20th UITIC INTERNATIONAL TECHNICAL FOOTWEAR CONGRESS
Porto 2018
16th–18th MAY

FROM FASHION TO FACTORY
A New Technological Age

An integrated approach for a more sustainable footwear

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Outline

1 | Fashion Footwear Industry: Trends

2 | R&D of New materials: Trends

3 | An integrated approach for a more sustainable footwear

4 | FAMEST - Footwear, Advanced Materials, Equipment and Software Technologies

1 | Fashion Footwear Industry: Trends

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NEW GLOBALIZATION

- Importance of brands
- Organization of retail
- Fashion & Style sensitivity
- Higher average number of pairs

ONLINE

- Different dynamic
- New questions raised by the online
- New buying experience
- Multiplatform
- Global network of customers

FEMALE POWER

- Increasing demand for women shoes
- Fashion
- Better fits & Comfort

Source: APICCAPS, 2014, Footwear consumer 2030 incorporating global trends foresight footwear market, Worldfootwear by Portuguese Shoes

Images source: Pixabay

1 | Fashion Footwear Industry: Trends

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AGEING & HEALTH

- Comfort & lifestyle
- Valorisation of different characteristics
- Higher price sensitivity demand
- Footwear adapted to health problems
- Evolution of the foot shape
- Footwear for the health sector professionals

LOW COST SHORTAGE

- Change in the product mix
- Emergence of new materials
- Growth in consumption

SUSTAINABILITY

- Social norms will be effective wheels of change
- Shift in consumer patterns
- Green materials & products

SOURCE: APICCAPS, 2014, FOOTWEAR CONSUMER 2030 INCORPORATING GLOBAL TRENDS FORESIGHT FOOTWEAR MARKET, Worldfootwear by Portuguese Shoes

IMAGES SOURCE: PIXABAY

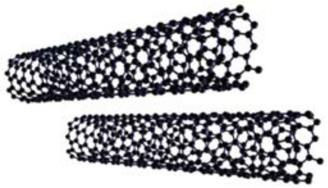
2 | R&D of New materials: Trends

NATURAL, BY-PRODUCTS & BIOBASED

BIODEGRADABLE, RECYCLED & RECYCLABLE

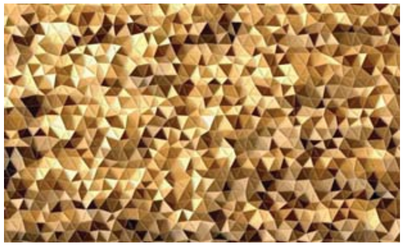
LIGHTWEIGHT

INNOVATIVE & REINFORCED COMPOSITES



NANO & FUNCTIONALISED

"SMART"



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2 | R&D of New materials: Trends

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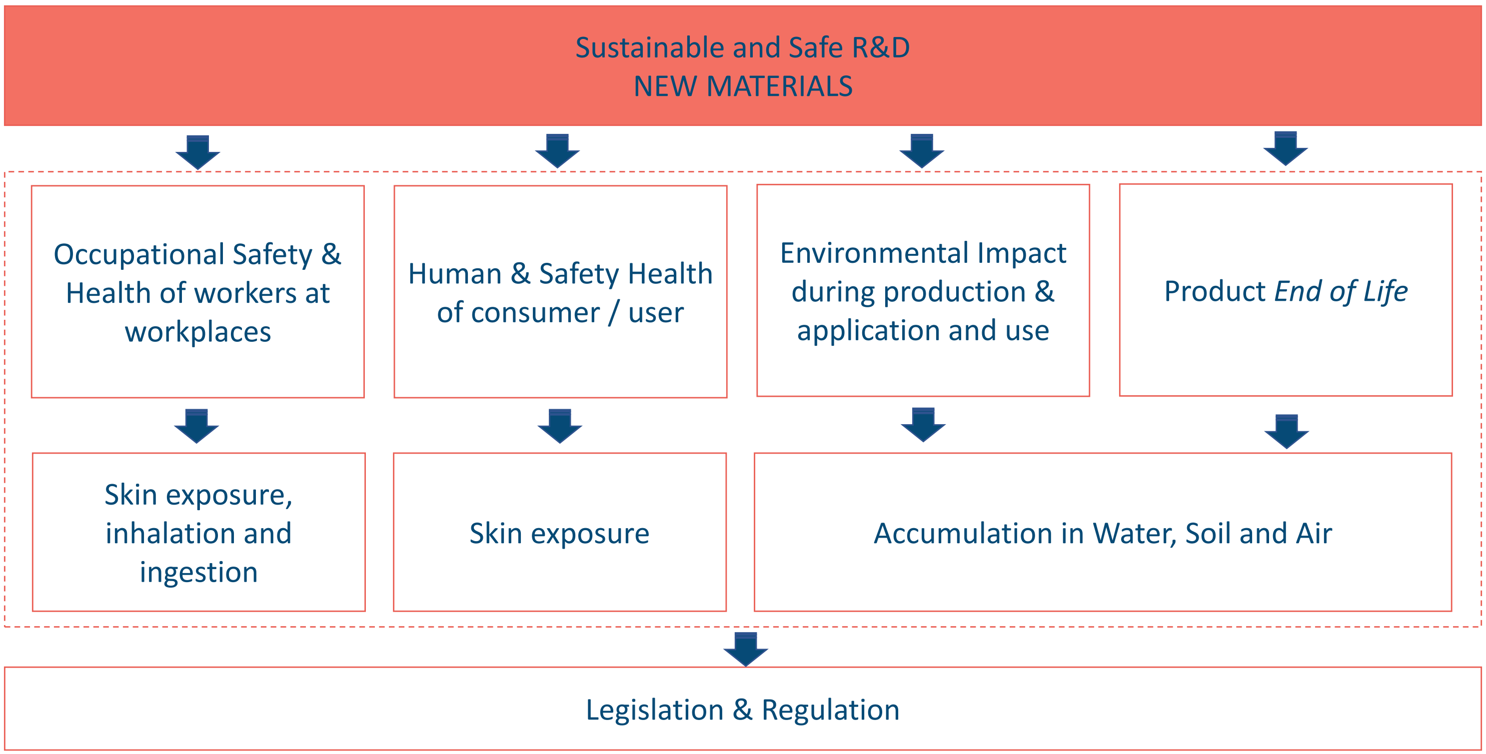
How can we produce more sustainable footwear products?

How safe are the new materials and solutions for the humans and environment?

What is the impact of the new materials and products?

How can we reduce the environmental footprint of our products?

2 | R&D of New materials: Trends



3 | An integrated approach for a more sustainable footwear

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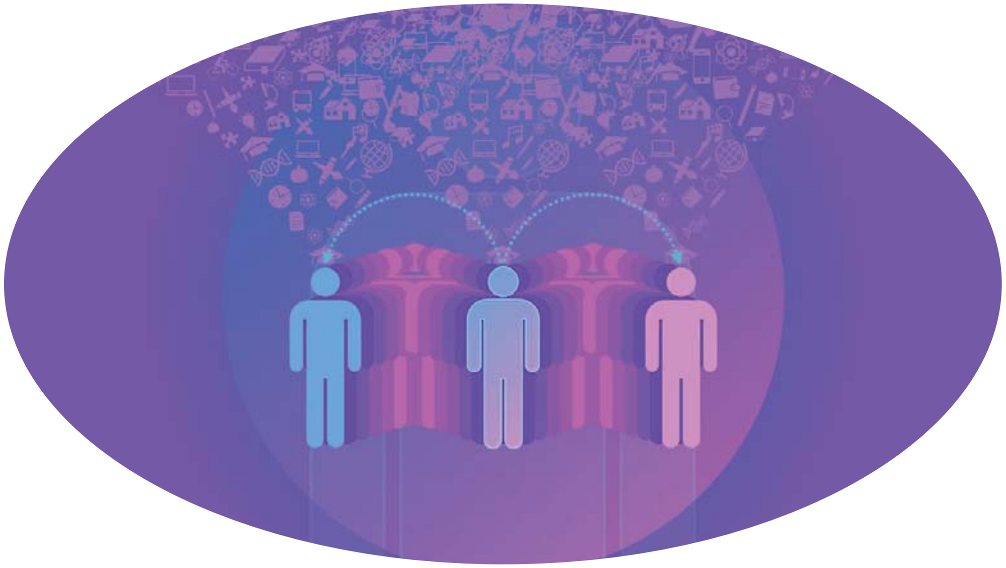
3.1 OBJECTIVE

Development of an holistic approach to ensure a more Safe and Sustainable R&D in Footwear Cluster, regarding:

- *Consumer / user of footwear*
- *Worker*
- *Environment*



IMAGES SOURCE: PIXABAY

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3.2 APPROACH

CONSUMER SAFETY & HEALTHY
Evaluation methodologies

WORKER SAFETY & HEALTHY
Evaluation methodologies

ENVIRONMENTAL IMPACT
Quantitative Evaluation

LCA of footwear
Simplified approach

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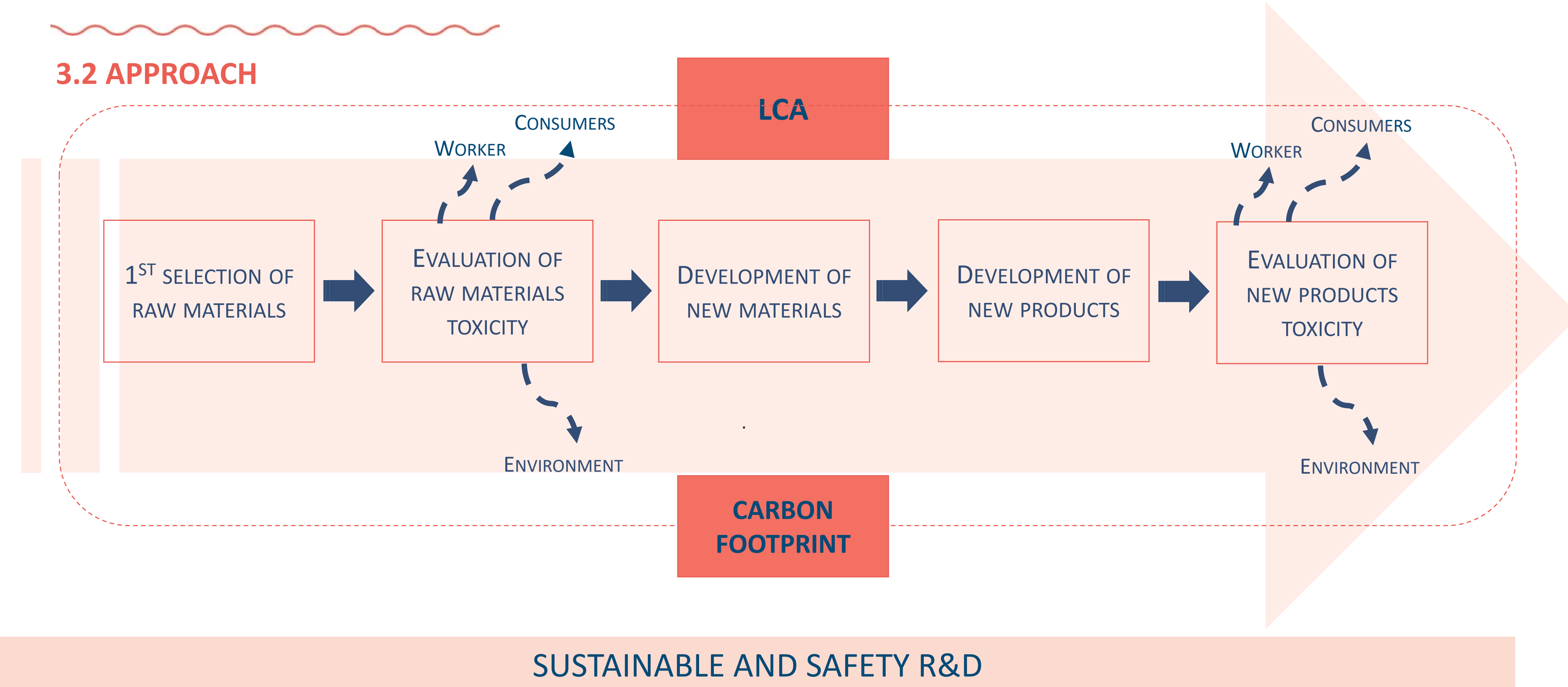
3.2 APPROACH



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3.2 APPROACH

A. EVALUATION METHODOLOGIES: HUMAN HEALTH & SAFETY

1. Evaluation of toxicity of raw materials and base materials

- toxicity tests with human cells: Intestine cells (Caco-2), Liver cells (HepG2), lung cells (SV-80) and skin cells (HaCAT)

2. Evaluation of chemical products mobilization from the new materials

- to acid and alkaline synthetic sweat
- by abrasion;

3. Evaluation of toxicity of final products

- toxicity tests with human cells: Intestine cells (Caco-2), Liver cells (HepG2), lung cells (SV-80) and skin cells (HaCAT)

4. Evaluation of production processes susceptible to generate aerosols & particles

- measurement & quantification
- good practices definition

5. Risk Management & Control

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3.2 APPROACH

B. EVALUATION METHODOLOGIES: ENVIRONMENTAL IMPACT

1. Evaluation of toxicity of raw materials and base materials

- Microtox bioluminescence test with bacteria *Vibrio fischeri* (% of decrease in the luminiescence)
- Microalgae *Raphidocelis subcapitata* growth inhibition
- Microcosm test (artificial microcosm containing a natural reference soil, earthworms and vegetation plants)

2. Calculation of Predicted Non-Effect Concentration (PNEC) & definition of limits (based on):

- EC20 & EC50 values
- No-Observed Effect Concentration (NOEC)
- Low Observed Effect Concentration (LOEC)

IMAGES SOURCE: PIXABAY

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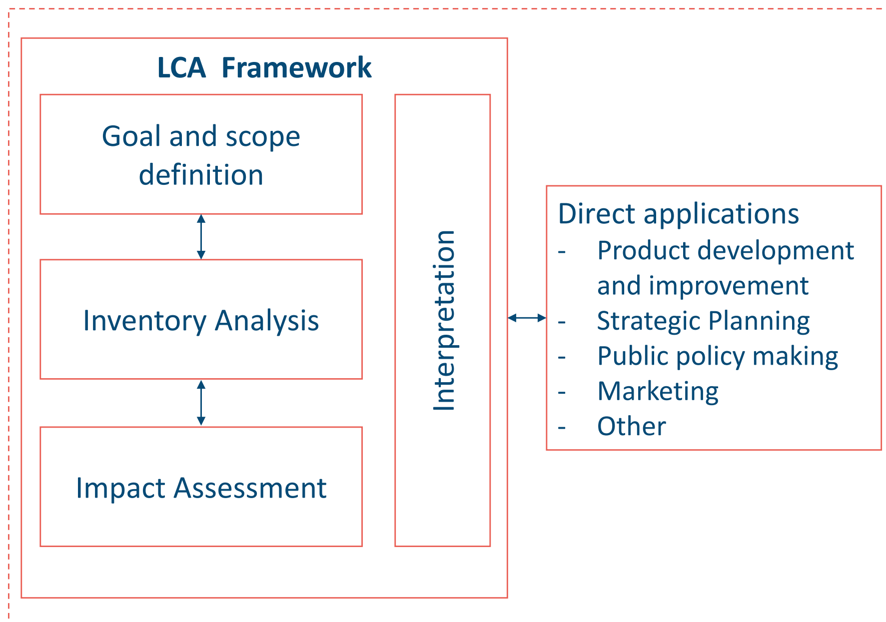
3.2 APPROACH

C. LIFE CYCLE ASSESSMENT (Simplified method)

1. Understand the Potential Impact of raw materials in Footwear Life Cycle
2. Select the materials based on LCA
3. Identify Raw-Materials and processes with major environmental benefits
4. Simplified approach based on ISO 14040 / ISO 14044 & LCA software, data from literature and data from tests



Source: ISO 14040:2006

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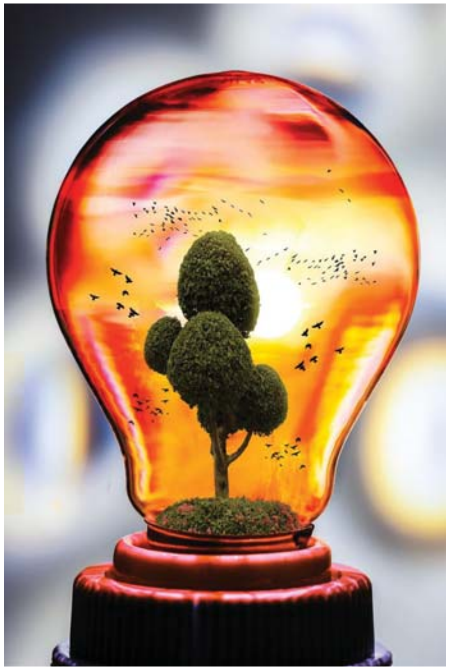
3.2 APPROACH

D. ECODESIGN & CARBON FOOTPRINT REDUCTION

*"**Eco design** is an innovative approach allowing companies to integrate environmental criteria from the product design phase with a view to reducing its impact throughout its life cycle (from the extraction of raw materials to the end of life)."*

*"**Carbon Footprint** of a product is a sum of greenhouse gas emissions and removals in a product system, expressed as CO_2 equivalents and based on life cycle assessment using single impact category of climate change."*



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3.2 APPROACH

D. ECODESIGN & CARBON FOOTPRINT REDUCTION

ECODESIGN STRATEGIES

1. New footwear concepts (e.g. bio based, recycled & recyclable, dismantling, minimalist, etc.)
2. Materials with lower environmental impact
3. Reduction of materials amount & diversity
4. Reduction of production process environmental impact
5. Reduction of environmental impact during the use of the product
6. Increase the durability of the products
7. Optimize and valorise the product and the *end-of-life*

IMAGES SOURCE: PIXABAY

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3.3 RESULTS

A. TOXICITY TESTS WITH HUMAN CELLS

Evaluation of decrease of metabolic activity using AlamarBlue method

Exposure of cell lines to NMs at different concentrations, during 24 and 48 hours

When the cells viability is ≥ 70%, the tested formulation is considered safe

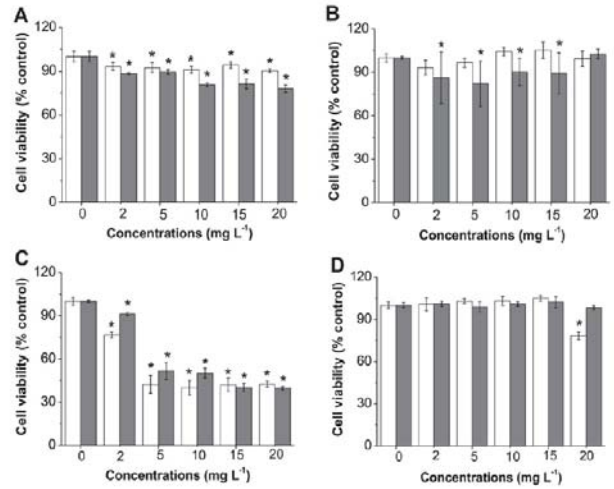

Figure 1 - Effect of nano-Cu firstly dispersed in DMSO on Caco-2 (A), HepG2 (B), SV-80 (C) and HaCaT (D) cell viability after 24 h (white bars) or 48 h (grey bars) of exposure (n=4).

NMs toxicity depends on the nanoparticle and on the cell line used.

For each NMs "each case is a case", and it is difficult to predict their toxicity based on similar NMs.

Source: Andreani, T., Nogueira, V., Pinto, V.V., Ferreira, M.J., Rasteiro, M.G., Silva, A.M., Pereira, R., Pereira, C.M., (2017). Influence of the stabilizers on the toxicity of metallic nanomaterials in aquatic organisms and human cell lines. Sci. Total Environ. 607–608, 1264–1277.

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3.3 RESULTS

B. MICROTOX TEST

Exposure of bacteria to NM suspension for 5, 10 and 30 minutes

Measurement of the luminescence of the bacteria

Fast, Robust and Reliable preliminary test for screening the aquatic toxicity of different NMs

Table 1 - *V. fischeri* toxicity results obtained from bioluminescence test (NMs in mg L^{-1} and stabilizer in %) at 5, 15 and 30 min of exposure (95% CI, inside parenthesis).

Metallic NMs	EC50 (mg L^{-1})		
	5 min.	15 min.	30 min.
Nano-Ag in water	> 20	20.8 (16.0-27.2)	11.8 (11.2-12.5)
Nano-Ag in PVA	> 20	15.7 (4.3-57.5)	6.2 (5.5-6.9)
Nano-Cu in water	> 20	12.7 (10.5-15.4)	7.4 (5.7-9.7)
Nano-Cu in DMSO 1%	> 20	> 20	6.6 (NC)
Stabilizers	HE		
DMSO 1%	8.72%	12.43%	9.49%
PVA 1.4%	17.22%	13.48%	15.04%

Source: Andreani, T., Nogueira, V., Pinto, V.V., Ferreira, M.J., Rasteiro, M.G., Silva, A.M., Pereira, R., Pereira, C.M., (2017). Influence of the stabilizers on the toxicity of metallic nanomaterials in aquatic organisms and human cell lines. Sci. Total Environ. 607–608, 1264–1277.

3.3 RESULTS

C. MICROALGAE GROWTH INHIBITION TEST

Preparation of algae inoculum for tests
(algae culture in exponential growth + algae culture medium) + incubation for 72 h under photoperiod conditions + determination of cell's density of algae inoculum

↓

Dilution of NMs in algae culture medium to prepare different concentrations

↓

Plates carried out under same conditions of cultures and required by the standard protocol, during 72 hours + cells resuspension twice a day and counting

↓

Determination of percentage of algae growth inhibition (comparing the number of cells in the control with the treatments)

Table2 - Effective concentrations (EC50), LOEC and NOEC in mg L^{-1} of metallic NMs to algae *R. subcapitata* after 72 h of exposure (95% CI, inside parenthesis).

Metallic NMs	EC_{50} (mg L^{-1})	LOEC (mg L^{-1})	NOEC (mg L^{-1})
Nano-Ag in water	6.9(6.5-7.1)	4.9	3.1
Nano-Ag in PVA	0.25 (0.04-0.47)	0.3	--
Nano-Cu in water	4.83 (4.37-5.29)	4.9	3.1
Nano-Cu in DMSO 1%	9.2 (8.4-10.1)	3.1	1.9

Source: Andreani, T., Nogueira, V., Pinto, V.V., Ferreira, M.J., Rasteiro, M.G., Silva, A.M., Pereira, R., Pereira, C.M., (2017). Influence of the stabilizers on the toxicity of metallic nanomaterials in aquatic organisms and human cell lines. Sci. Total Environ. 607–608, 1264–1277.

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3.3 RESULTS

D. MICROCOSM EXPERIMENT

Creation of an artificial microcosm containing natural reference soil, earthworms and vegetation plants

Understand the fate and toxicity of footwear materials containing new treatments in the soil environment and the effect on the overall community

1) Earthworms survival, growth and reproduction
2) Colonization behaviour or earthworms
3) Seeds germination and seedlings growth
4) Feeding activity of earthworms in each side of the microcosm boxes
5) Soil microbial activity

Figure 2 - Microcosm experiment before and after the germination of *Brassica oleracea* seeds.

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4 | FAMEST - Footwear, Advanced Materials, Equipment and Software Technologies

4.1 PROJECT AREAS

FAMEST SHOE
Tools and concepts for future footwear

FAMEST MAT
New chemical products, materials & functional products

FAMEST TECH 4.0
Advanced Technologies for production & commercialization

FAMEST GREEN
Solutions for sustainable management in footwear cluster

4 | FAMEST - Footwear, Advanced Materials, Equipment and Software Technologies

4.2 PROJECT OBJECTIVES

INNOVATION

Product design | Materials & Components | Equipment & Processes | New business models | Digital Economy | Sustainable & Responsible Development

QUALIFICATION

Young People| Human Resources | Companies & Institutions to strength the competences of Footwear Cluster (creation, promotion and management)

INTERNATIONALIZATION

Intensity the image of National Footwear Cluster

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4.3 PARTNERS

Footwear & Retail	Kyaia; Centenário; eureka (SHOES : ACCESSORIES : BAGS); CARITÉ (SHOEMAKING GROUP); Jefar; JOIA calçado, s.a.; AMF; ARCOPEDICO
Materials & components	Curtumes Aveneda, lda; Curtumes Boaventura; RUTRA, LDA.; DIAS RUIVO; Aloft; Atlanta; AGLOMEX - Componentes para Calçado; 3D CORK
Chemical Products	INDINOR INDÚSTRIAS QUÍMICAS, SA
Equipment & Software	cei by ZIPOR; flowmat sistemas industriais, lda; inocam; SOLUÇÕES INFORMÁTICAS [KSI]; oficinaware; Pegasil by ZIPOR
Research	ctcp centro tecnológico do calçado de portugal; Centro de Computação Gráfica; CTIC Centro Tecnológico das Indústrias do Couro; U.PORTO FC Faculdade de Ciências Universidade do Porto; U.PORTO FEUP Faculdade de Engenharia Universidade do Porto; U.PORTO Faculdade de Desporto Universidade do Porto; isep Instituto Superior de Engenharia do Porto; Universidade do Minho; inegi driving innovation; INESCTEC; ipb Instituto Politécnico de Bragança

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4.4 CO-FINANCED

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An integrated approach for a more sustainable footwear

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FCUP: Carlos M. Pereira, Ruth Pereira, Tatiana Andreani, Verónica Nogueira

Thank you very much!

Portuguese Footwear Technological Centre

APICCAPS
Portuguese Footwear, Components and Leather Goods Manufacturers' Association

UITIC
International Union of Shoe Industry Technicians

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