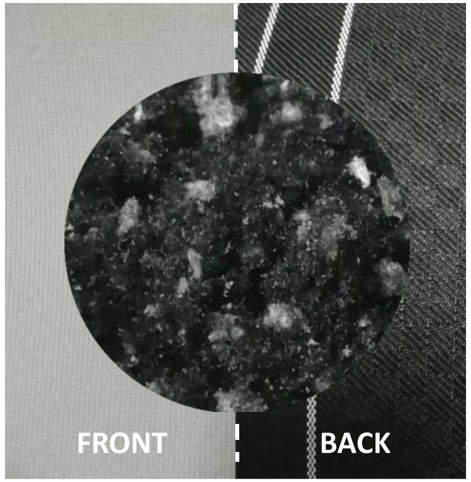
CLIP
Materials: PET



COBRA
Material: PET e PU



VISUAL
Materials: PET e PU



Use of liquid nitrogen in waste in order to keep it below its T_g, temperature below which the polymer loses molecular mobility becoming more rigid.

Recycled waste form agglomerates**, which makes it difficult to use in the extrusion process.**

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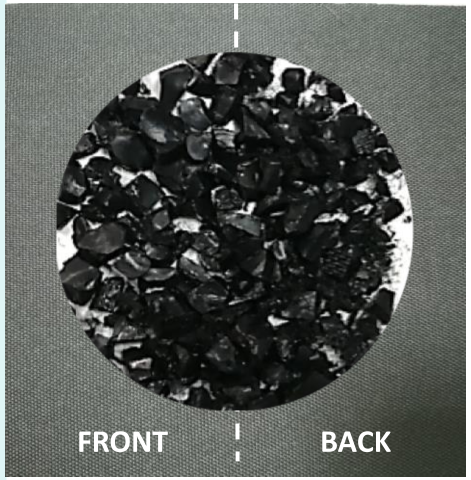
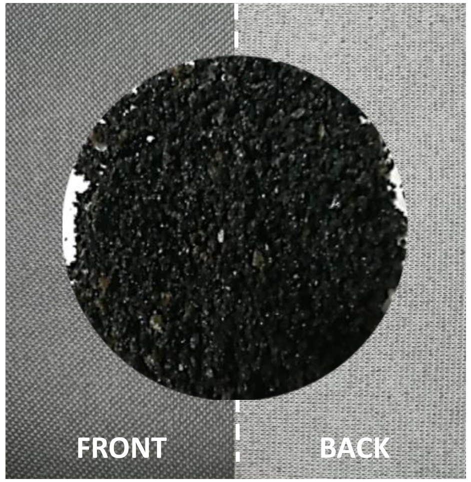
Hot agglomeration

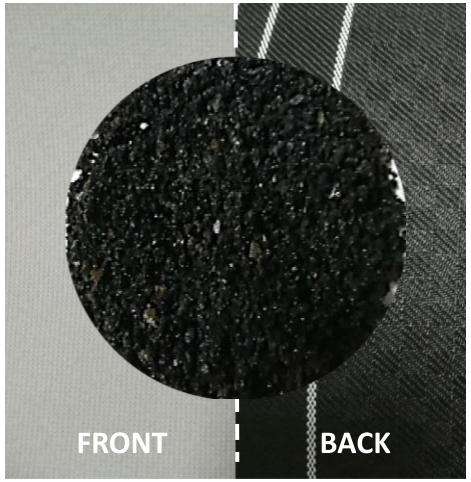
CLIP
Materials: PET



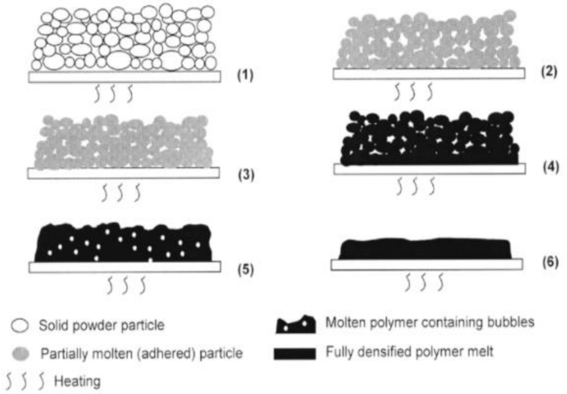
COBRA
Material: PET e PU



VISUAL
Materials: PET e PU



Application of high temperatures, **above the T_m of the materials, to put the residues in a molten state, allowing their agglomeration**. After agglomeration, the residues are cooled, becoming rigid.



Recycled waste is in the form of **rigid granules, making them ideal for use in the extrusion process** .

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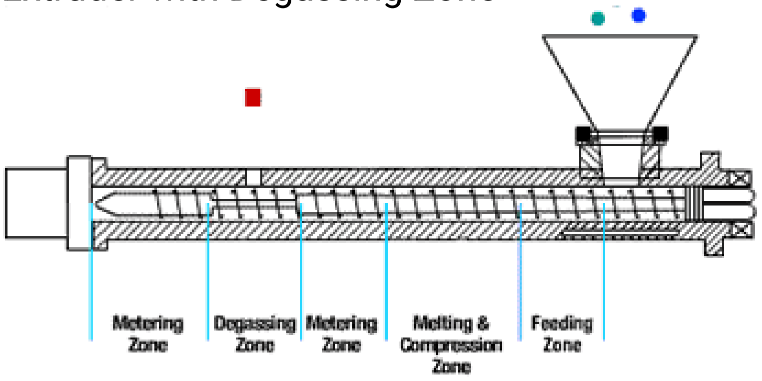
Recycled waste recovery strategy - Extrusion

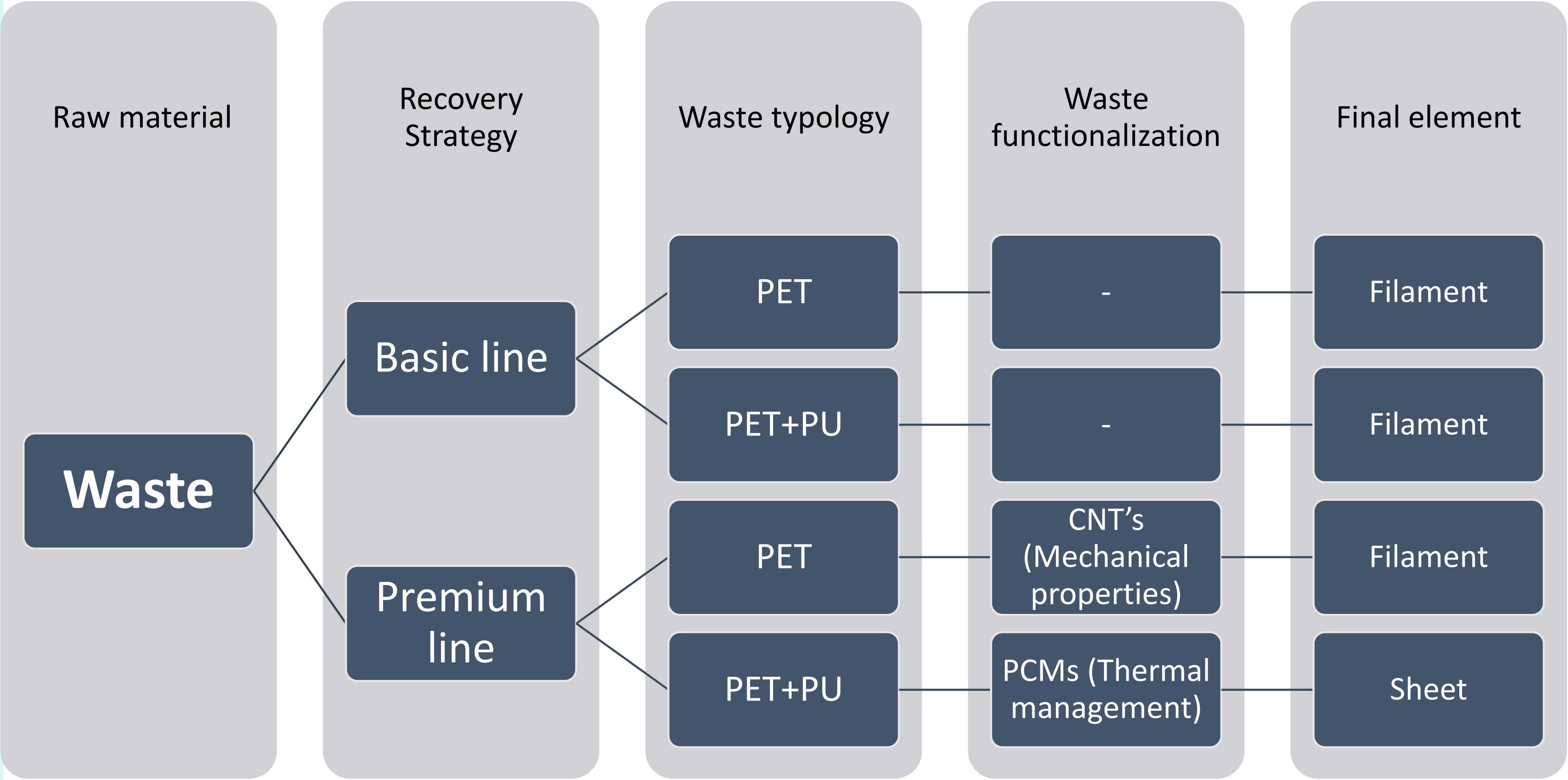
Extruder with Degassing Zone



- In this process, the material is extruded through a channel with a specific cross section (die), acquiring its shape. This process allows the production of sheets, filaments, profiles, etc.

- In the plate and filament production process, it is possible to adjust the following parameters in order to optimize the sample thickness:
  - Processing temperature;
  - Screw rotation speed;
  - Feeding speed;
  - Speed and aperture of pull rolls.

Recycled waste recovery strategy



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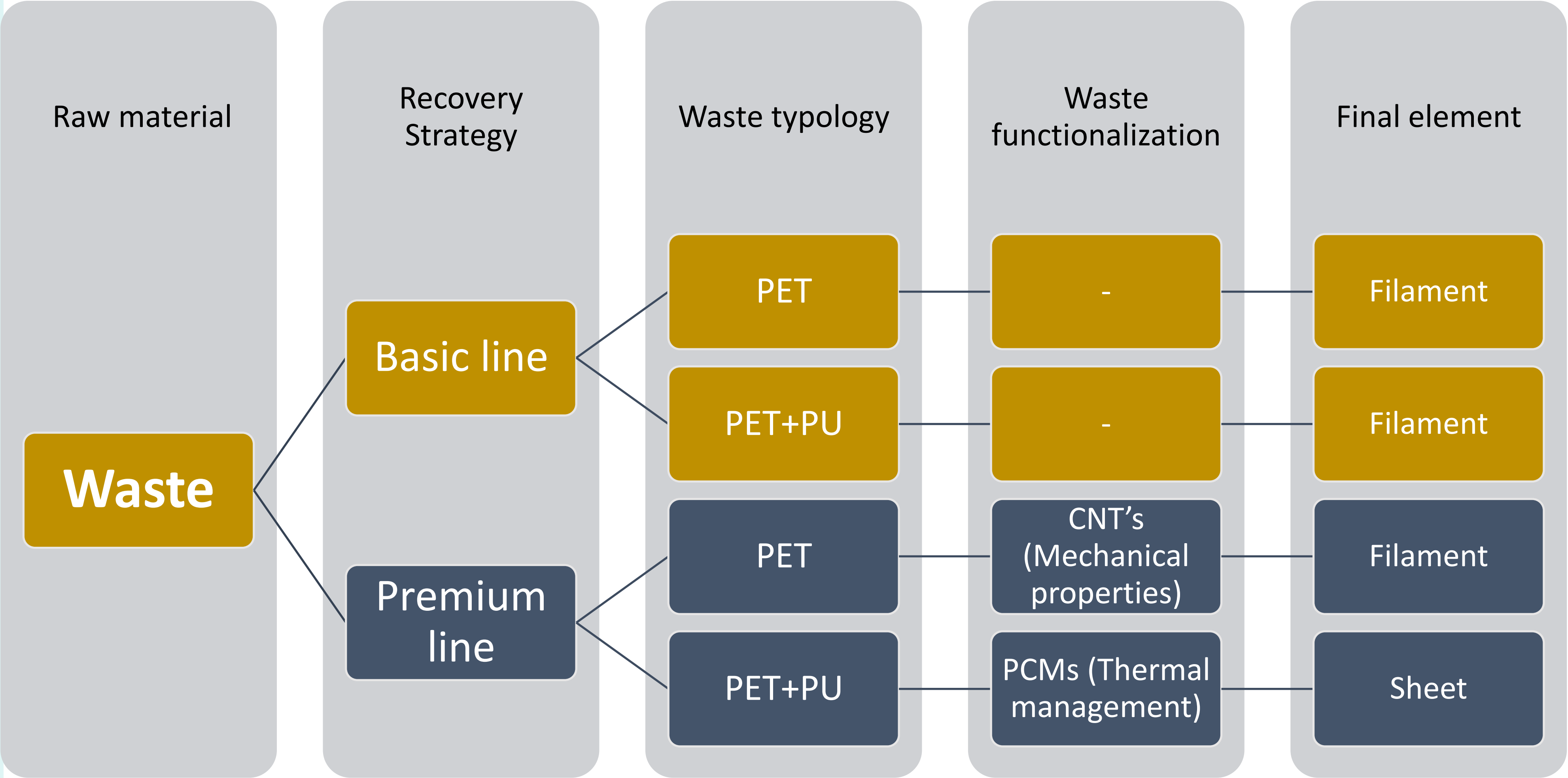
Estratégia de valorização de resíduos reciclados



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Study of % of incorporation of waste

Sample Plan			
Sample	% virgin PET	% recycled PET	% recycled PET+PU
PET_100	100	-	-
PET80_rPET20	80	20	-
PET60_rPET40	60	40	-
PET40_rPET60	40	60	-
PET20_rPET80	20	80	-
PET80_rPET+PU20	80	-	20
PET60_rPET+PU40	60	-	40
PET40_rPET+PU60	40	-	60
PET20_rPET+PU80	20	-	80

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Characterization - Study % of PET waste incorporation

Sample	Maximum Stress (MPa)	Maximum Deformation (%)	Young's Module (GPa)
PET_100	13,46 ± 1,96	3,22 ± 0,23	0,50± 0,06
PET80_rPET20	12,10 ± 2,37	2,86 ± 0,94	0,45 ± 0,01
PET60_rPET40	9,96 ± 1,00	2,72 ± 0,16	0,35 ± 0,06
PET40_rPET60	7,41 ± 0,39	2,95 ± 0,51	0,29 ± 0,13
PET20_rPET80	6,75 ± 1,22	2,89 ± 0,36	0,22 ± 0,10

- With an incorporation of 20% by mass of PET waste, results similar to those of virgin PET are obtained. With the increasing integration of PET waste, there is a progressive decrease in mechanical properties.
- The percentage of 60% PET waste was defined as the ideal one to incorporate together with virgin PET, to develop prototypes.

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Characterization - Study % of PET+PU waste incorporation

Sample	Maximum Stress (MPa)	Maximum Deformation (%)	Young's Module (GPa)
PET_100	13,46 ± 1,96	3,22 ± 0,23	0,50± 0,06
PET80_rPET+PU20	10,00 ± 2,25	3,20 ± 1,22	0,19 ± 0,07
PET60_rPET+PU40	7,56 ± 1,75	2,82 ± 0,64	0,13 ± 0,02
PET40_rPET+PU60	5,25 ± 0,20	2,79 ± 0,60	0,11 ± 0,03
PET20_rPET+PU80	3,50 ± 0,20	2,55 ± 0,75	0,09 ± 0,06

- With the integration of PET+PU waste, the mechanical properties of the samples suffer a greater decrease compared to samples developed with PET waste.
- The percentage of 60% PET+PU waste was defined as the ideal one to incorporate together with virgin PET, to develop prototypes.

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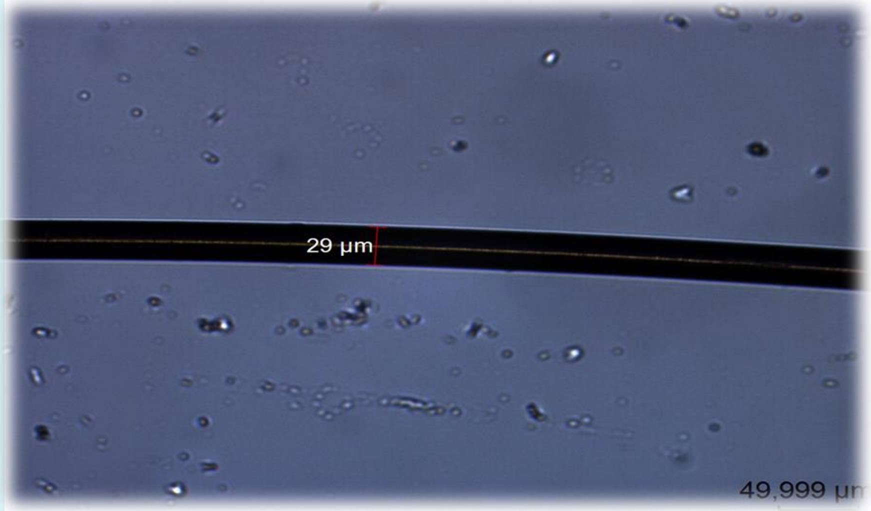
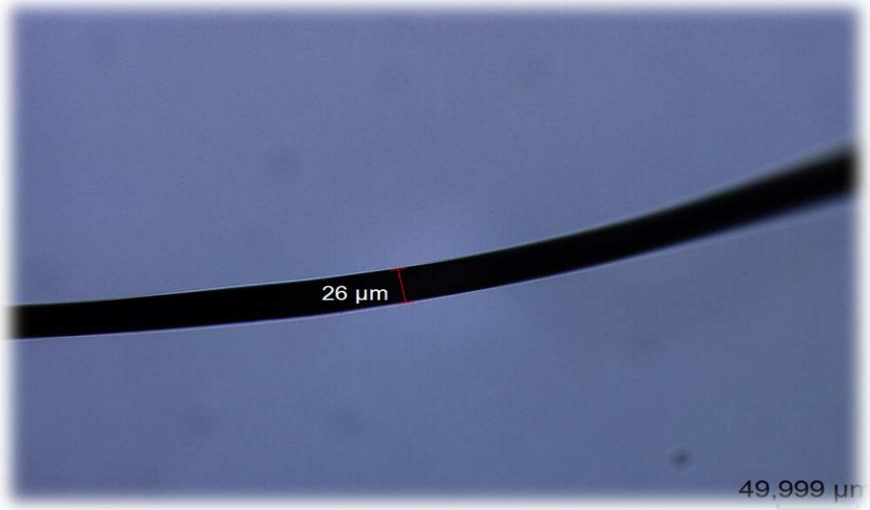
Characterization - Study % of waste incorporation

Image of filaments produced with recycled PET waste.



Microscopic image of a filament produced from recycled PET waste.



Microscopic image of a filament removed from the original PET textile waste.

- The **filament** obtained with the incorporation **of recycled PET has a diameter similar to the filaments present in the original PET textile waste**.
- **It was not possible to obtain filaments,** with a diameter similar to those present in the original PET textile waste, **with the PET+PU waste, since the recycled PU foam has a dimension close to 2 mm, which causes the filament to break when these are being extruded.**

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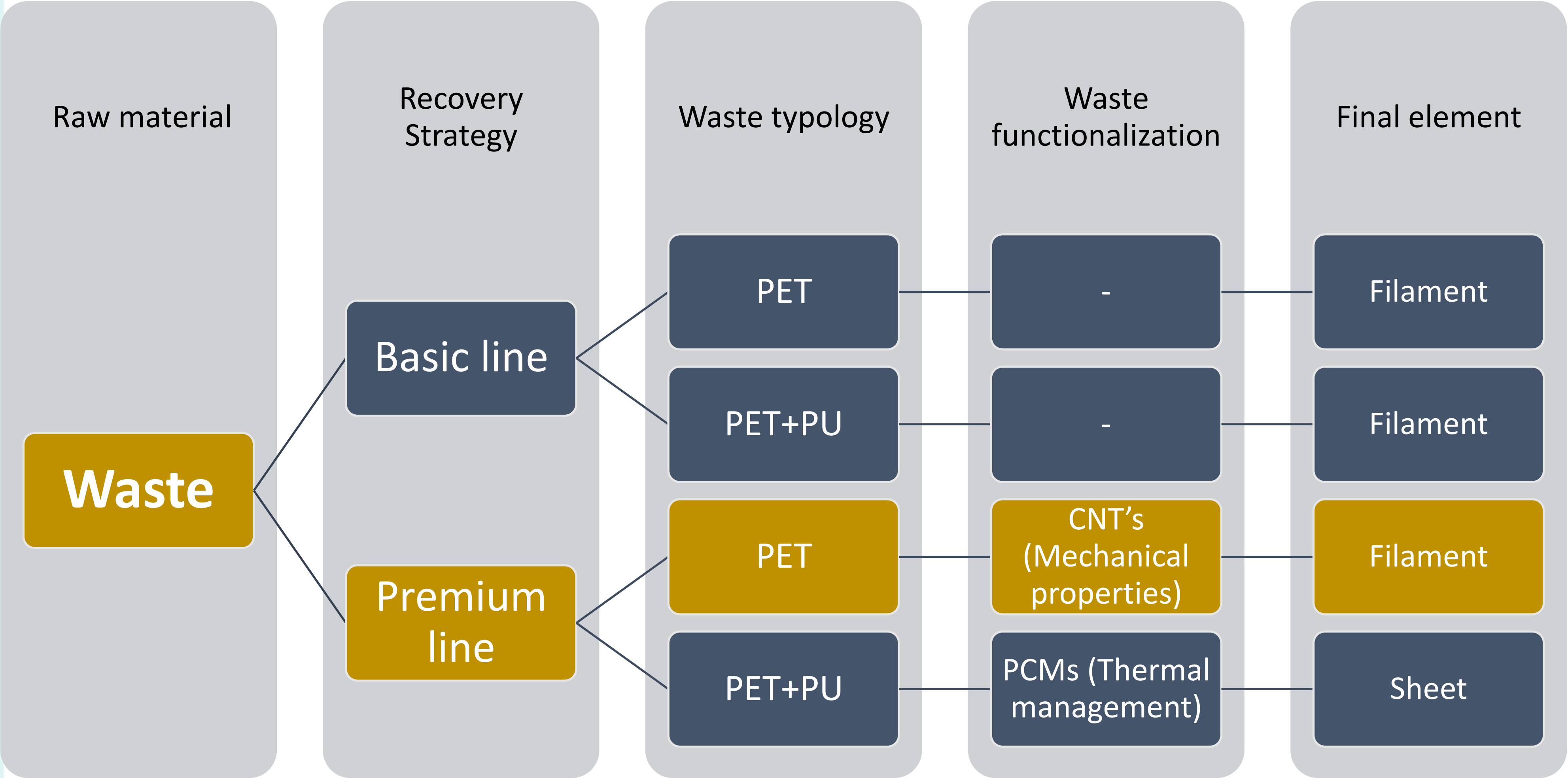
Recycled waste recovery strategy



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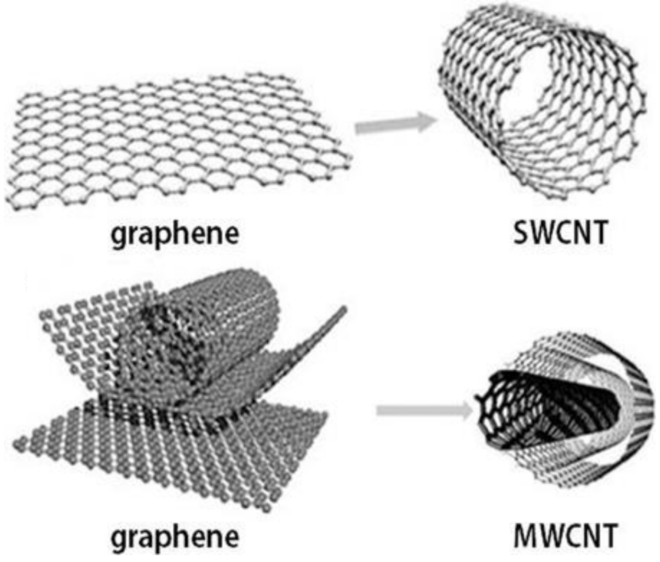
Study of the % of incorporation of CNT's

- Carbon nanotubes (CNT's) are nanoparticles that consist of rolled sheets of single-layer carbon atoms (graphene);

- CNTs can be single-walled (only one graphene sheet) or multiple-walled (two or more concentric graphene layers spaced apart by 0.34 nm);

- In addition to their excellent electrical properties, CNT's also have unique thermal and mechanical properties.



Study of the % of incorporation of CNT's

Sample Plan

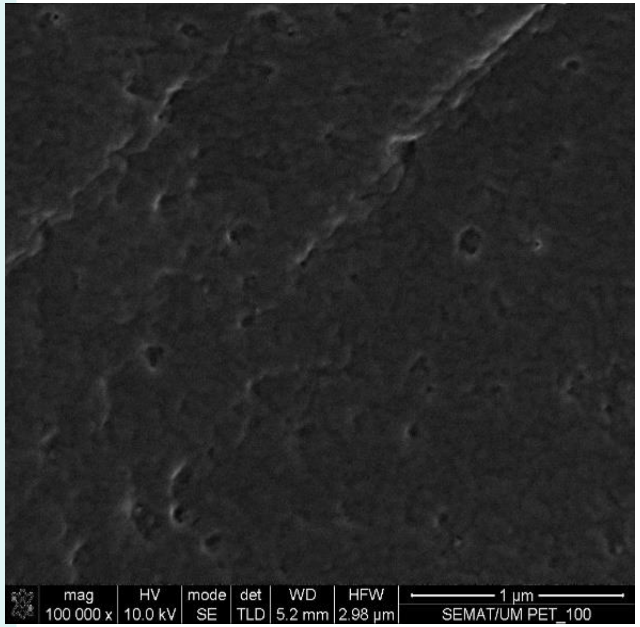
Virgin PET	Recycled PET	CNT’s
40% w/w incorporation	60% w/w incorporation	0.5, 1 e 1.5% w/w incorporation

Characterization - Study of the % incorporation of CNT's

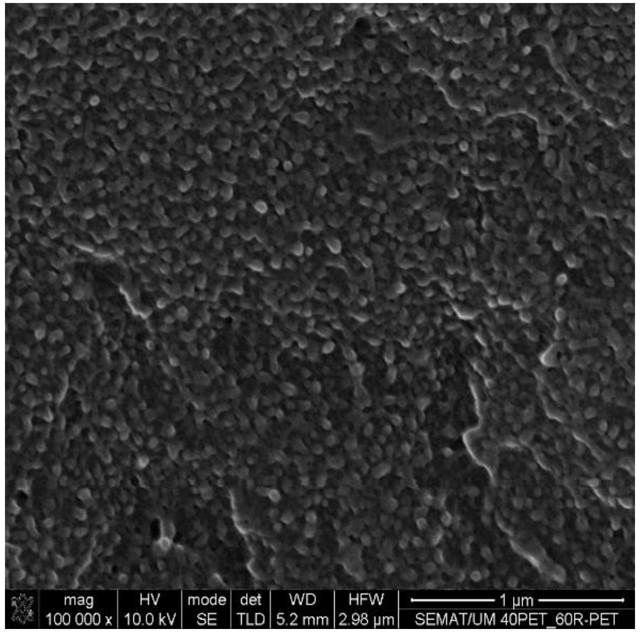
Sample	Maximum Stress (MPa)	Maximum Deformation (%)	Young's Module (GPa)
PET_100	13,46 ± 1,96	3,22 ± 0,23	0,50± 0,06
PET40_rPET60	7,41 ± 0,39	2,95 ± 0,51	0,29 ± 0,13
PET40_rPET60_0.5CNT’s	7,93 ± 1,21	2,20 ± 0,39	0,34 ± 0,06
PET40_rPET60_1CNT’s	13,78 ± 0,78	3,64 ± 0,55	0,44 ± 0,07
PET40_rPET60_1.5CNT’s	14 ± 2,20	3,57 ± 0,36	0,44 ± 0,06

- **With the incorporation of 60% waste and 1% CNT's, mechanical properties similar to** those of filaments developed with **100% virgin PET** are obtained**.**
- With the use of **1.5% of CNT's there was no significant improvement in mechanical properties,** against the sample that contained 1% of CNT's. So it was defined that the optimal % of incorporation of CNT's is 1%.

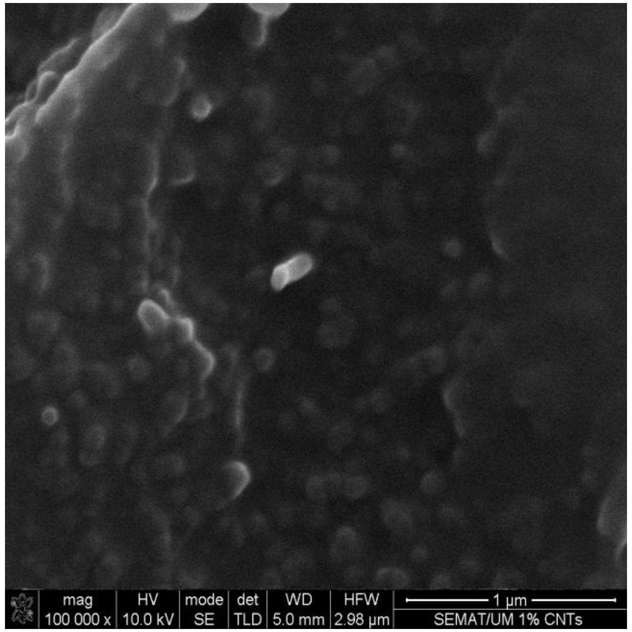
Characterization - Study of the % incorporation of CNT's



Cross section of the PET_100 sample.



Cross section of the PET40_rPET60 sample.



Cross section of the PET40_rPET60_1CNT's sample.

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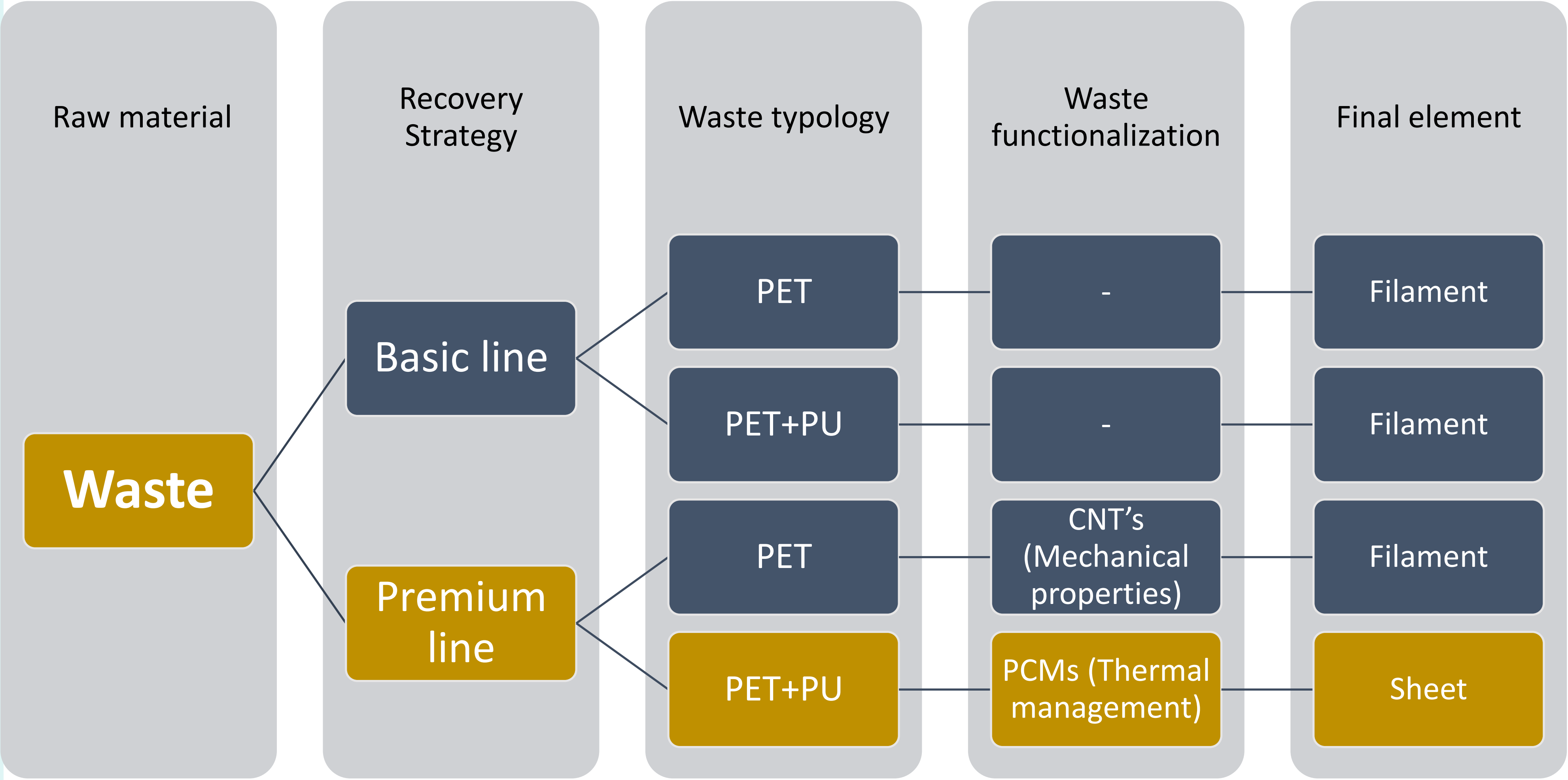
Strategies for valorization of recycled waste

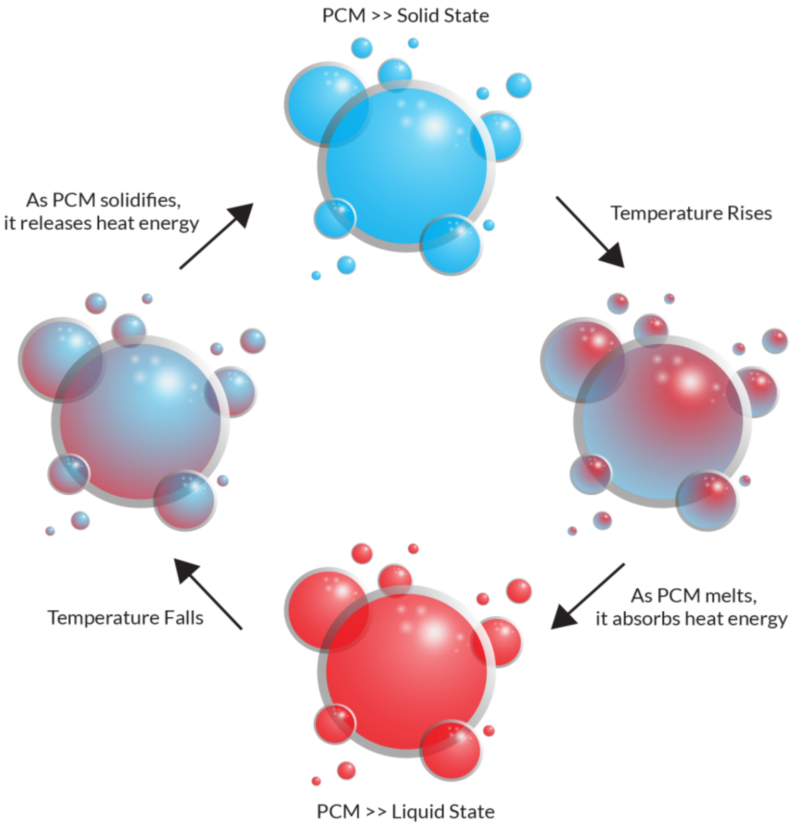


Study of % of incorporation of PCMs

- PCMs are characterized by having the ability to change their physical state depending on the ambient temperature, storing energy in the form of latent heat.

- When the ambient temperature surrounding the PCM reaches its melting point, it changes from solid to liquid.

- When the temperature decreases to values below the PCM's solidification point, it changes from a liquid to a solid state, releasing the previously accumulated energy to the environment.

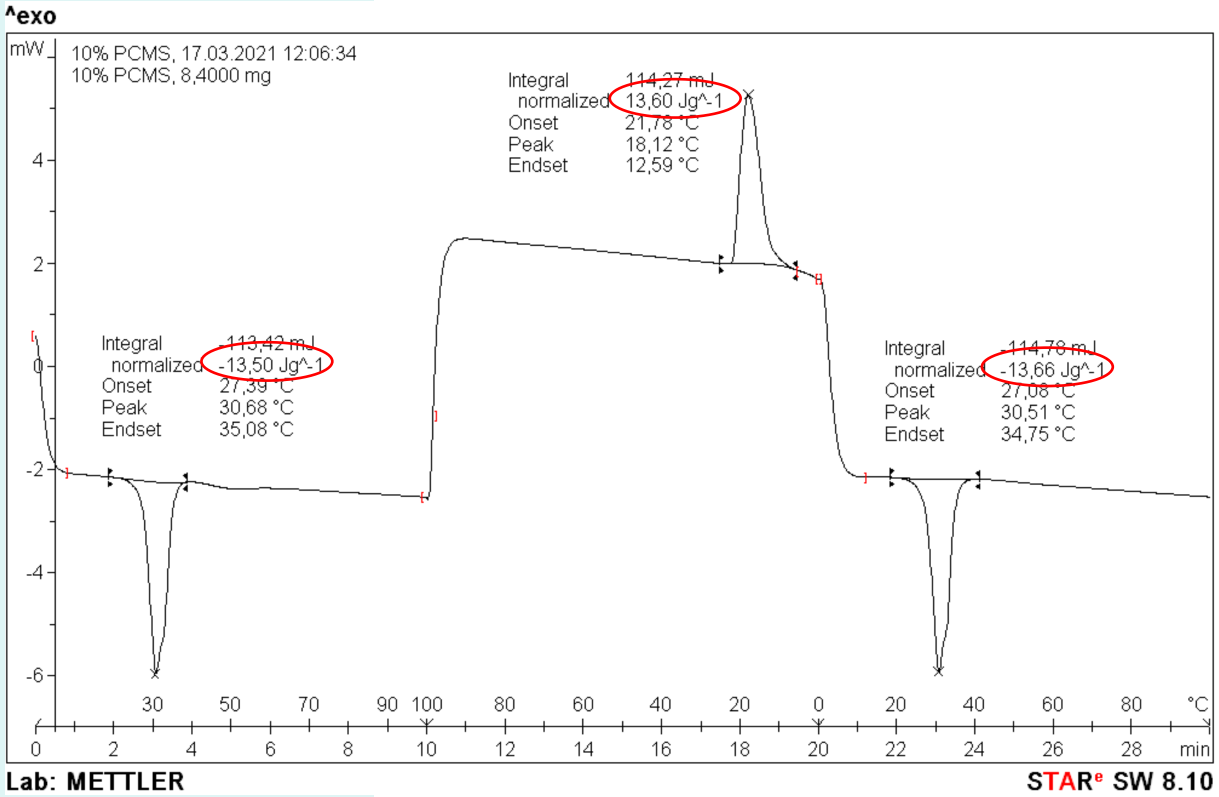


Study of % of incorporation of PCMs

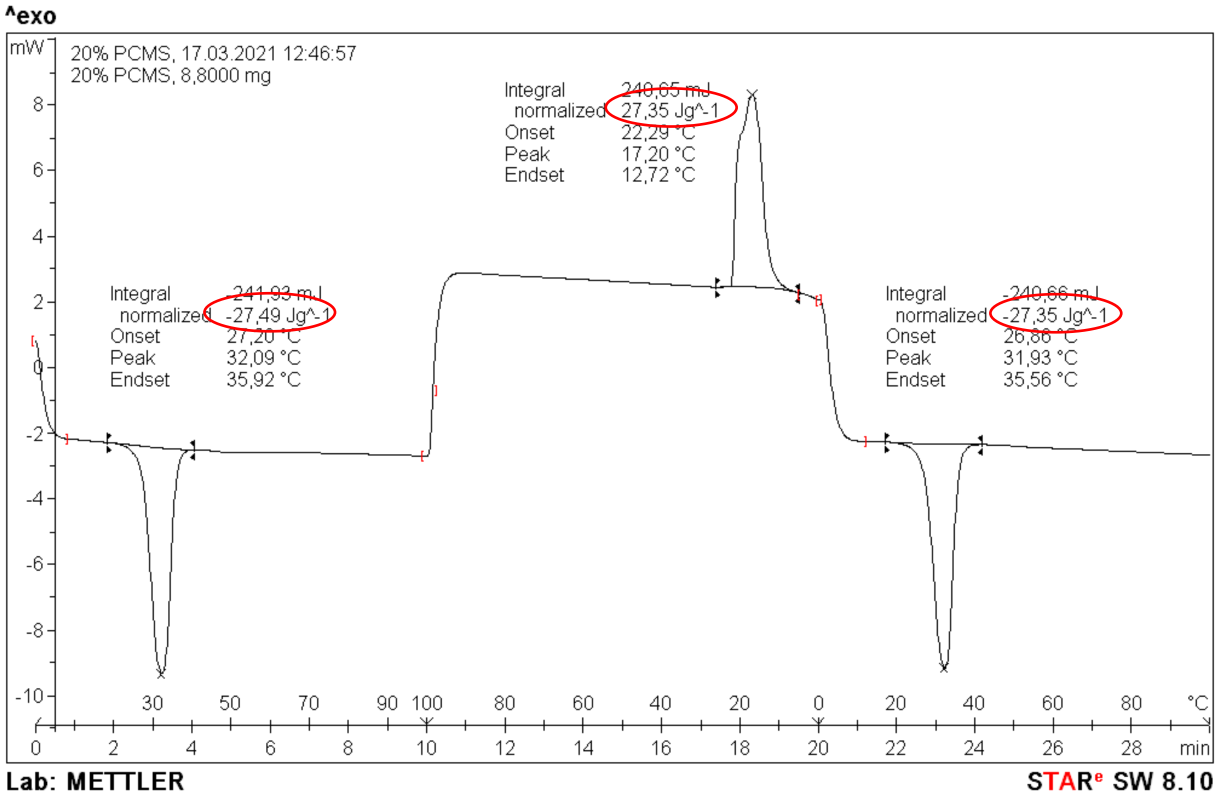
Sample Plan

Virgin PET	Recycled PET +PU	PCMs
40% w/w incorporation	60% w/w incorporation	10 and 20% w/w incorporation

Characterization - Study of the % incorporation of PCMs



DSC plot of sample with 10% PCMs.



DSC plot of sample with 20% PCMs.

- With the increasing percentage of PCMs from 10% to 20%, the latent heat of fusion and crystallization doubled.

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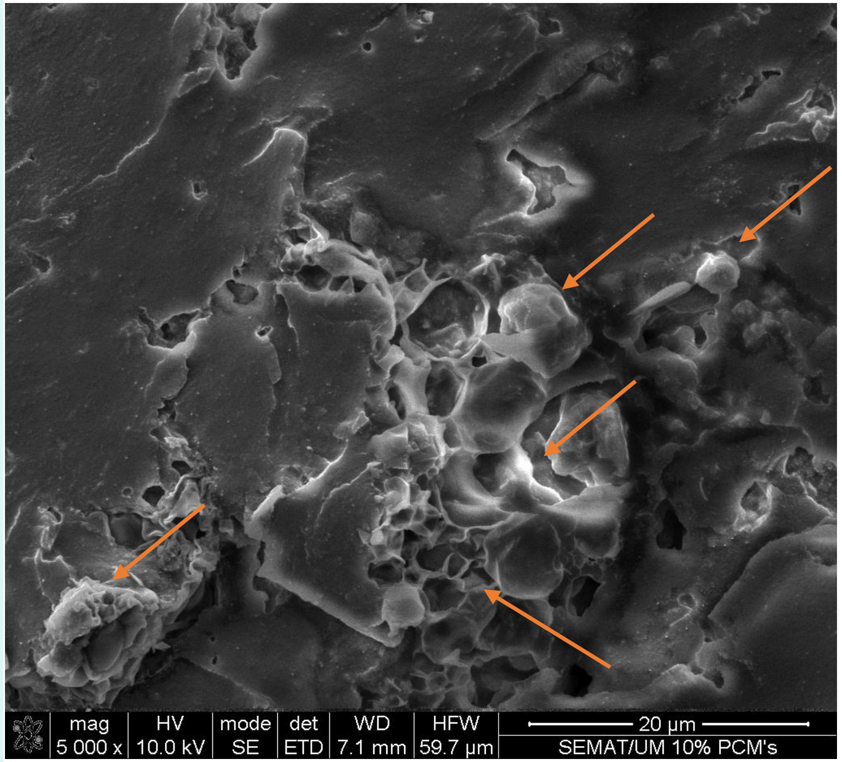
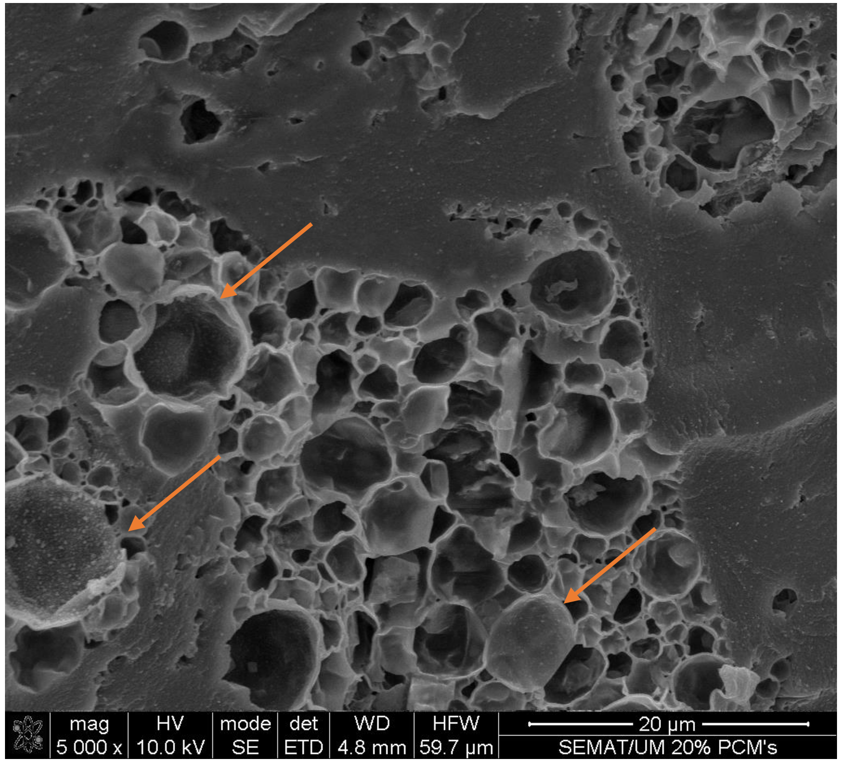
Characterization - Study of the % incorporation of PCMs



Cross section of the sample with 10% PCMS.



Cross section of the sample with 20% PCMS.

- The SEM tests demonstrate that it was possible to incorporate the PCMs during the extrusion process without breaking the microcapsules surrounding the phase change material.

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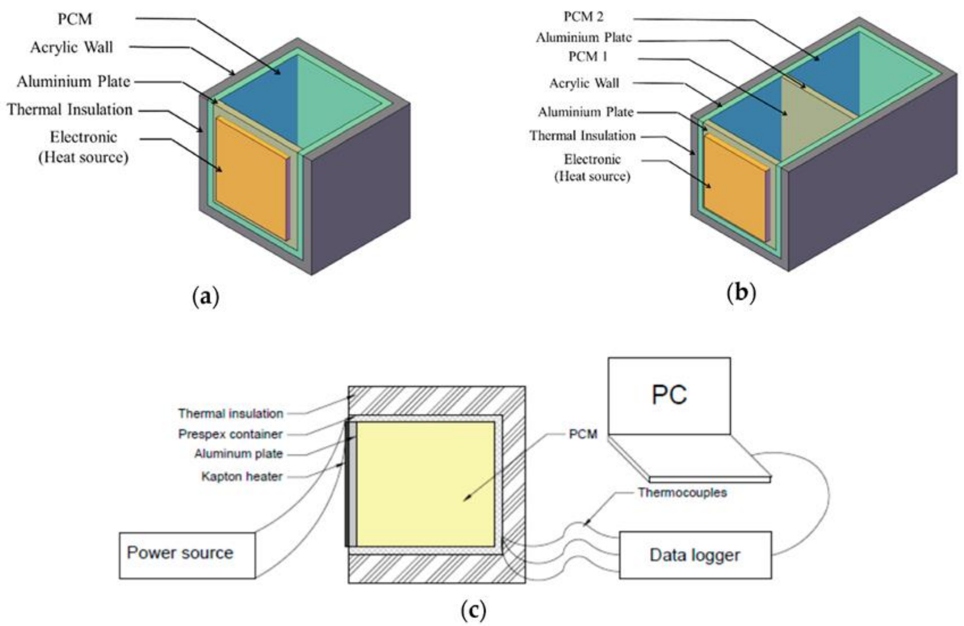
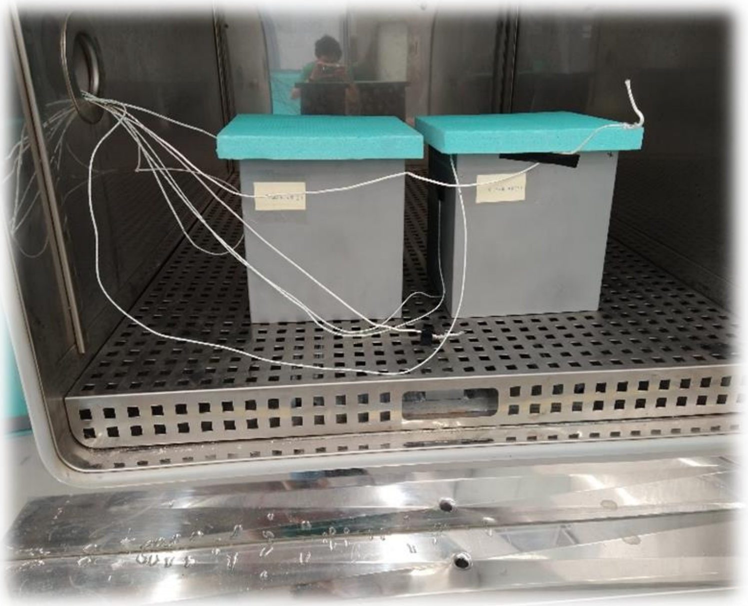
Characterization - Study of the thermal management of PCMs





- An experimental setup was developed in order to assess the level of thermal control that PCMs provide to the prototypes where they are included.

- A comparison was made between a sample with 20% by mass of PCM and one without PCMs.

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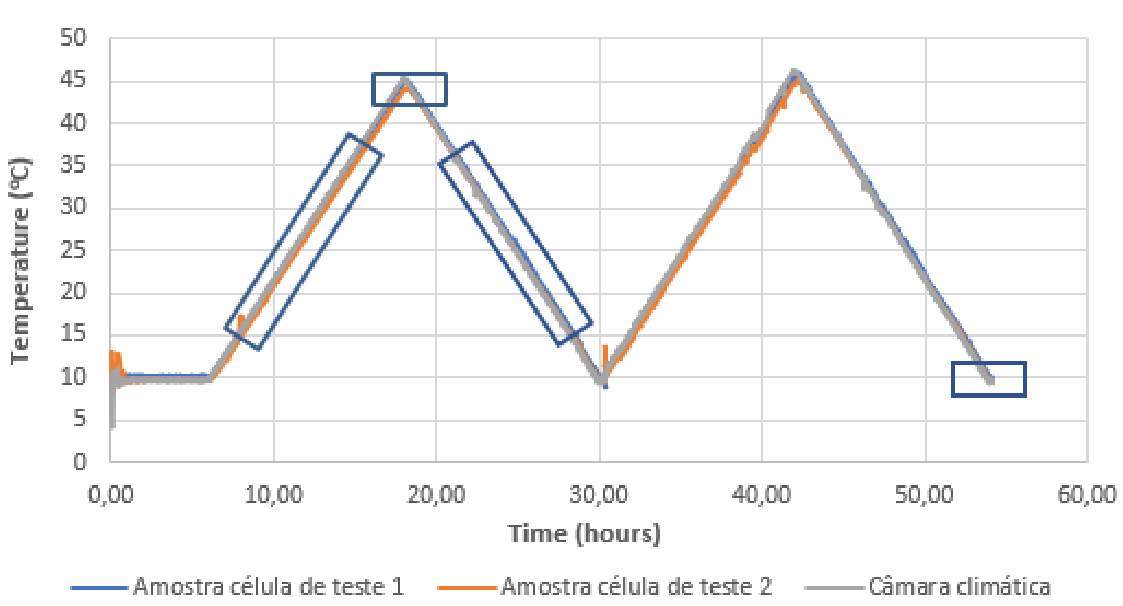
Characterization - Study of the thermal management of PCMs



Test Cell 1 - Sample with PCMs

Test cell 2 - Sample without PCMs

Climatic chamber - Ambient temperature

- The plate with PCMs, present in test cell 1, contributed to a lower thermal amplitude ($\Delta T = T_{max} - T_{min}$), of around 1,42°C, compared to the thermal amplitude of test cell 2.
- The application of PCMs contributes to an increase in thermal inertia between the inner and outer lateral face of the test cells, with an increase in the temperature difference of the two faces of approximately 50%, compared to test cell 2, where no PCMs were applied.

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Scientific Publications

Study of the influence of the incorporation of CNT's on the mechanical and sensing properties of nanocomposites produced with textile waste PET

Carlos Mota[1], Fernando Leite[1], João Bessa[1], Fernando Cunha[1], Raul Fangueiro[1,2], Guilherme Paixão[3] e João Belino[3]

[1]*Centre for Textile Science and Technology (2C2T), University of Minho, Guimarães, Portugal*
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[2]*Department of Mechanical Engineering, University of Minho, Guimarães, Portugal*
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[3]*Borgstena Textile Portugal, Unipessoal Lda, Nelas, Portugal*
guilherme.paixao@borgstena.com

Study of the thermal performance of PCMs combined with thermoplastics recycled matrices in an extrusion process

Fernando Leite[1,2], Carlos Mota[1,2], João Bessa[1,2], Fernando Cunha[1,2], Raul Fangueiro[1,2,3], Guilherme Paixão[4] and João Belino[4]

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Technology

- Transfer Technology
- Generate R&D Projects

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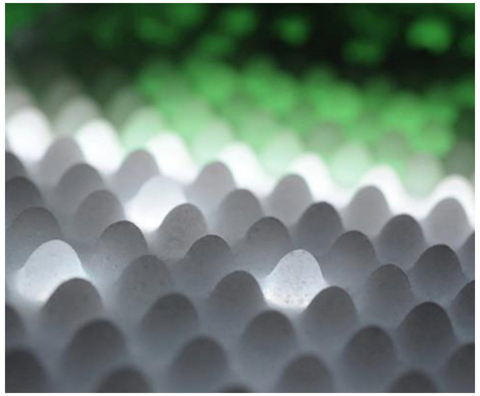
Concept Development - Technology

Sustainability



Functionality

Shape

Colour

givaware

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Concept Development - Sheet

Car interior components: Panels | Headliners | Pillars

givaware

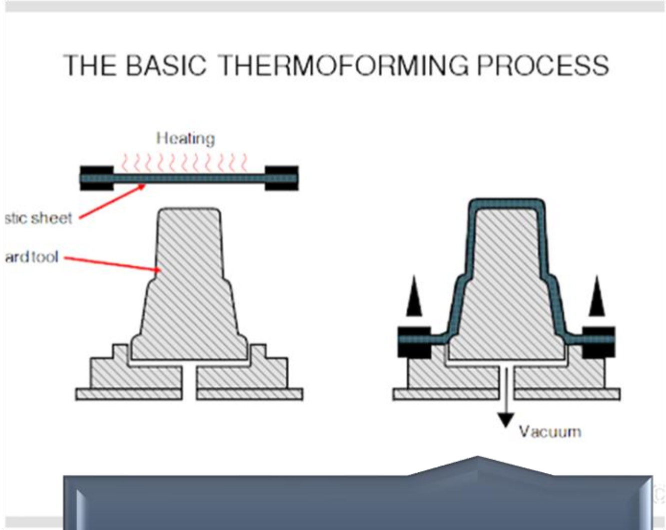
BORGSTENA textile solutions

Fibrenamics

Concept Development - Sheet

Car interior Components: Panels | Headliners | Pillars

Extrusion of sheet



Thermoforming

Car components

givaware

BORGSTENA textile solutions

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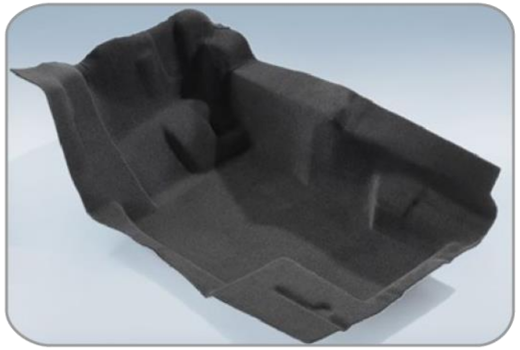
Concept Development - Filaments

Car Interior Components: Seat Fabric | Textiles | Accessories



givaware

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Concept Development - Filaments

Car Interior Components: Seat Fabric | Textiles | Accessories

Extrusão of masterbatch

Production of filament

Weaving

givaware

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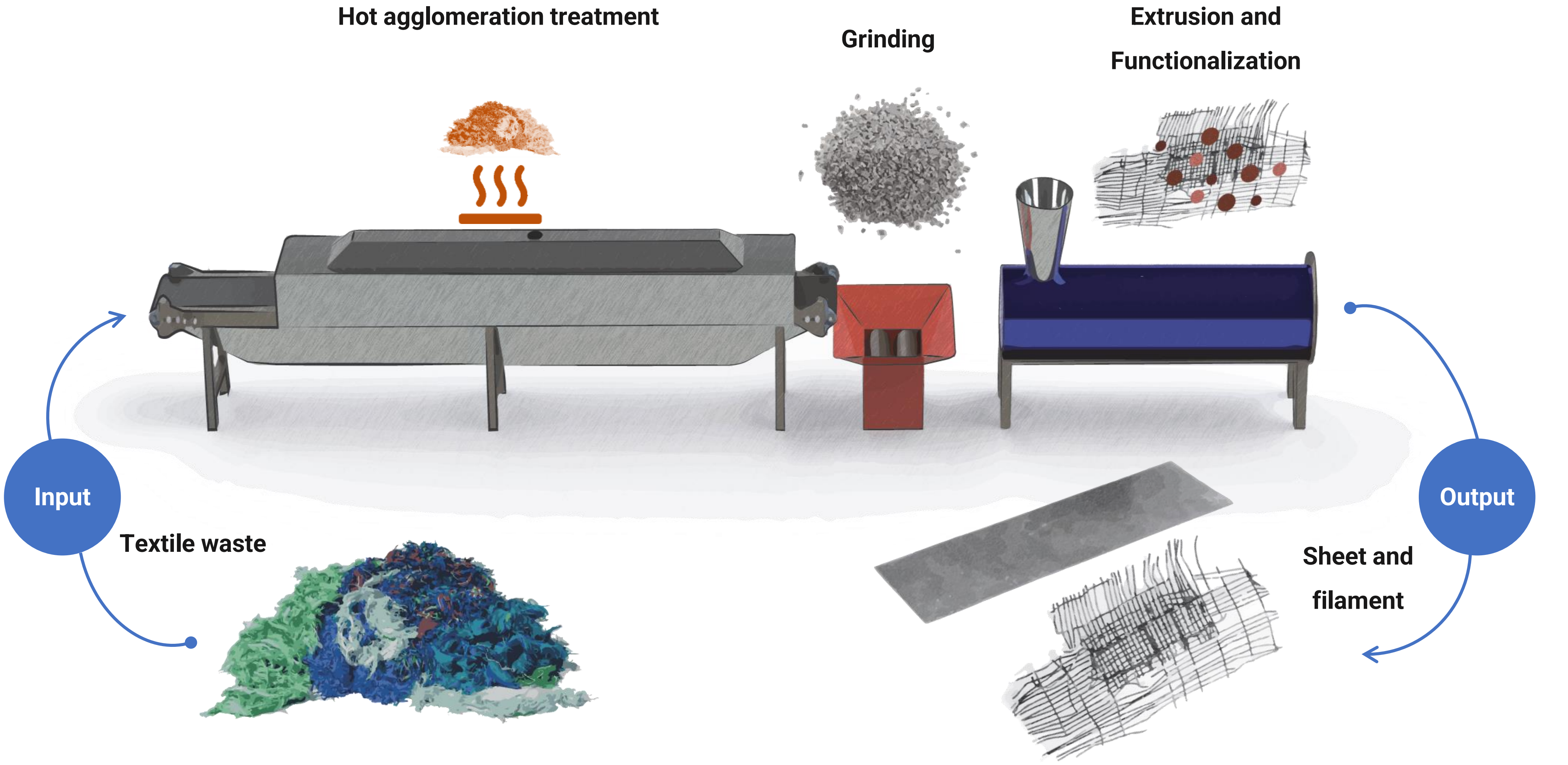
Production line layout



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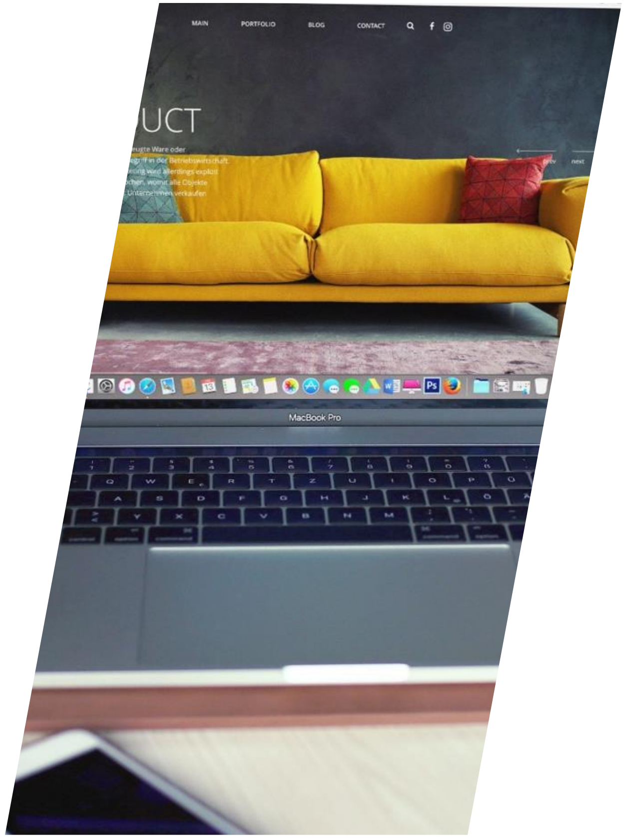
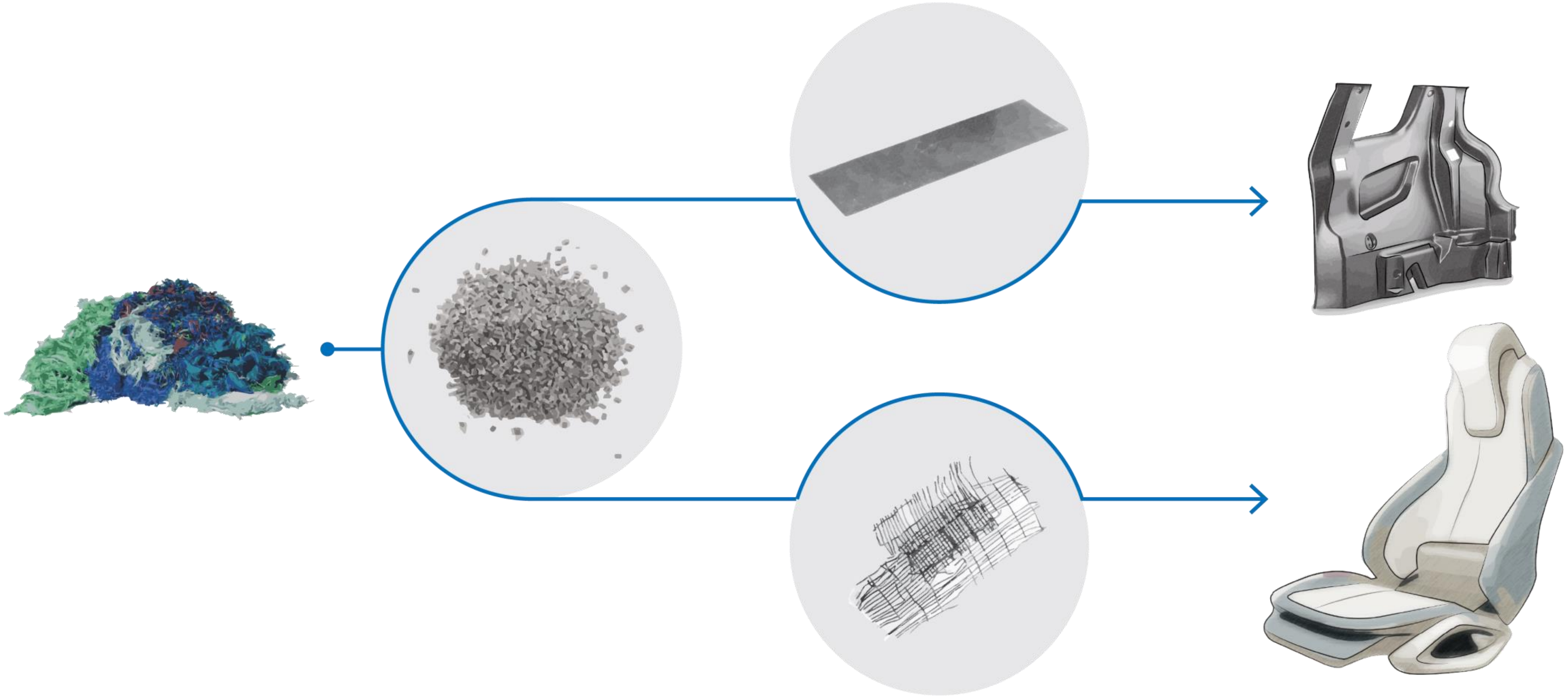


Business

- Value chains

- Generate businesses

Demonstrator models



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Website and Social Media Publications

Website Fibrenamics - https://www.fibrenamics.com/projetos/autoecomat

Website AFIA - https://afia.pt/borgstena-avanca-na-economia-circular/

Facebook Fibrenamics - https://www.facebook.com/Fibrenamics

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Participation in Fairs and Workshops

JEC WORLD 2019 The Leading International Composites Show

PARIS-NORD VILLEPINTE
March 12-13-14, 2019

- Março/2019
- Feira na área dos materiais compósitos

automotive interiors EXPO2019

- Maio/2019
- Feira na área dos componentes de interior automóvel

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Open-Day

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Acknowledgments

Funding from Portugal 2020-01-0247-FEDER-045249, entitled "AutoEcoMat - Development of multifunctional ecological materials for vehicle components, from the recycling and recovery of industrial waste".

Cofinanciado por:

COMPETE 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

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Q&A

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