

# **22<sup>nd</sup> PA7 Steering Group Meeting KNOWLEDGE SOCIETY**



# **DANUBIUS YOUNG SCIENTIST AWARD 2021 SERBIA**

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**Faculty of Agriculture, University of Belgrade**

# DANUBIUS YOUNG SCIENTIST AWARD 2021

## SERBIA

- **Name:**  
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- **Position:**  
Research assistant
- **Affiliation:**  
University of Belgrade, Faculty of Agriculture,  
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- **Research interest:**  
encapsulation systems for active food packaging and functional food ingredients,  
biodegradable materials, natural sources of active compounds



# DANUBIUS YOUNG SCIENTIST AWARD

## SERBIA 2021



**DANUBIUS YOUNG SCIENTIST AWARDS**



**DOCTORAL DISSERTATION**

**SYNTHESIS AND CHARACTERIZATION OF  
ACTIVE FIBERS AND FILMS BASED ON  
POLY( $\epsilon$ -CAPROLACTONE) AND ZEIN**

**Mentor: Prof. Dr. Viktor Nedović**

**UNIVERSITY OF BELGRADE, FACULTY OF AGRICULTURE  
DEPARTMENT OF FOOD TECHNOLOGY AND BIOCHEMISTRY**

**APRIL, 2021**



# GLOBAL ENVIRONMENTAL ISSUES

## FOOD LOSS AND WASTE

Oxidation processes

**33% food never eaten**  
=  
**173 kg per person per year**

Microbial growth

## POLYMERIC PACKAGING MATERIALS

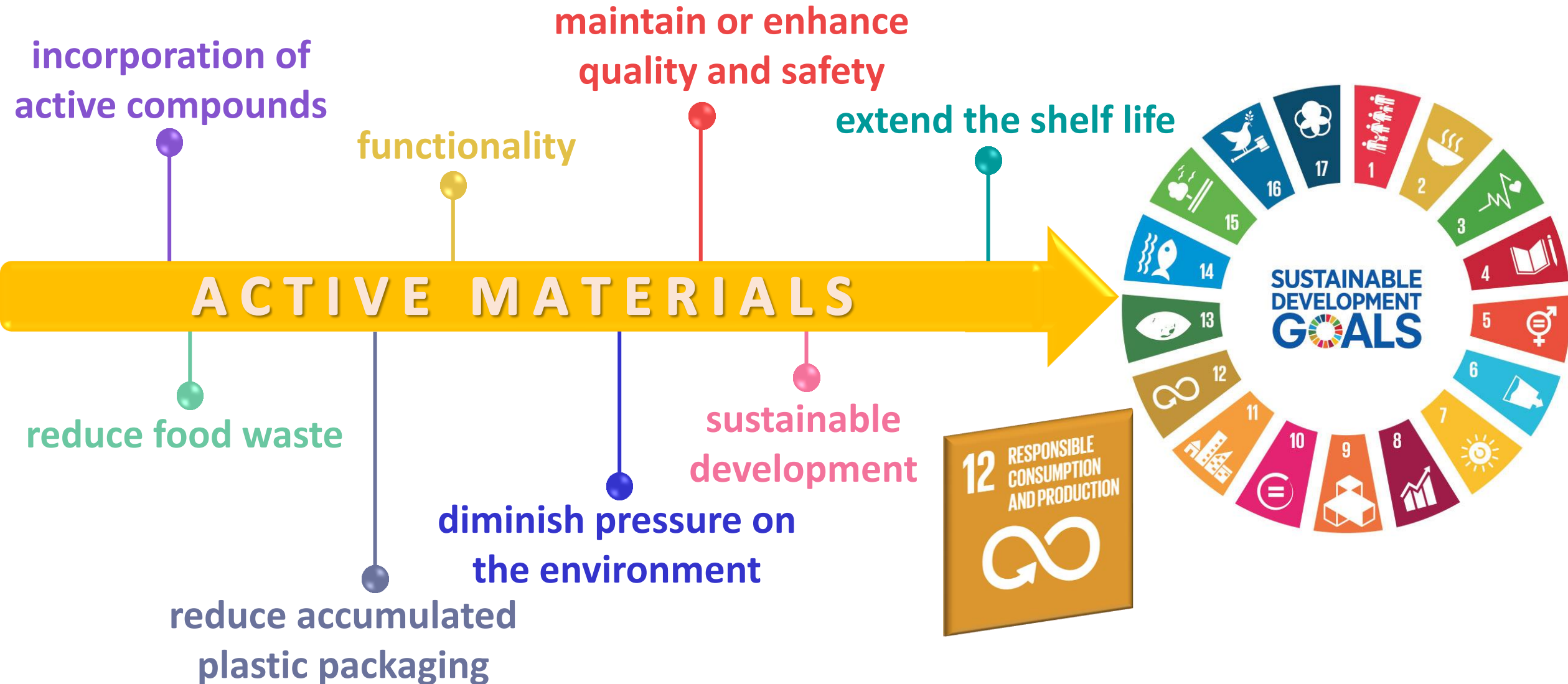
**8 million t per year of plastic waste in Europe**  
=  
**800 Eiffel towers**

Waste accumulation problems

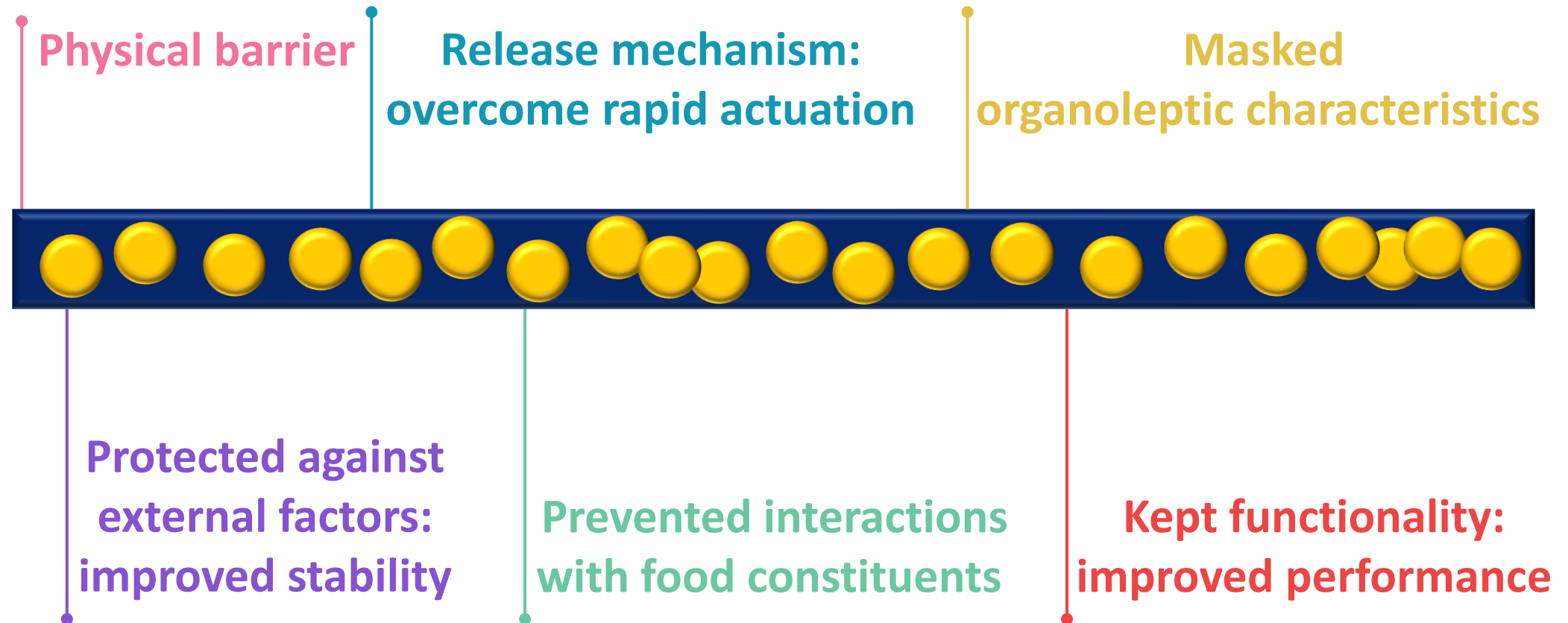
Depletion of natural resources



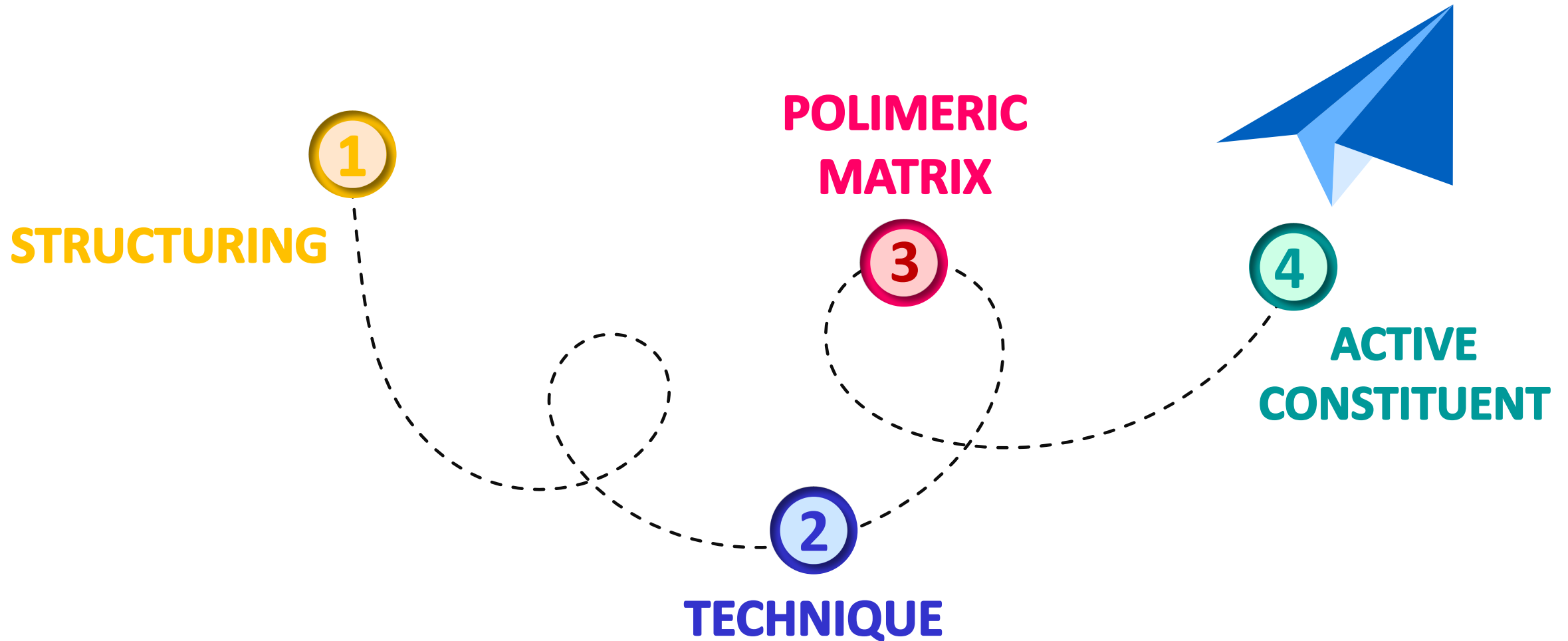
# NOVEL CONCEPT OF FOOD PACKAGING



# INCORPORATION OF ACTIVE COMPOUNDS WITHIN POLYMERIC MATRIX



# DEVELOPMENT OF ACTIVE MATERIALS





# RESEARCH AIMS

## ● DEVELOPMENT OF ACTIVE, ECO-FRIENDLY FOOD PACKAGING MATERIALS

- use of naturally derived active compounds
- use of biodegradable polymers of different origins
- various polymeric structures incorporating active constituent
- the effects of the active constituent incorporation and its content, nature, and structure of the polymeric matrix on the properties of the materials

1.

# PREPARATION AND CHARACTERIZATION OF ACTIVE CONSTITUENT

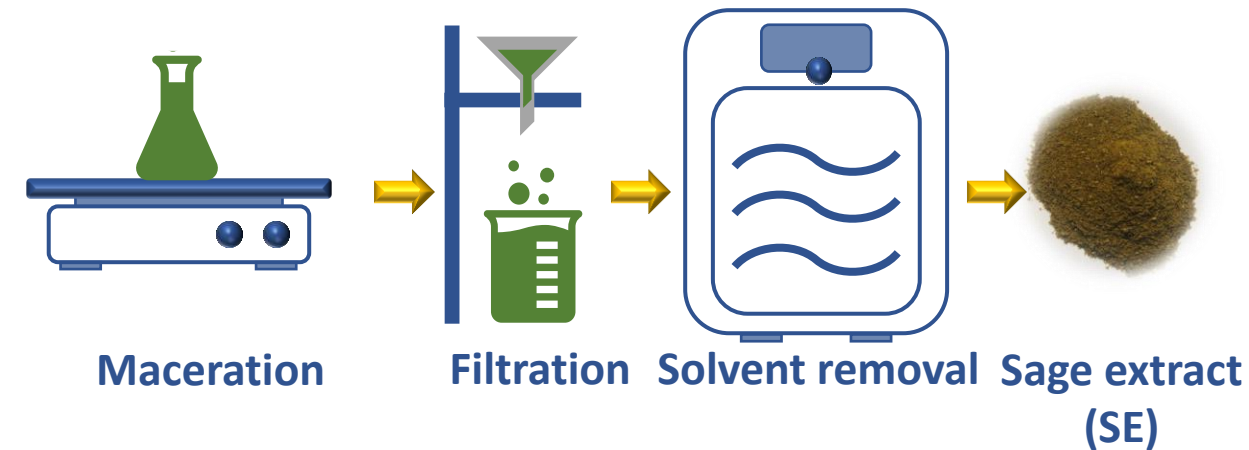
- SAGE (*Salvia officinalis* L.)**

- Good source of phenolic compounds

- Antioxidant activity:  
inhibition of 2,2-diphenyl-1  
picrylhydrazyl (DPPH<sup>•</sup>) free radicals

- Antibacterial activity:  
against foodborne pathogens  
*Staphylococcus aureus* and *Escherichia coli*

- Potential to be used as  
a natural, functional constituent



Maceration

Filtration

Solvent removal

Sage extract  
(SE)

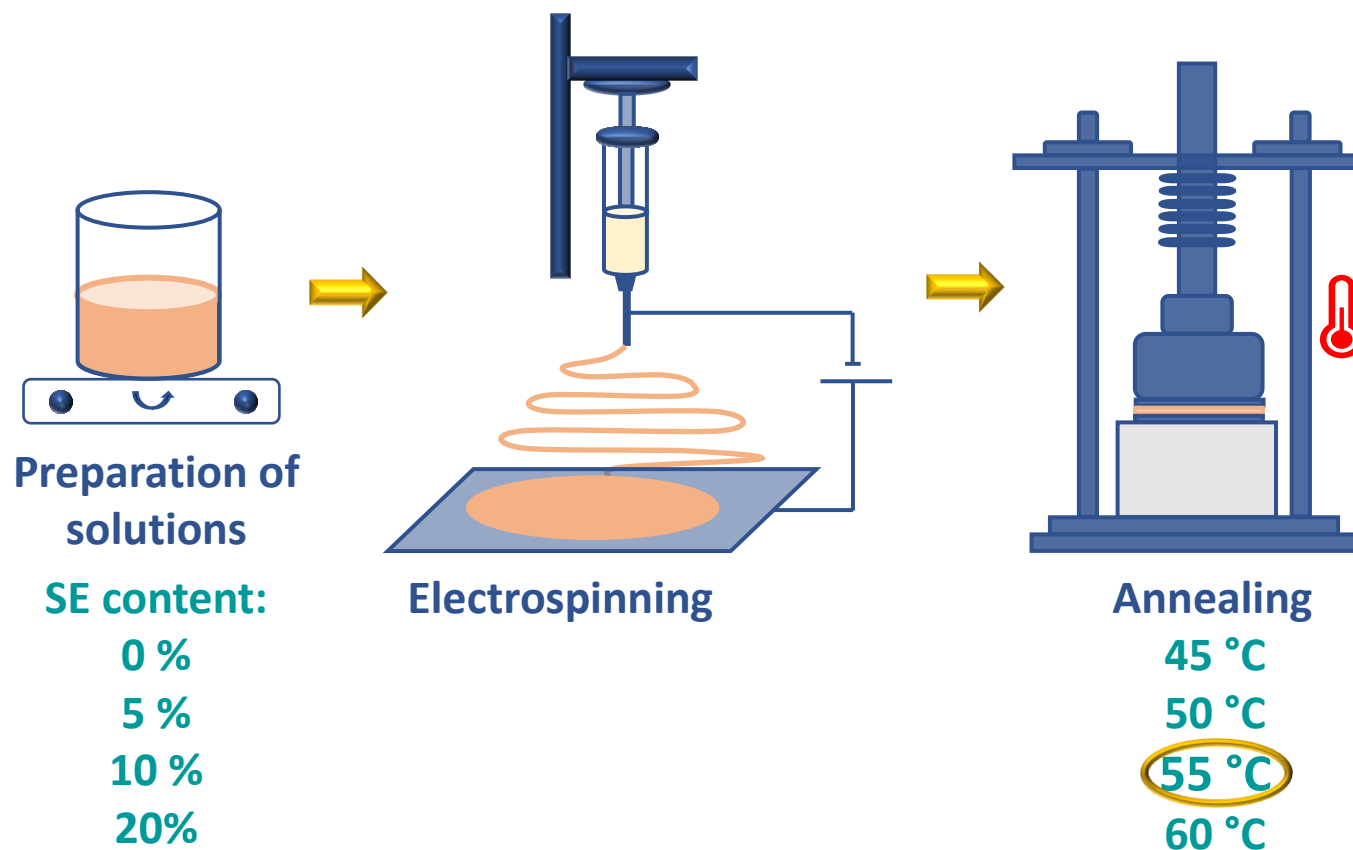
time

extraction medium  
plant to solvent ratio

2.

# SYNTHESIS AND CHARACTERIZATION OF POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

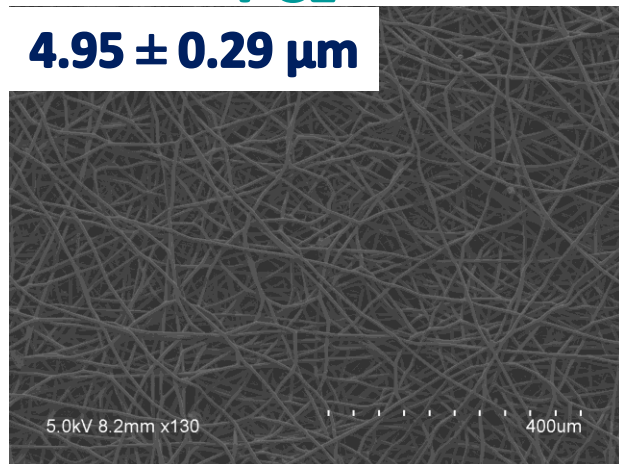
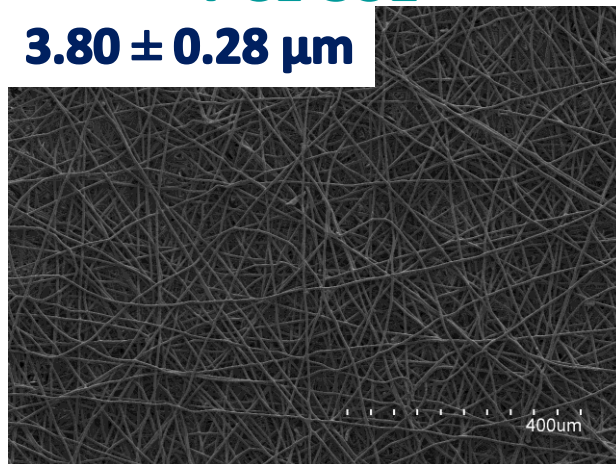
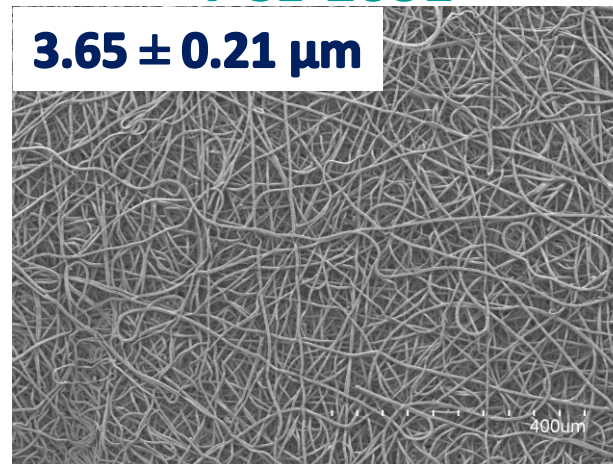
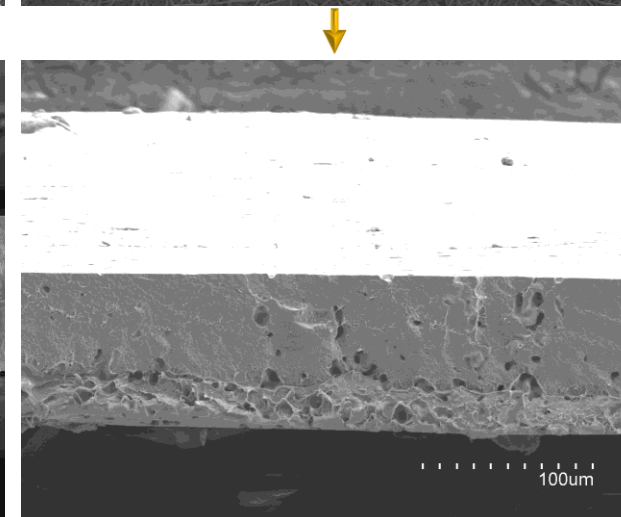
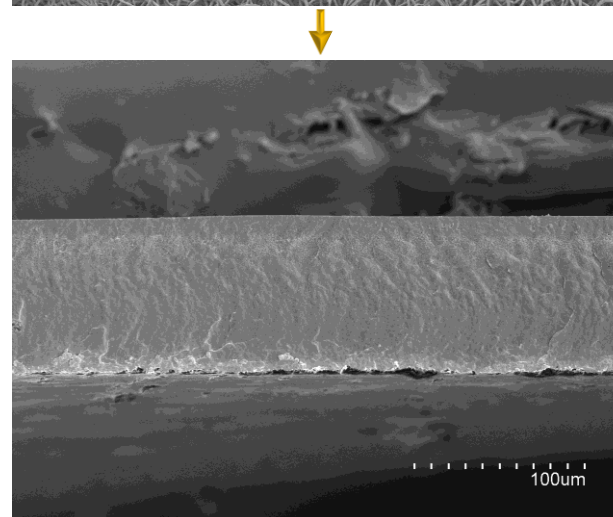
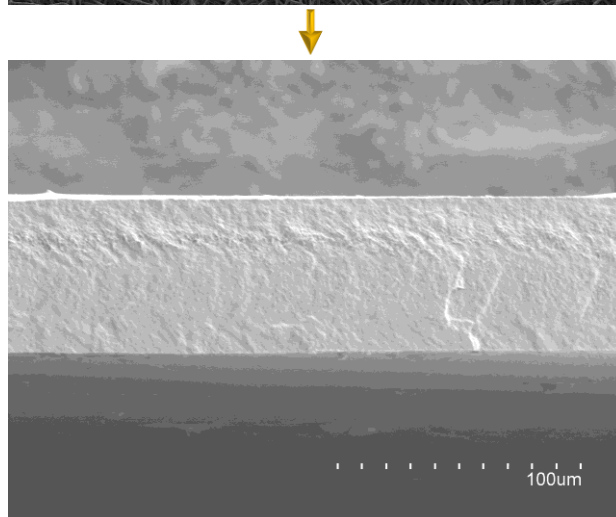
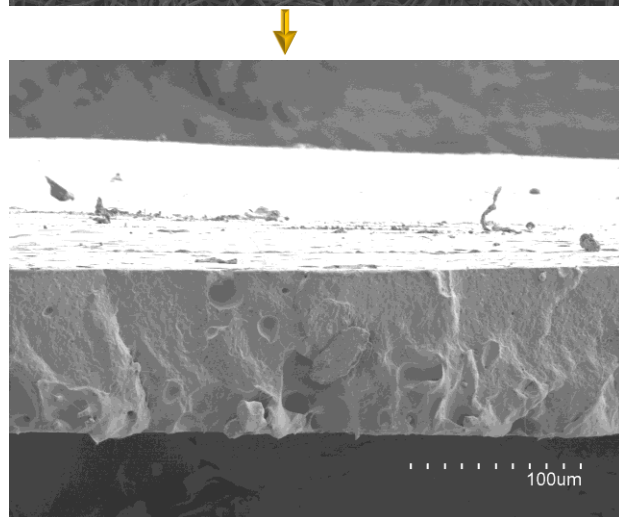
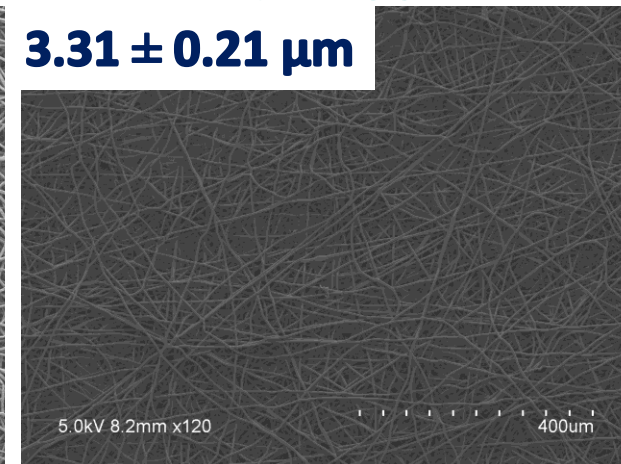
- Chemical synthesis
- Biodegradable



2.

# POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

## THERMAL TREATMENT OF THE ELECTROSPUN FIBROUS MATS

**PCL** $4.95 \pm 0.29 \mu\text{m}$ **PCL-5SE** $3.80 \pm 0.28 \mu\text{m}$ **PCL-10SE** $3.65 \pm 0.21 \mu\text{m}$ **PCL-20SE** $3.31 \pm 0.21 \mu\text{m}$ 

- Stand-alone packaging applications
- Turned into structures of compact, continuous films



# POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

## ELECTROSPUN MATERIALS

PCL

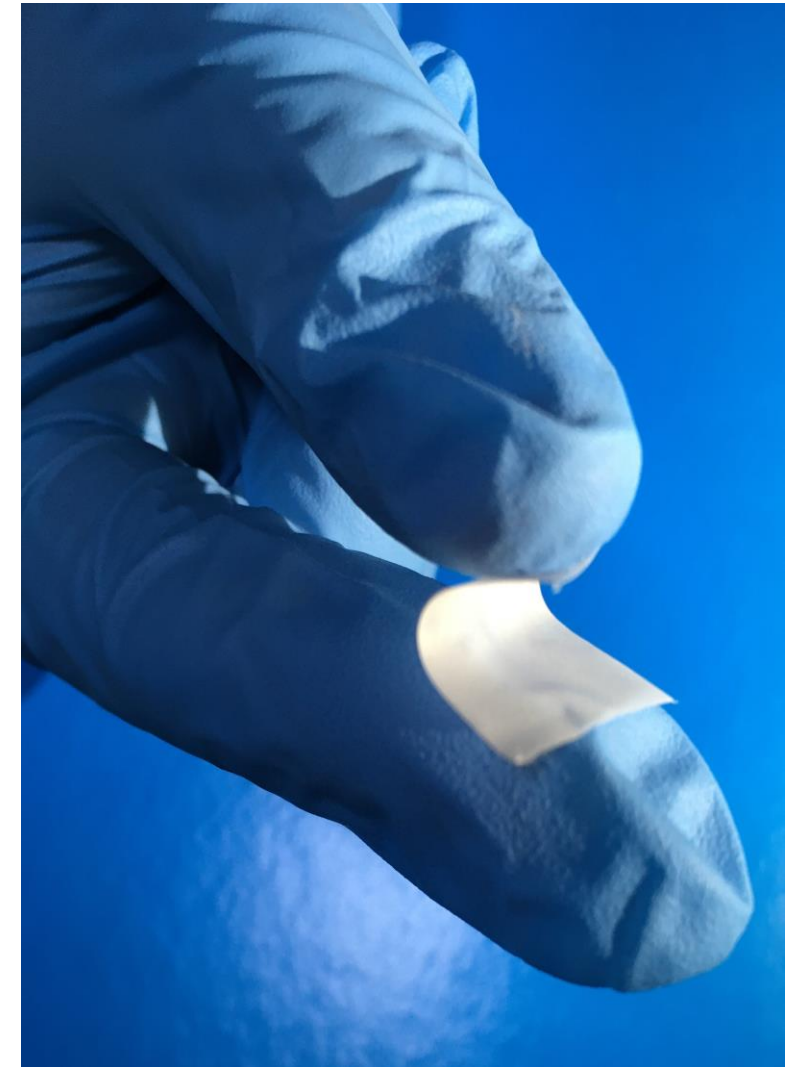
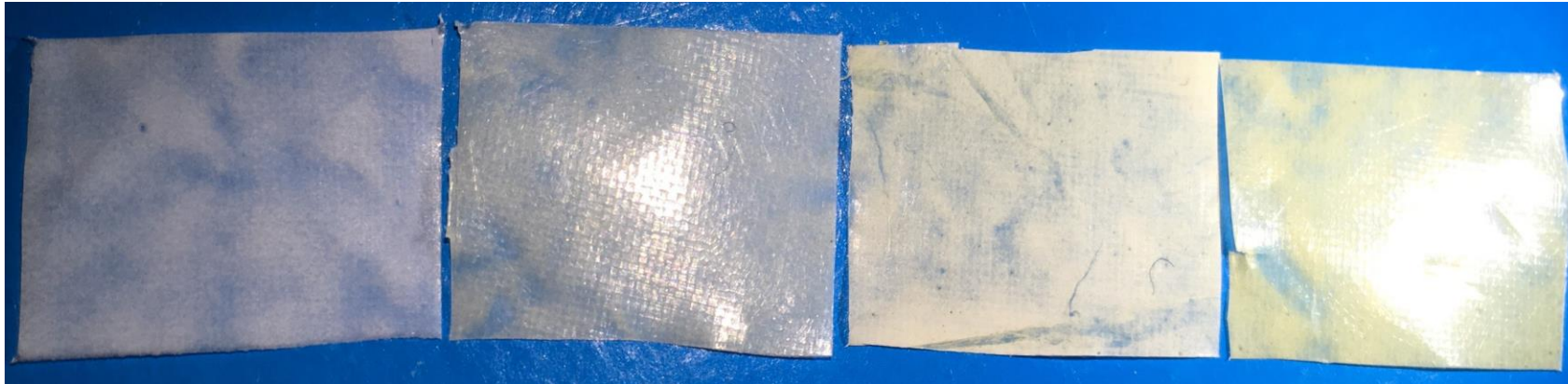
PCL-5SE

PCL-10SE

PCL-20SE



## ANNEALED MATERIALS

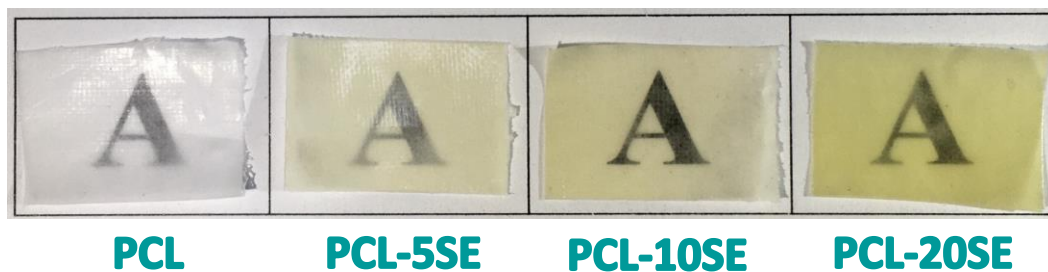
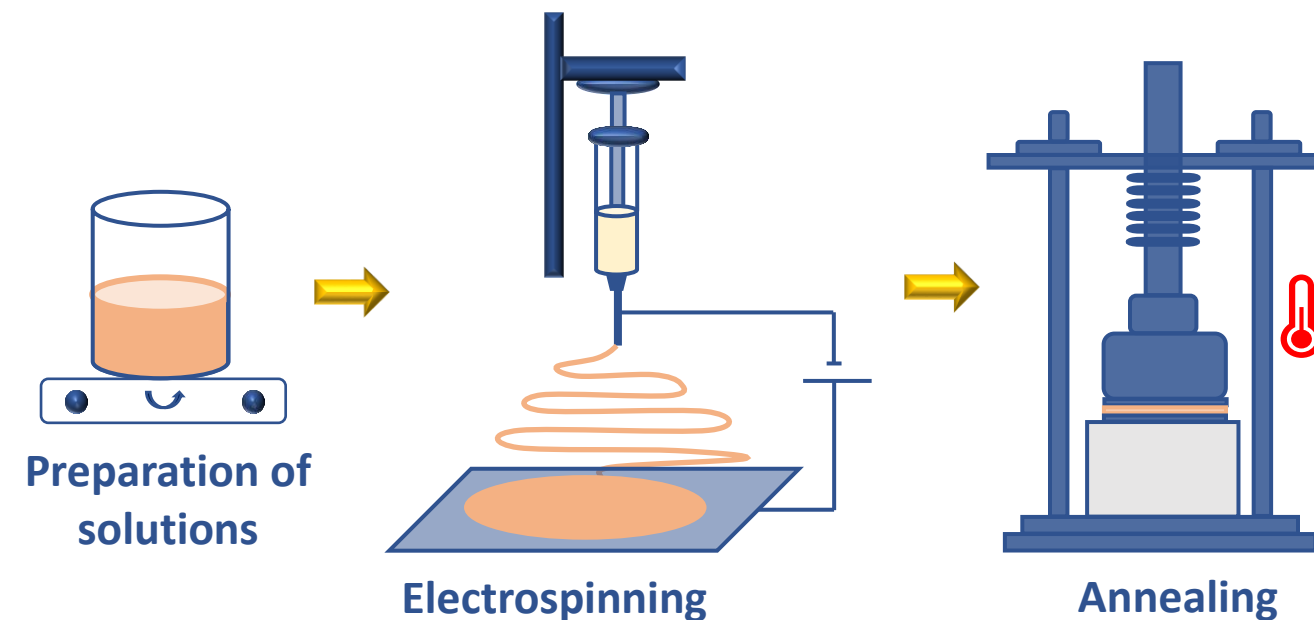




2.

# POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

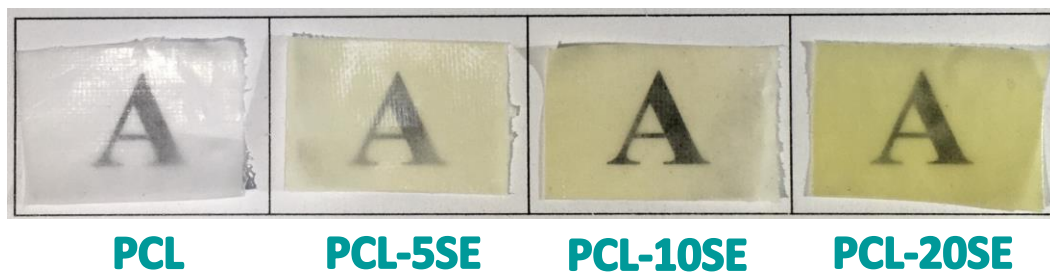
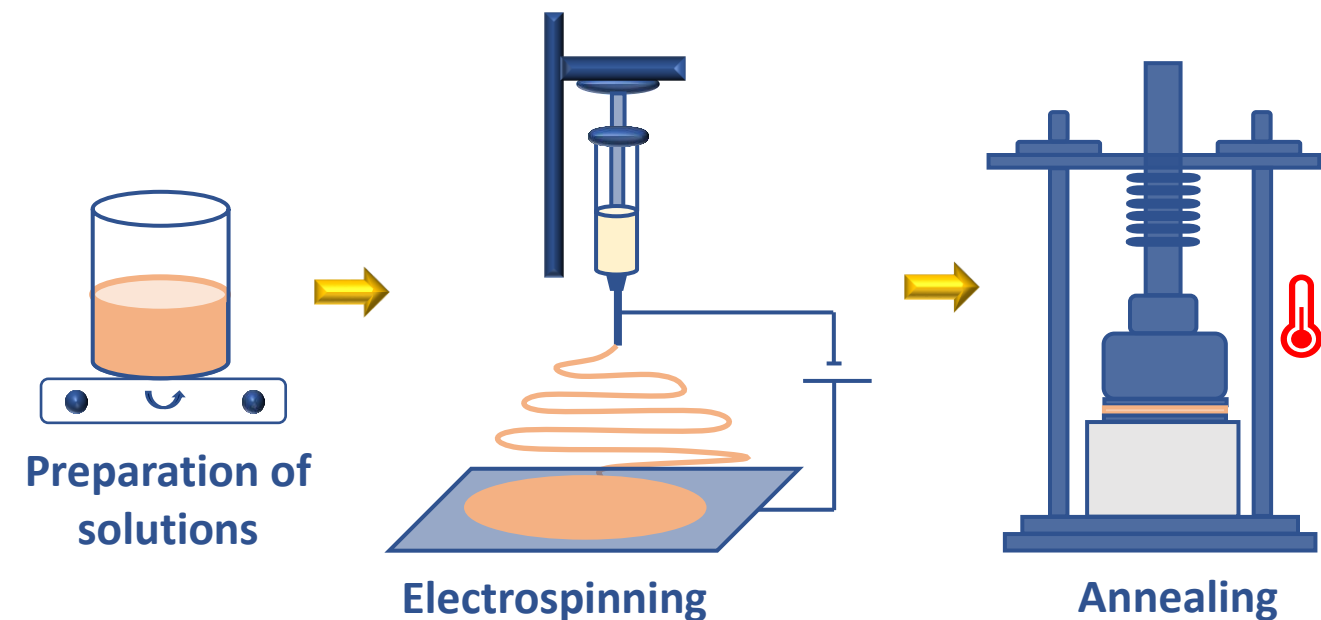
- Thin (0.08-0.10 mm)
- Transparent
- Hydrophobic surfaces resistant to water
- Efficient incorporation
- Homogenous dispersion
- No chemical interactions
- Thermally stable
- Protection against thermal degradation



# 2.

# POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

- Mechanically strong: fracture resistant
- Satisfying water vapor and aroma barrier performances
- Ability to release phenolic compounds to media simulating foods
- Induced antioxidant functionality: ability to neutralize DPPH $^{\bullet}$  free radicals
- Induced antibacterial functionality: ability to inhibit the growth of foodborne bacteria: *S. aureus* and *E. coli*



2.

# POLI( $\epsilon$ -CAPROLACTONE)-BASED MATERIALS

A

PCL

PCL-5SE

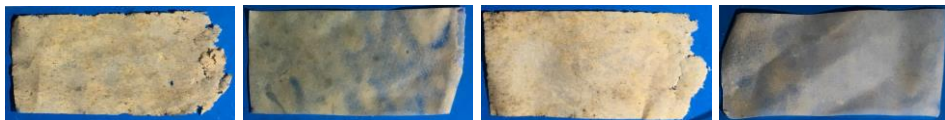
PCL-10SE

PCL-20SE

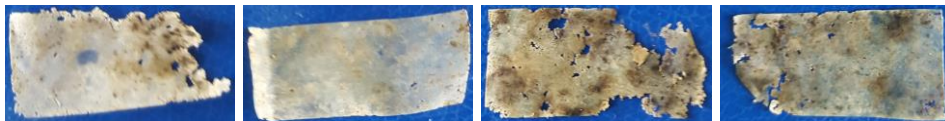
1m.



2m.



3m.



4m.



B

PCL

PCL-5SE

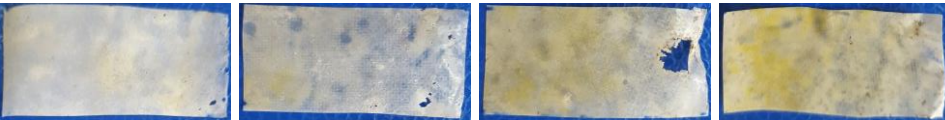
PCL-10SE

PCL-20SE

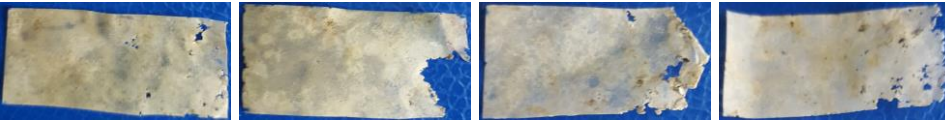
1w.



2w.



3w.



4w.

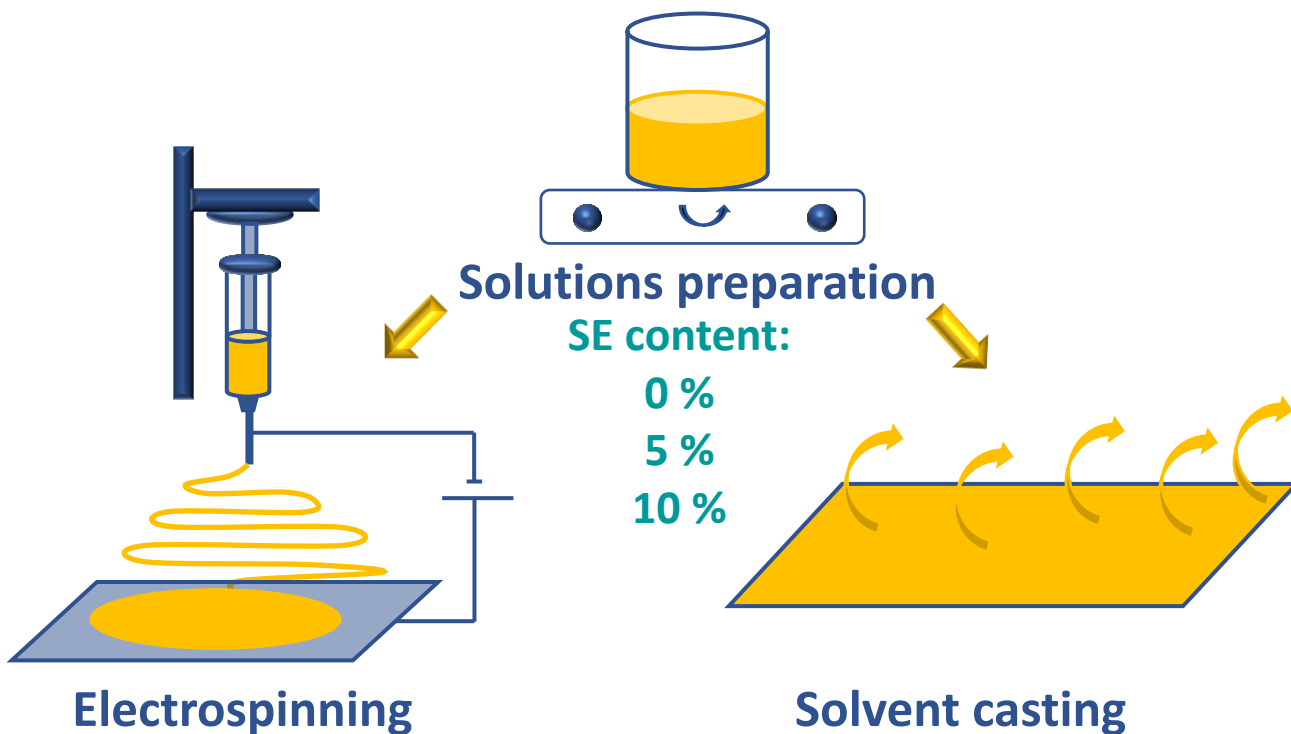


- **A:** degradation in compost by soil microorganisms: 3-4 months
- **B:** addition of *Pseudomonas aeruginosa* bacterial culture to the compost: degradation in 4 weeks
- Potential to be used as active, biodegradable packaging materials with the aim to prevent oxidation processes and bacterial contamination of foods, and be ecologically acceptable

3.

# SYNTHESIS AND CHARACTERIZATION OF PROTEIN-BASED MATERIALS

- Edible food contact materials: blend of zein with gelatin (ZG)
- Food industry byproducts

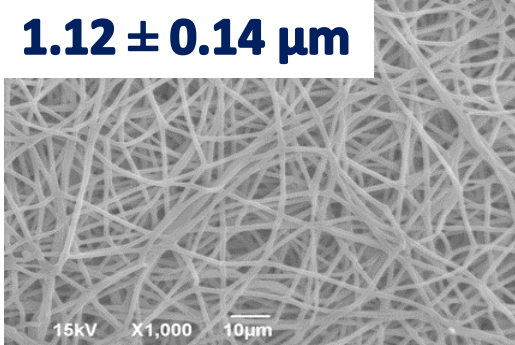


# PROTEIN-BASED MATERIALS

## ● ELECTROSPINNING

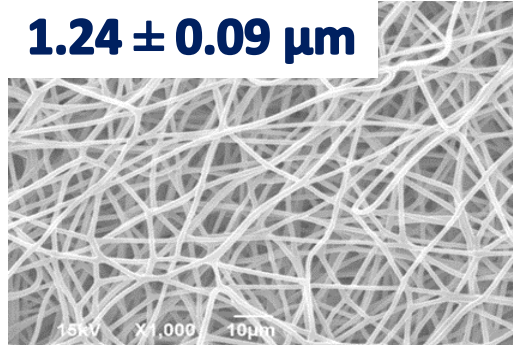
**ZGe**

$1.12 \pm 0.14 \mu\text{m}$



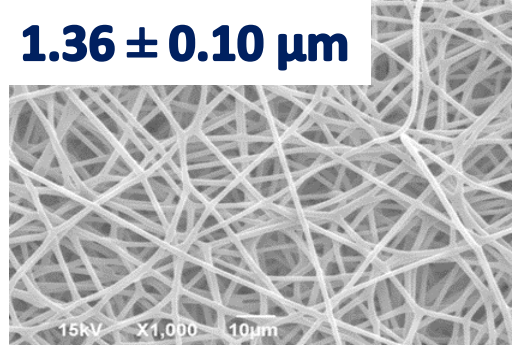
**ZG-5SEe**

$1.24 \pm 0.09 \mu\text{m}$



**ZG-10SEe**

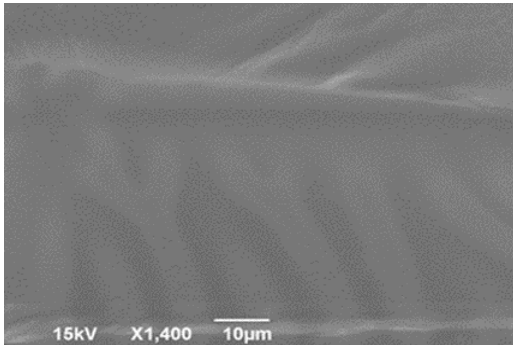
$1.36 \pm 0.10 \mu\text{m}$



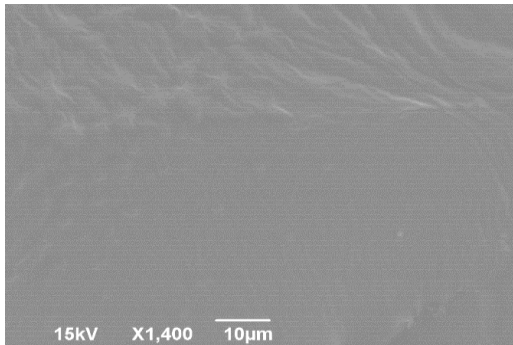
- Non-transparent
- Mats composed of densely oriented fibers

## ● SOLVENT CASTING

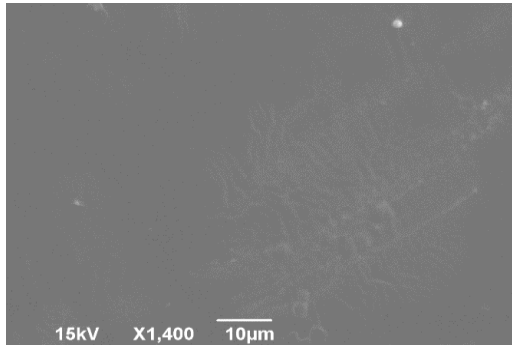
**ZGs.c.**



**ZG-5SEs.c.**



**ZG-10SEs.c.**

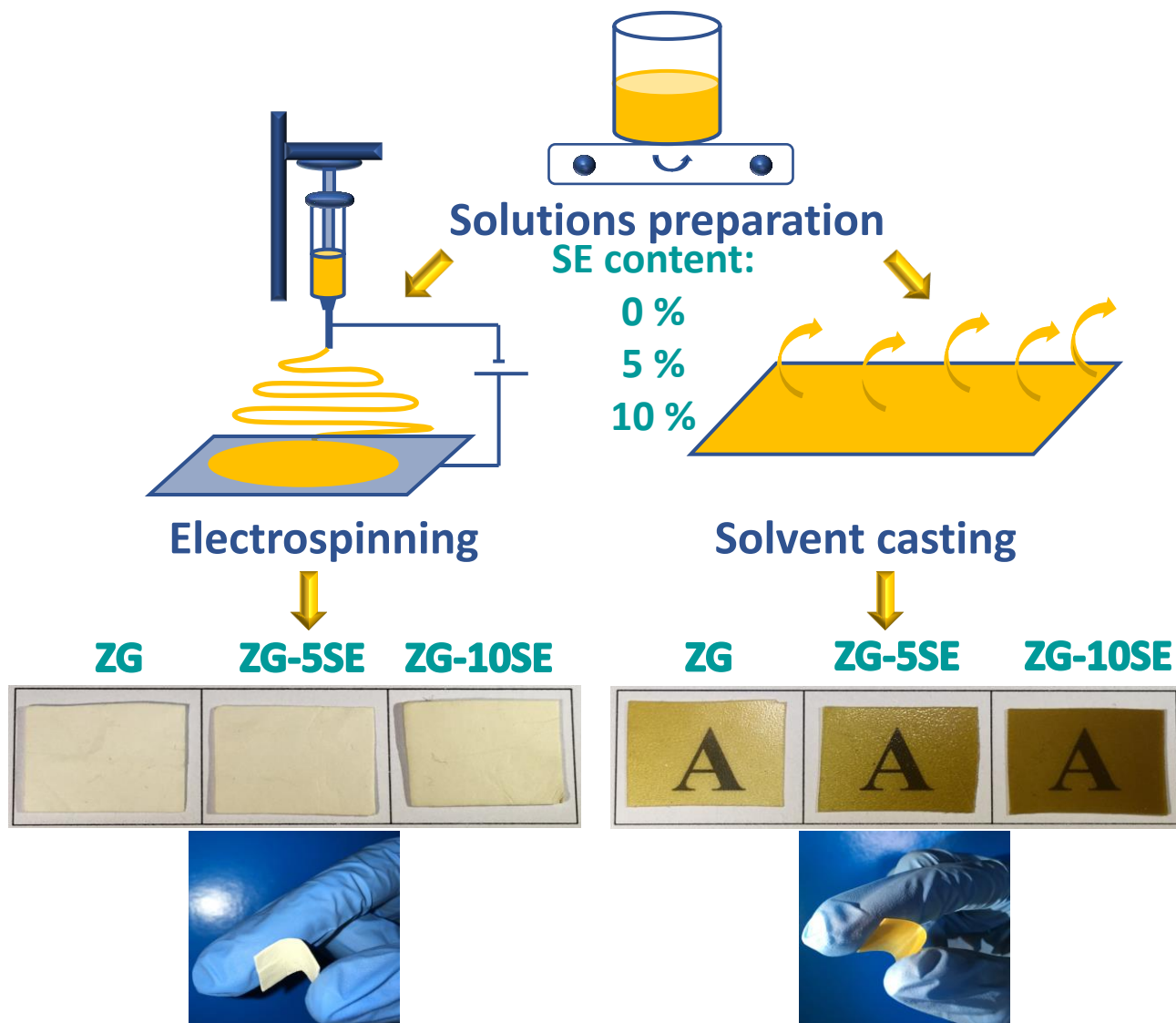


- Transparent
- Continuous and compact films



3.

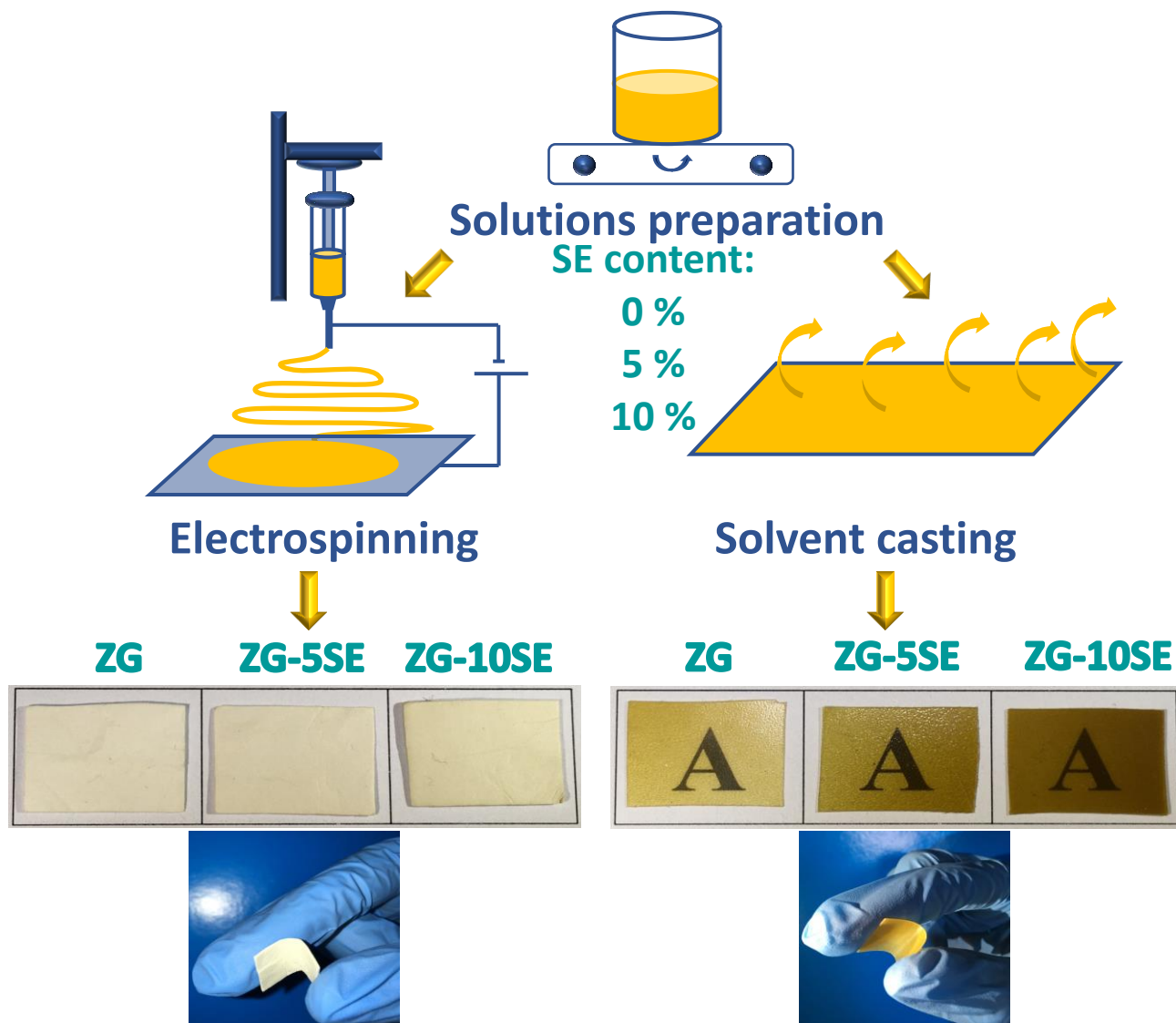
# SYNTHESIS AND CHARACTERIZATION OF PROTEIN-BASED MATERIALS



- Structural differences: differences in the materials' properties
- Compatibility
- Efficient incorporation
- Homogenous dispersion
- No phase separations
- No strong chemical interactions

3.

# SYNTHESIS AND CHARACTERIZATION OF PROTEIN-BASED MATERIALS

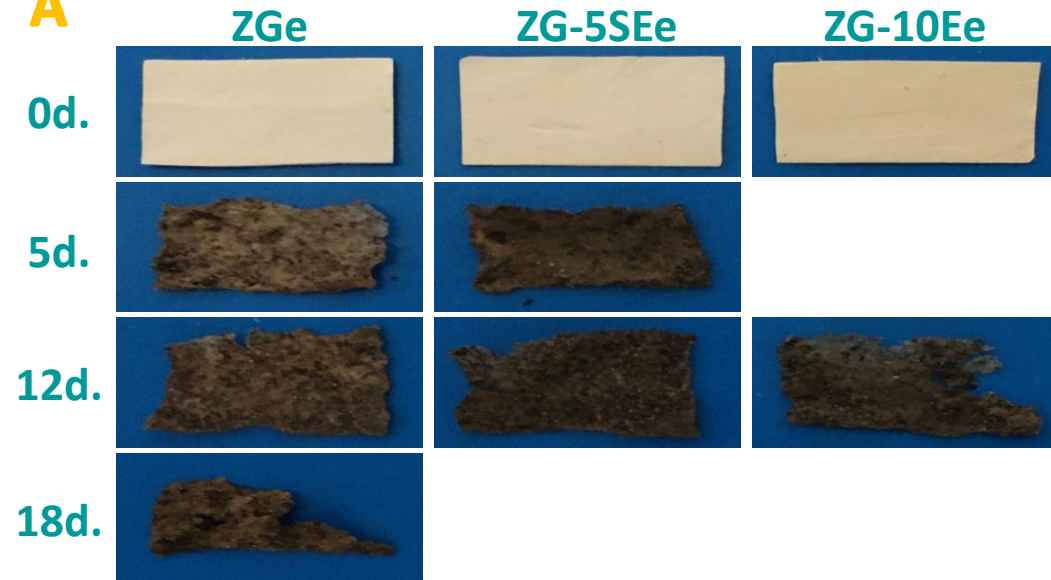


- A higher temperature for the denaturation of the films
- Ability to release phenolic compounds to media simulating foods
- Contribution to antioxidant functionality: ability to neutralize DPPH<sup>•</sup> free radicals
- Contribution to antibacterial functionality: ability to inhibit the growth of food-borne pathogens: *S. aureus* and *E. coli*

3.

# SYNTHESIS AND CHARACTERIZATION OF PROTEIN-BASED MATERIALS

A

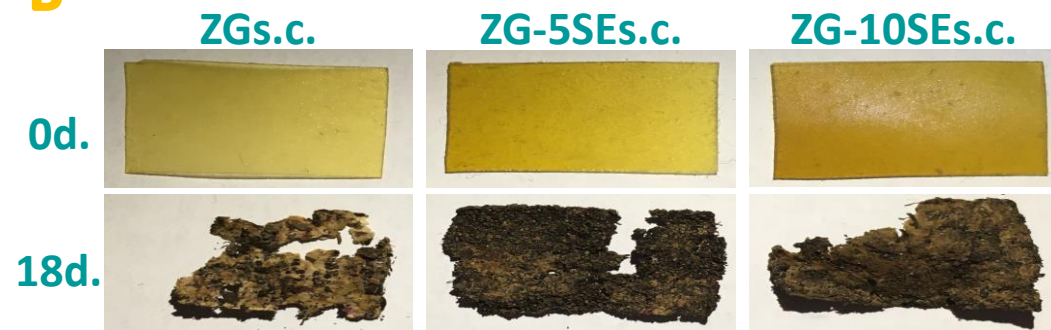


- **A:** Mats degradation in compost by soil microorganisms: 18-25 days

- **B:** Films degradation in compost by soil microorganisms: 18 days

- Potential to be used as active, biodegradable packaging materials with the aim to prevent oxidation processes and bacterial contamination of foods, and be ecologically acceptable

B



# CONCLUSION



- **The antioxidant, antibacterial, and biodegradable materials:**  
use in active packaging concept with a function to prevent food deterioration caused by the oxidation processes and microbial growth, being eco-friendly
- **Multi-faceted values:**  
the utilization of natural active compounds: an alternative to synthetic preservatives  
the utilization of the food industry byproducts to obtain biopolymers  
maintain or even improve food quality and safety  
reduce the accumulation of slowly degradable plastic waste
- **The relevance:**  
towards global sustainable development goals  
support endeavors to diminish pressure on the environment by reducing food waste and accumulated plastic packaging waste  
support transition to more economical, ecological, and circular approaches

# FURTHER RESEARCH



- **Modern and dynamic research field**
- **The developed approaches: innovative, simple, and cost-effective**
- **Further researches and implementation**
- **Development of eco-friendly packaging materials through efficient use of natural resources and promotion of sustainable development**
- **Optimization of the materials synthesis to increase commercial acceptability: sustainable replacement of conventional polymeric materials**



# ACKNOWLEDGEMENT



**University of Belgrade  
Faculty of Agriculture**



**University of Belgrade  
Faculty of Technology and Metallurgy**



Instituto de Agroquímica  
y Tecnología de Alimentos

**Spanish National Research Council  
Institute of Agrochemistry  
and Food Technology**



**University of Belgrade  
Institute of molecular genetics  
and genetic engineering**

# THANK YOU FOR THE ATTENTION



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Ana Salevic

*“I am among those who think that science has great beauty. A scientist in his laboratory is not only a technician, he is also a child placed before natural phenomenon, which impress him like a fairy tale.”*

— Marie Curie