

ENCONTRO
COM A CIÊNCIA
E TECNOLOGIA
EM PORTUGAL
16 a 18 MAIO 2022
#ciencia2022PT

Universidade do Minho
Escola de Ciências

Materials biotecnológicos na transição para uma (bio)economia circular

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Motivation The need for eco-friendly polymeric materials



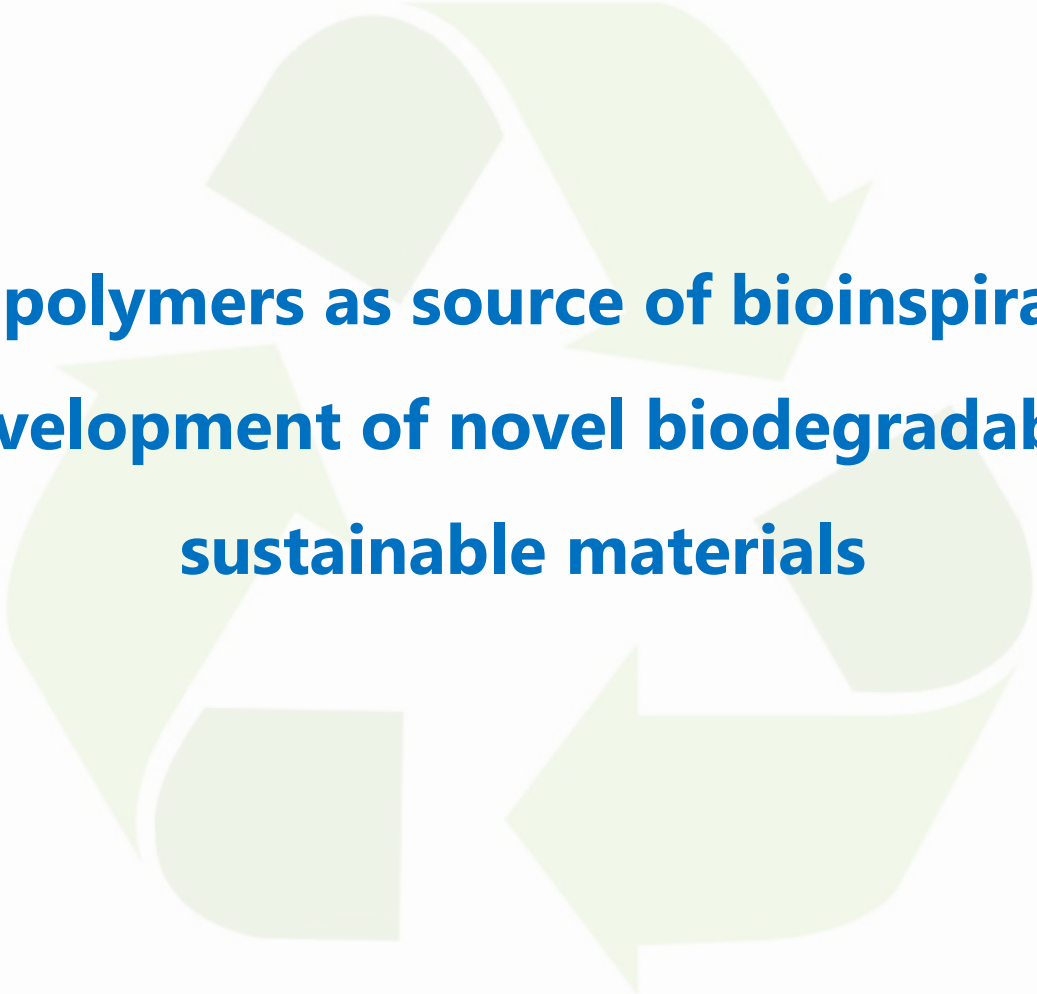
**Environmental
pressure**



**Health and
well-being**



Nature: Source of Inspiration and Design



**Protein polymers as source of bioinspiration for
the development of novel biodegradable and
sustainable materials**

Natural Structural Proteins

mechanical properties | unmatched biocompatibility and biodegradability

Impact
absorbers



Energy store for
running



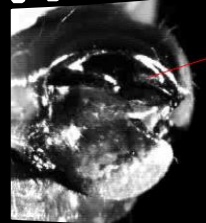
Flow
smoothers



Energy store
in flight and
swimming



Power
amplifiers



Protective
covering



Structural
support and
prey catching



Structural Proteins / Protein Polymers (PPs)

- ➔ Involved in structural protein functions
- ➔ Proteins consist of **short repetitive** amino acid motifs/blocks
- ➔ The short repetitive motifs provide a **structural element** to account for the basic properties of the natural protein

Proteins	Repeat unit sequence	
Elastin	VPGVG, VPGG, APGVGV	β -turns, β -spiral
Silk fibroin	GAGAGS	antiparallel β -sheets
Byssus	GPGGG	
Abductin	GGFGGMGGGx	
Flagelliform silk	GPGGx	
Dragline silk	GPGQQ, GPGGY, GGYGPGS	
Keratin	AKLKLAEAKLELA	

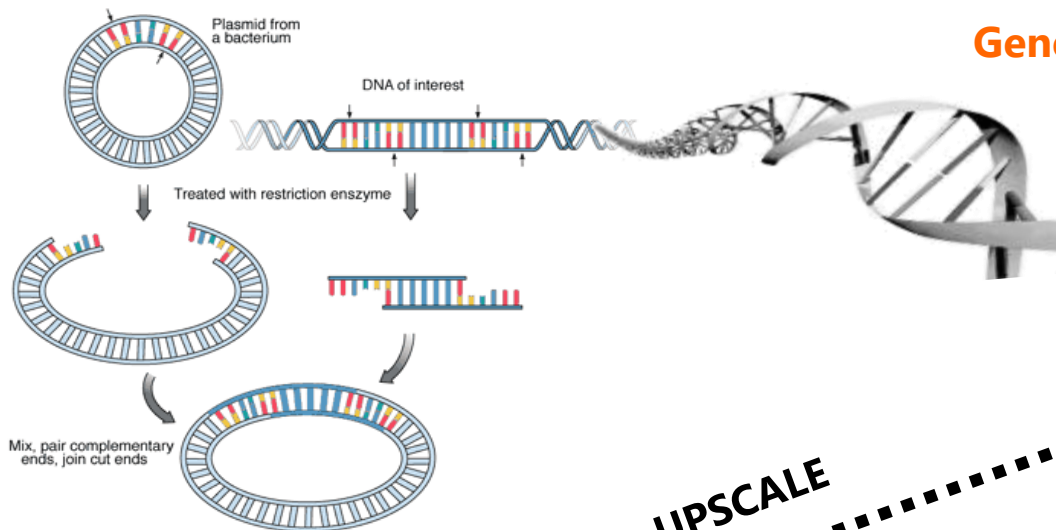
V – valine
 P – Proline
 G – Glycine
 A – Alanine
 S – Serine
 F – Phenylalanine
 M – Methionine
 Q – Glutamine
 Y – Tyrosine
 K – Lysine
 L – Leucine
 E – Glutamic acid

Biotechnological Protein Polymers

Synthetic Protein Polymers / Biotechnological Materials

- Inspired by natural structural proteins
- Designed/tailored by exploiting the 20 natural occurring amino acids – *de novo* design
- Modular design / Multiple Block Assembly – allowing to combine in the same protein two or more distinct properties
- Prepared by: **Recombinant DNA technology**
gene construction / microbial expression
 - » *production of polymers with precise composition*
 - » *precise sequence*
 - » *precise length*

Microbial Cell Factories

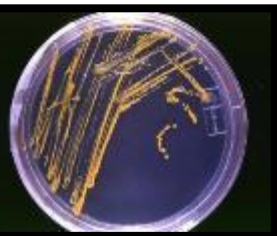


Genetic Engineering

Upscale production

UPSCALE

Protein Expression



200 ml | BioFlo 110 Fermentor | bioengineering 75L LP351 bioreactor | 500 L BIOSTAT

de novo Biotechnological Protein Polymers

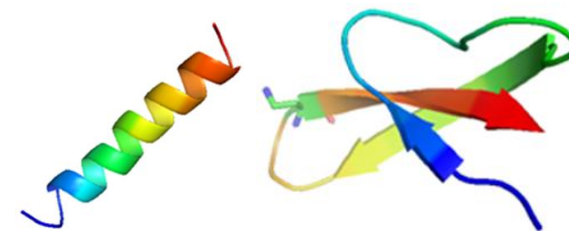
Natural Blueprint



Mammalian tropoelastin



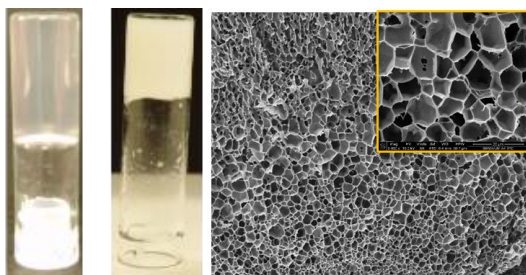
Silk fibroin



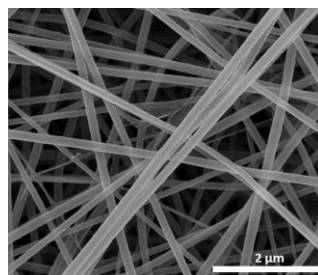
Antimicrobial peptides



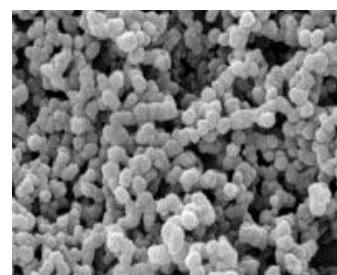
Fabrication



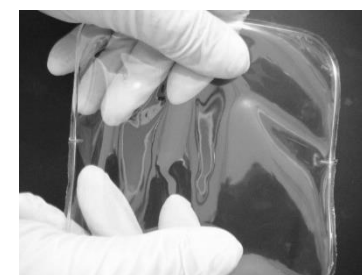
Hydrogels



Nanofibers

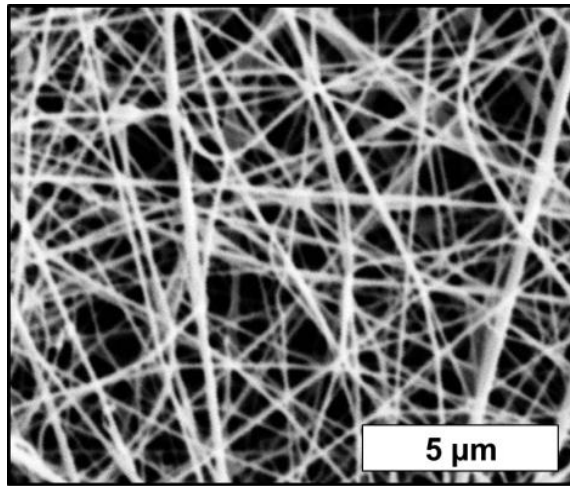


Nanoparticles



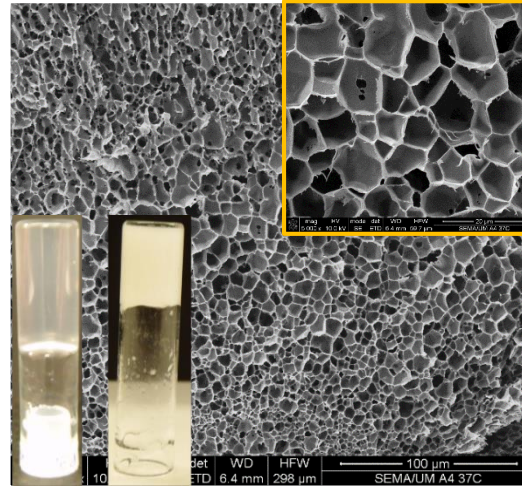
Films

biotechnological functional materials



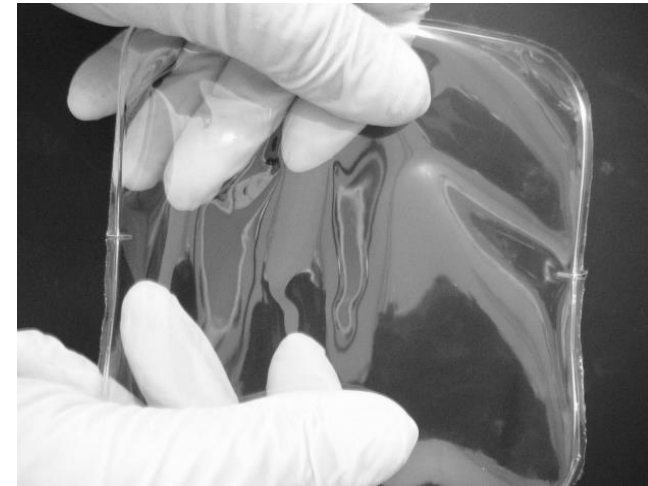
Fibre mats

- No cytotoxicity
- Good mechanical and wettability properties



Hydrogels

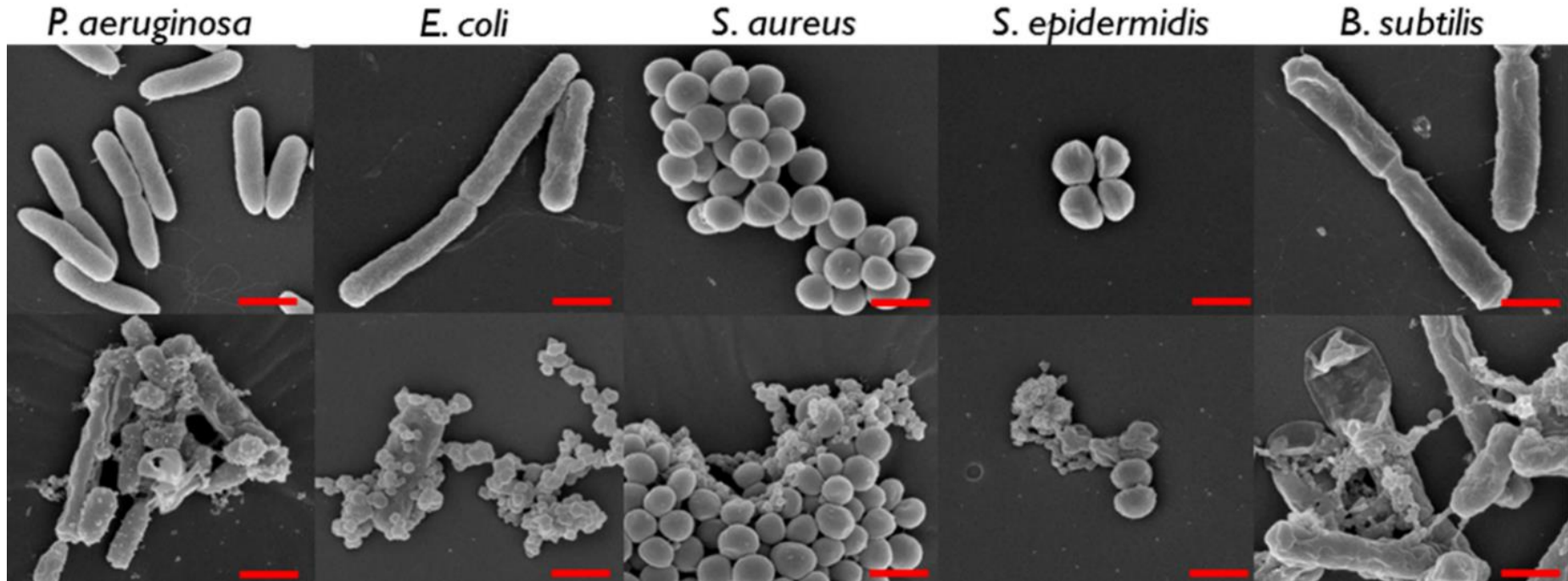
- Good mechanical and wettability properties
- Customized porosity and softness (concentration)
- Gelation at mild temperatures (~37 °C)



Free standing films

- No cytotoxicity
- Good mechanical properties (~ PLA)
- Thermal stability
- High transparency

de novo Biotechnological Protein Polymers



- Broad antimicrobial activity
- No cytotoxicity (even after 72 h; tests with human cell lines)

- ❑ **Good mechanical properties and thermal stability**
- ❑ **Absence of cytotoxicity**
- ❑ **Versatility of processing**

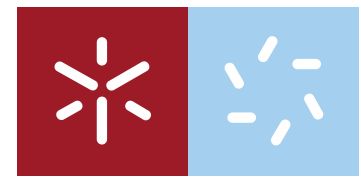


Development of multifunctional composites

- Improved antimicrobial incorporation of silver nanoparticles
- Active biocomposites incorporation of essential oils
- Piezoresistive materials incorporation of carbon nanotubes
- Magnetic materials incorporation of magnetic nanoparticles
- New generation of bioplastics blending with Poly lactic acid (PLA)

PROMISING SUSTAINABLE AND ECO-FRIENDLY MATERIALS





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Thanks for your attention !

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