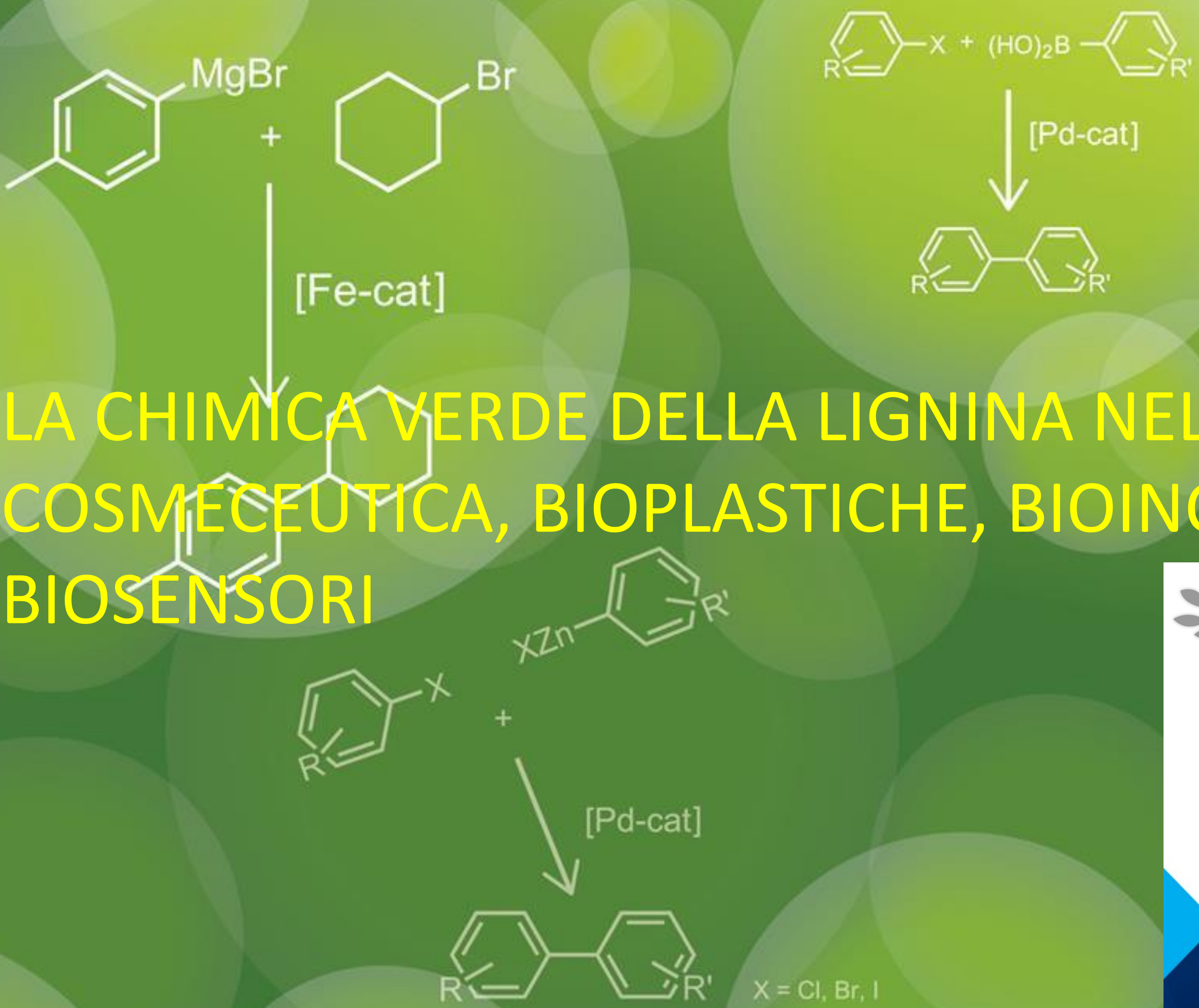
LA CHIMICA VERDE DELLA LIGNINA NELLA BIORAFFINERIA: COSMECEUTICA, BIOPLASTICHE, BIOINCHIOSTRI E BIOSENSORI



UNIVERSITAS STUDIORUM TUSCIAE
VITERBIUM MCMLXXIX

UNINDUSTRIA
UNIONE DEGLI INDUSTRIALI E DELLE IMPRESE
ROMA • FROSINONE • LATINA • RIETI • VITERBO

Presentazione di eccellenze

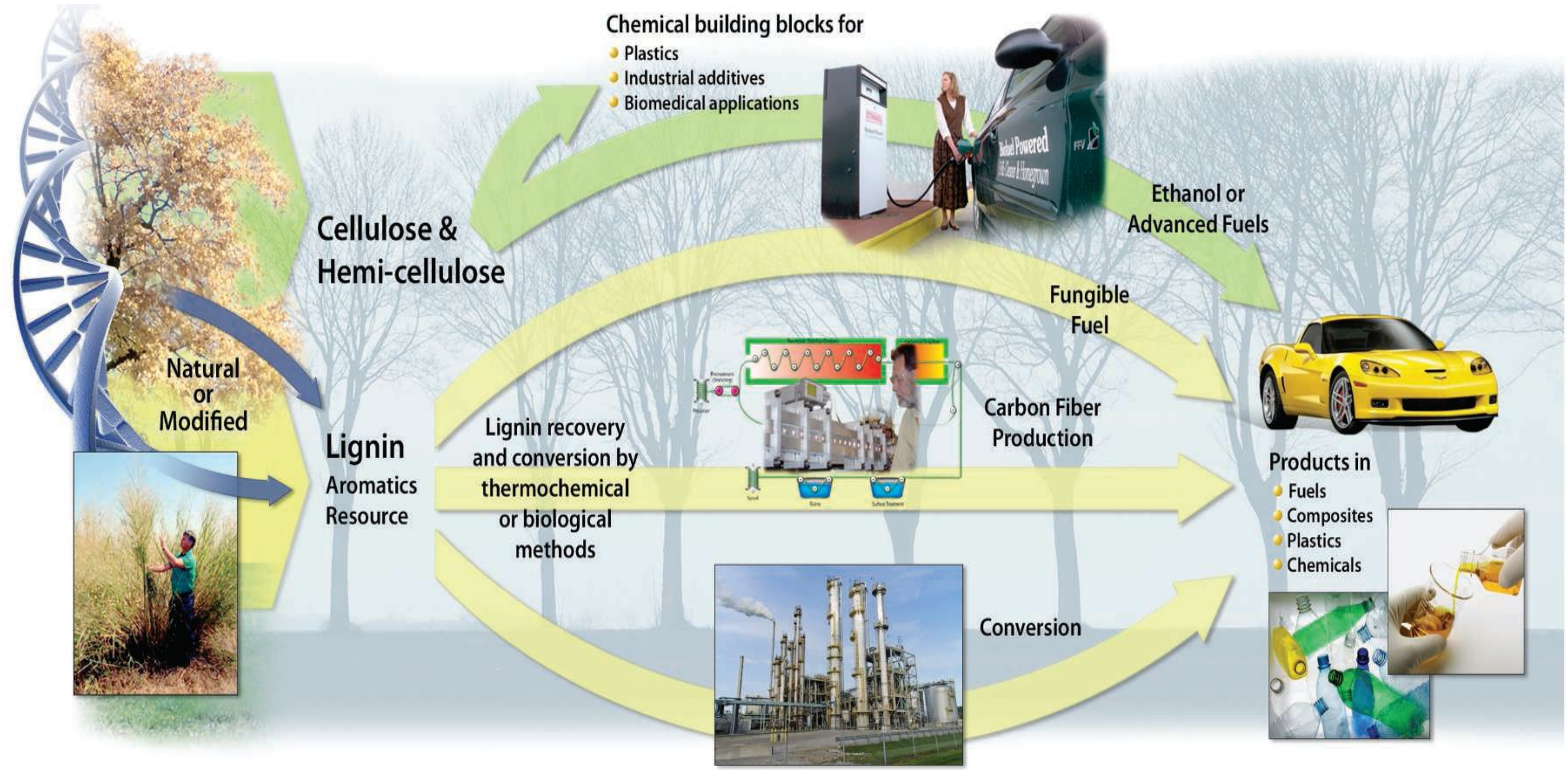
Ciclo di incontri con le Università del Lazio firmatarie dell'Accordo Quadro

GREEN CHEMISTRY

CIRCULAR ECONOMY Inspired

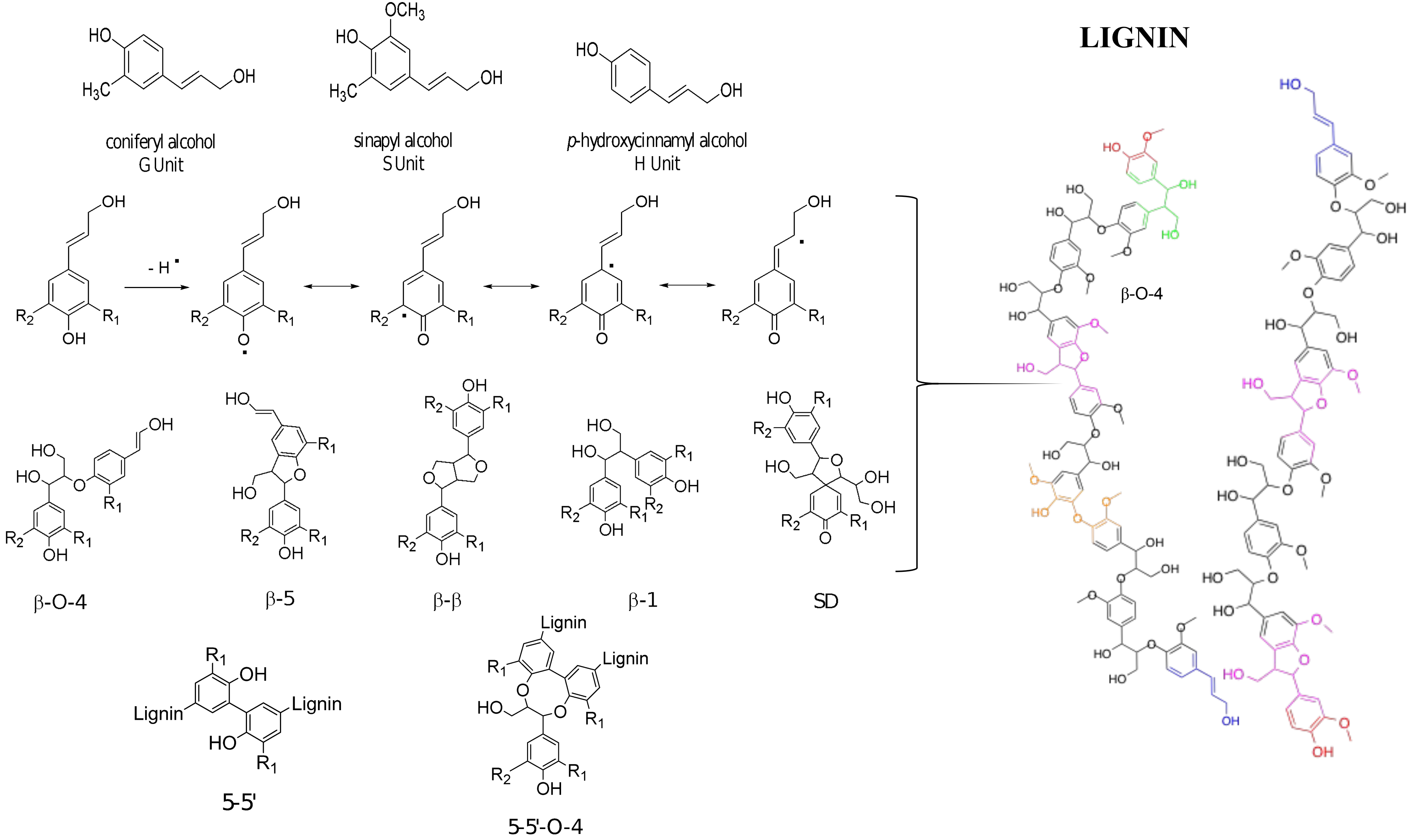
About lignin…

«Lignin, nature's dominant aromatic polymer, is found in most terrestrial plants in the approximate range of 15 to 40% dry weight and provides structural integrity»



«The U.S. Energy Security and Indipendence Act of 2007 mandates the development of 79 billion liters of second-generation biofuels annually by 2022. Assuming a yield of 355 liters per dry ton of biomass, 223 million tons of biomass will be used annually producing about 62 million tons of lignin.»

Chemistry of lignin



Lignins from industrial process

Kraft lignin (KL)

Wood chips → cellulose pulp

Wood chips → black liquor $\xrightarrow{\text{boiler}}$ **KL** 90,000 (t /yr)

(Z. Strassberger, S. Tanase, G. Rothenberg, RSC Adv. 4 (2014) 25310.)

Lignosulfonated (LS)

Wood chips → cellulose pulp

Wood chips → black liquor $\xrightarrow{\text{boiler}}$ **LS** 1 milion (t /yr)

Soda lignin (SL)

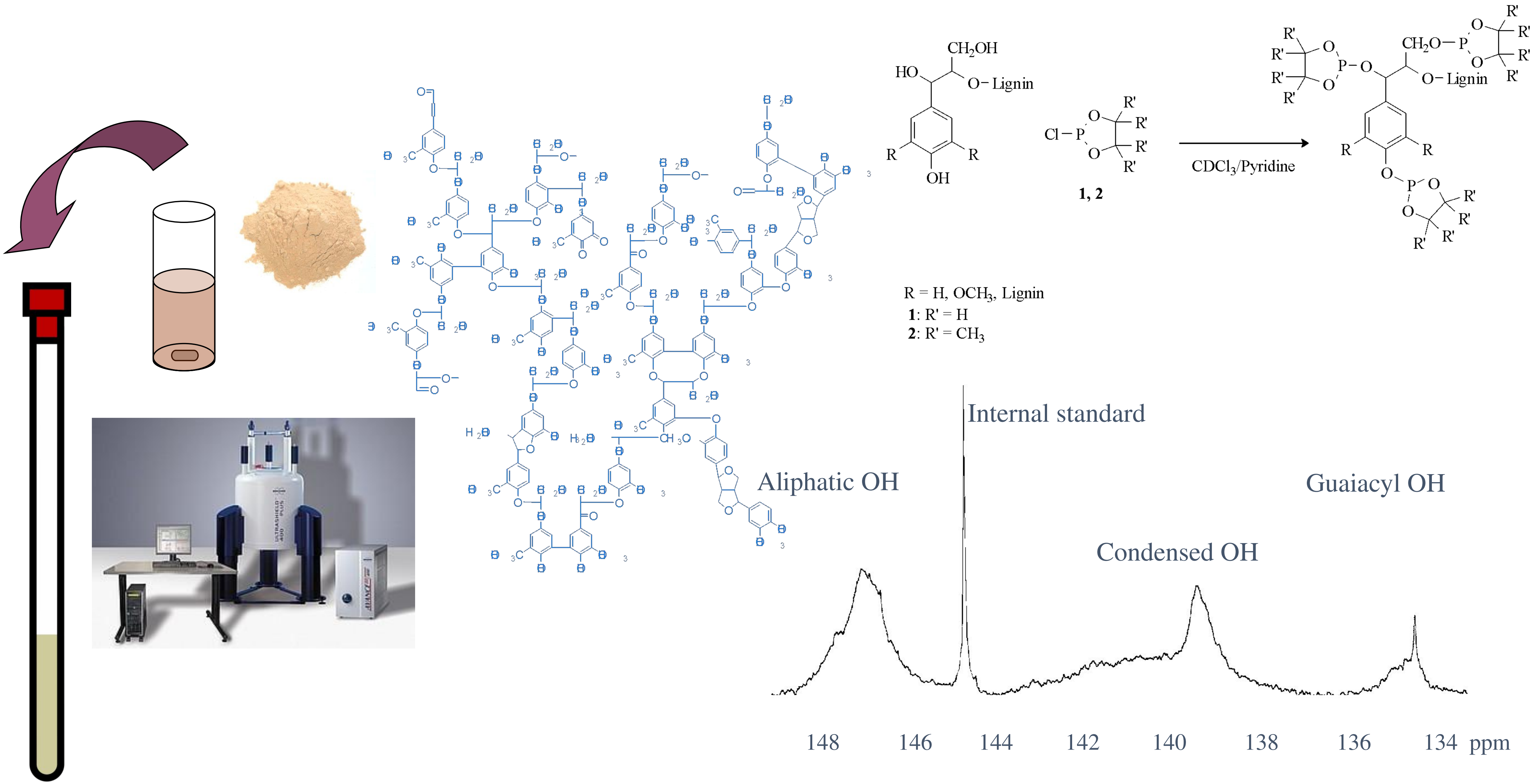
Wood chips → cellulose pulp

Wood chips → black liquor $\xrightarrow{\text{boiler}}$ **SL** sulfur free

Organosolv lignin (OSL)

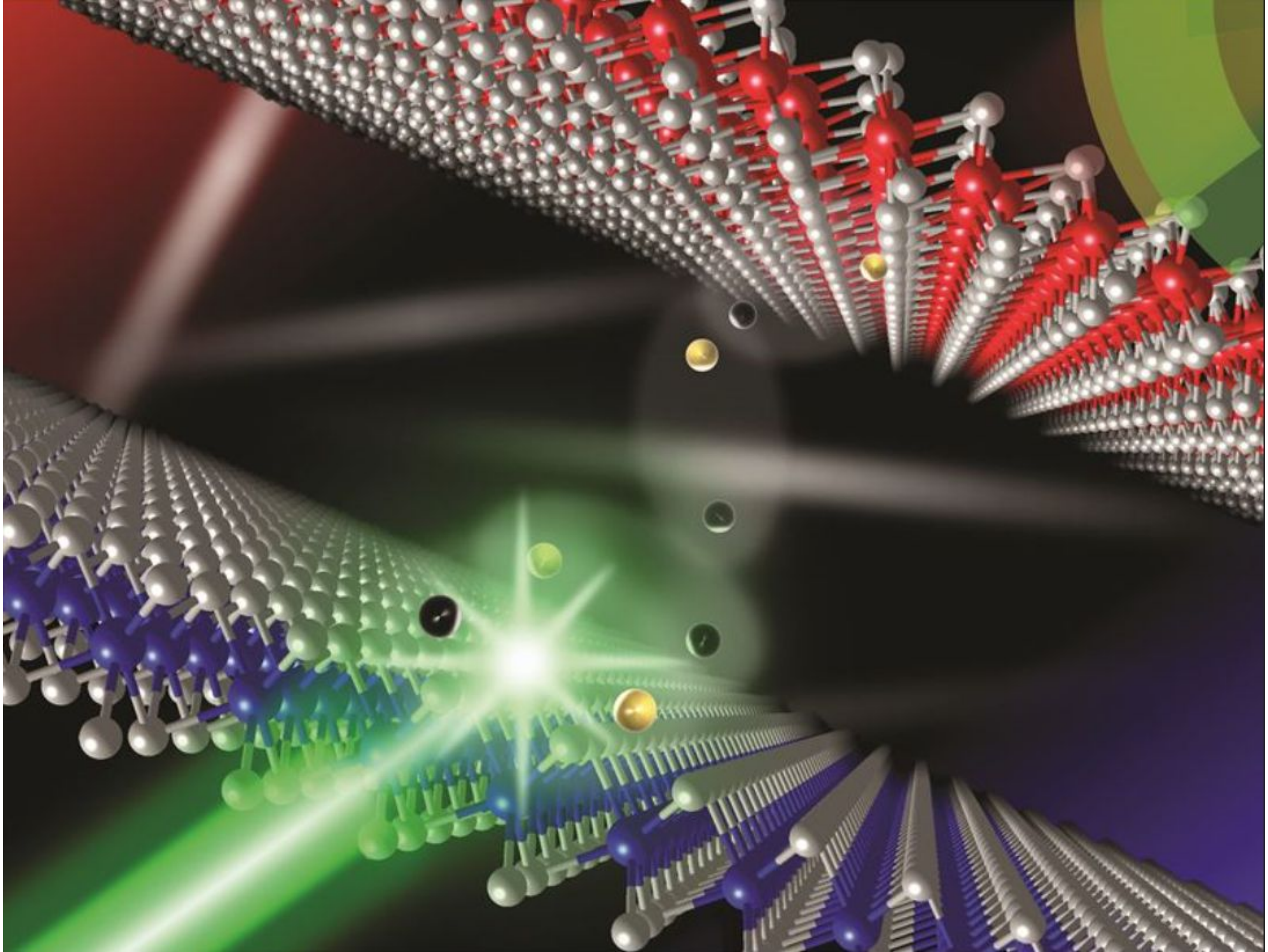
Wood chips — I. organic solvent / II. diluite acid → cellulose pulp

Wood chips — I. organic solvent / II. diluite acid → black liquor $\xrightarrow{\text{boiler}}$ **OSL** sulfur free high-cost



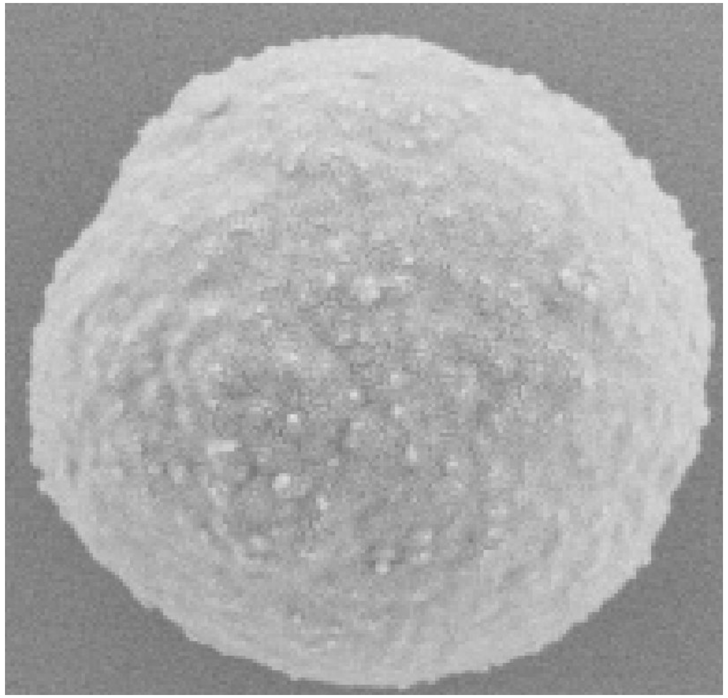
CH2OH
HO
O- Lignin
R
R
OH
Cl - P
1, 2
CDCl3/Pyridine
R = H, OCH3, Lignin
1: R' = H
2: R' = CH3
Internal standard
Aliphatic OH
Condensed OH
Guaiacyl OH
148
146
144
142
140
138
136
134
ppm

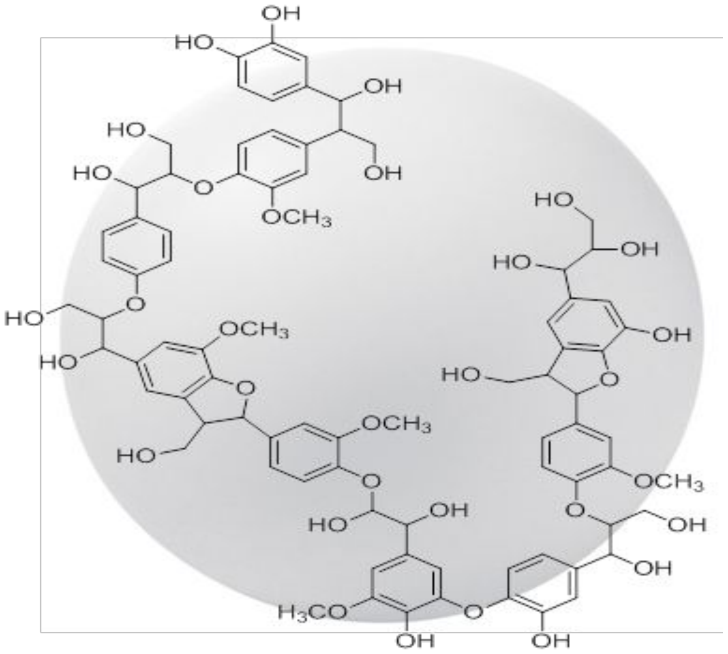
MICRO-SCALE

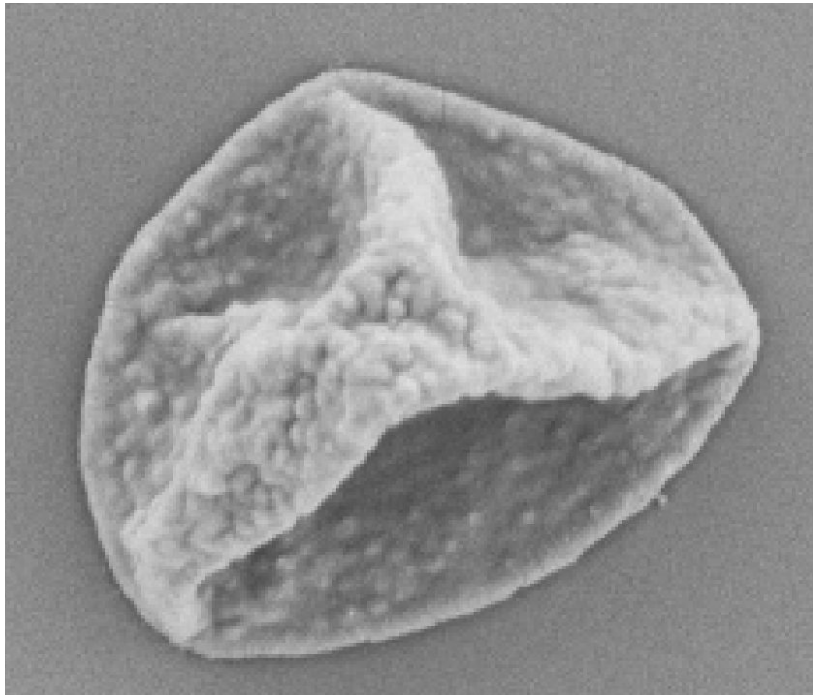


NANO-SCALE

Lignin nanocapsule





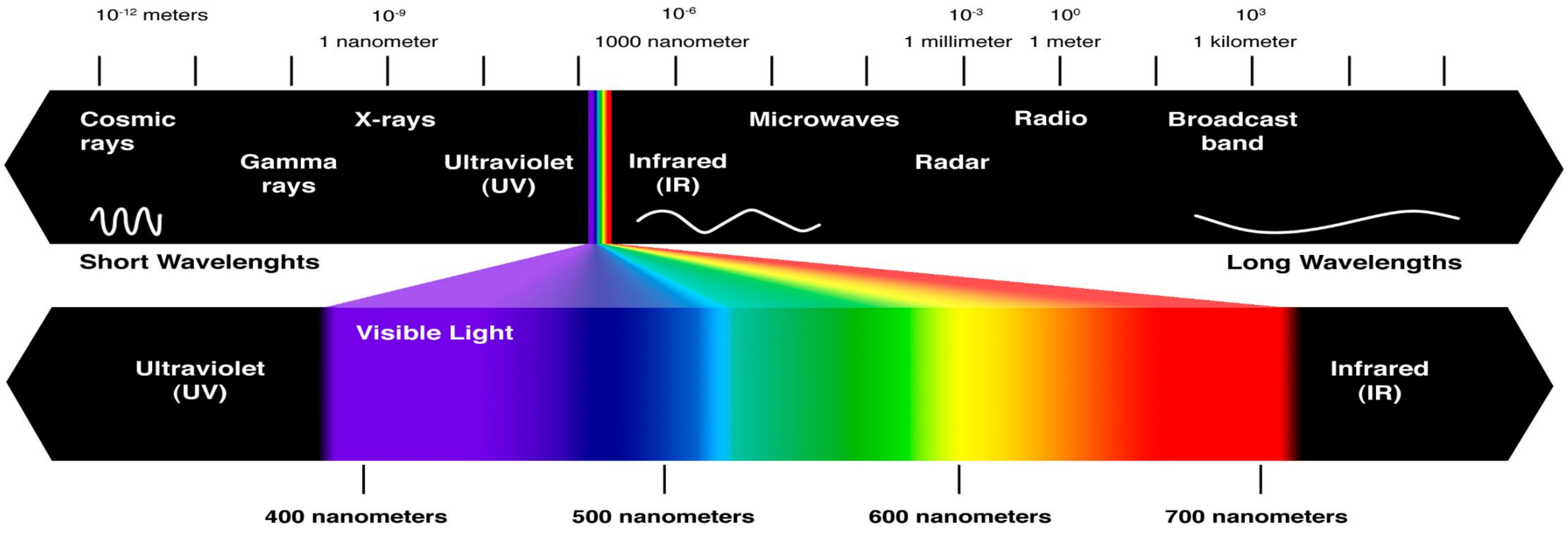


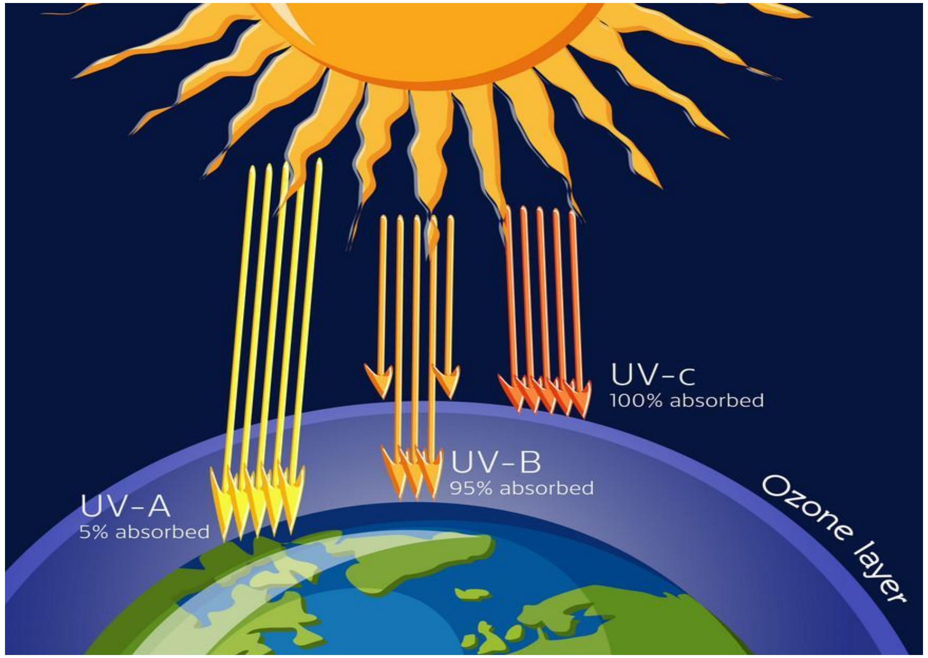
TESTIMONIAL DAY

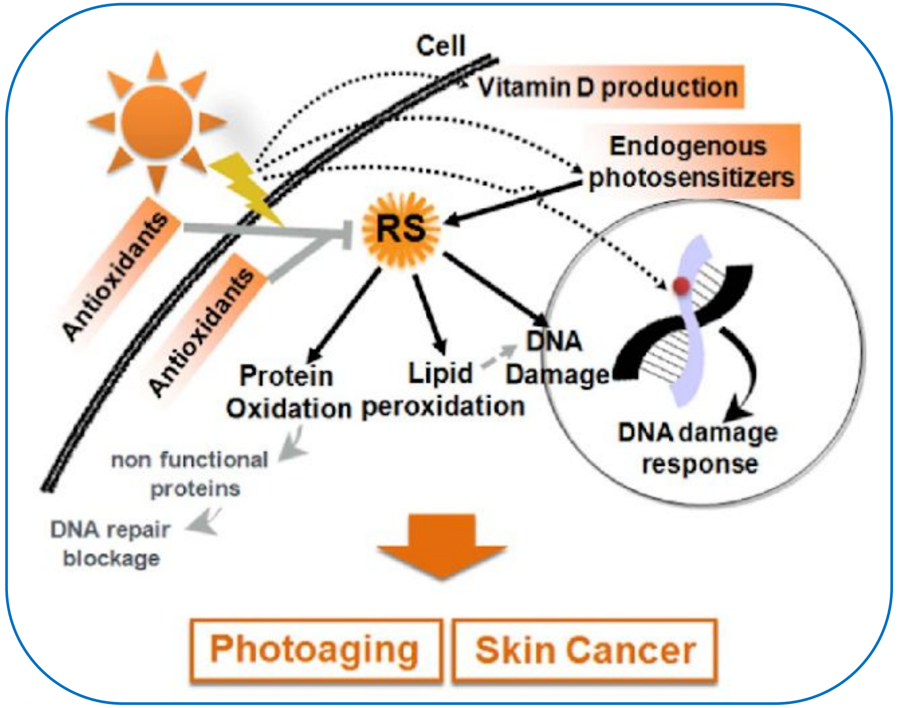
In effettiva collaborazione, nell’ambito del bando POR life 2020 Benessere/Wellbeing, la IDI Farmaceutici e il Dipartimento DEB dell'Università della Tuscia hanno presdisposto il progetto “**UNICO**”.

Il progetto integra competenze in ambito biomedico, chimico ed industriale per la realizzazione di un innovativo filtro solare “cosmeceutico” basato su un ingrediente “naturale” a base di **lignina**, un componente del legno non tossico ed ecocompatibile, in grado di assorbire sia UV-A che UV-B.

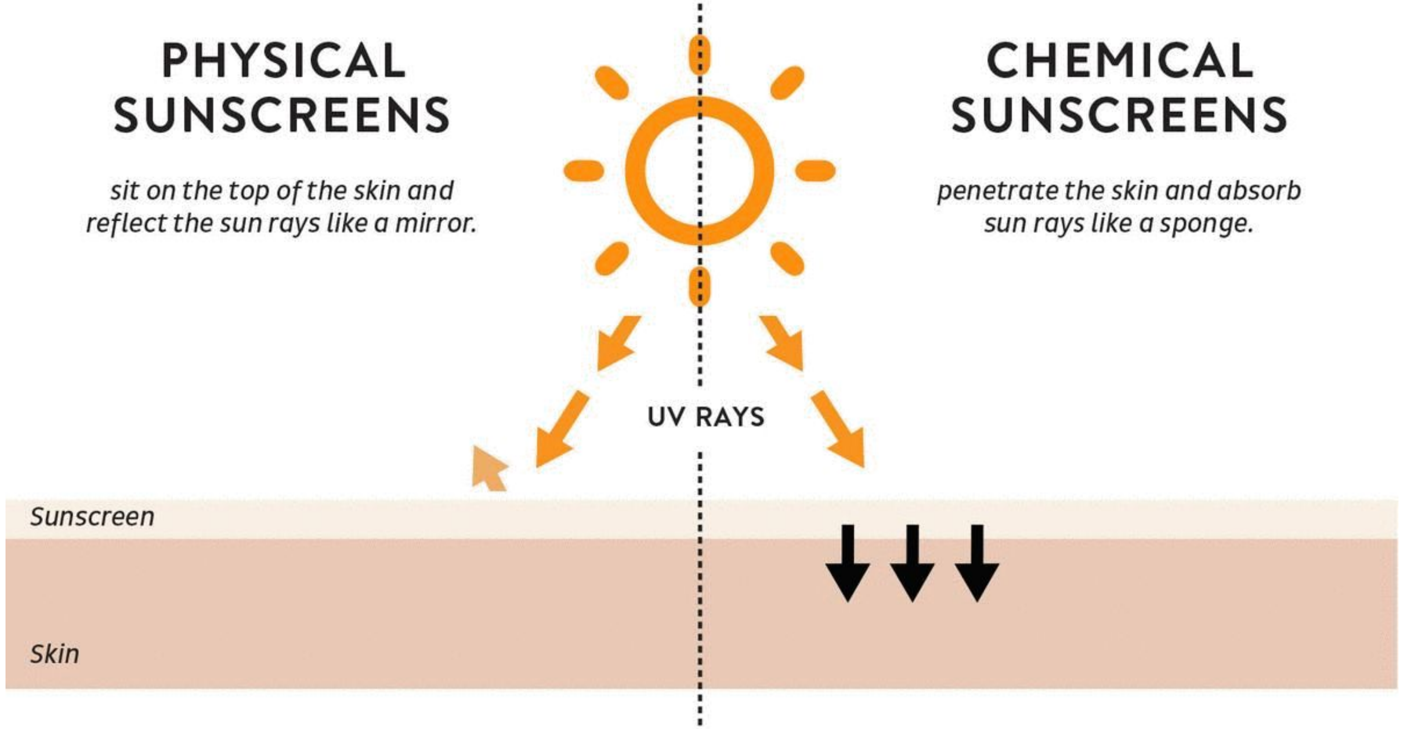
TESTIMONIAL DAY

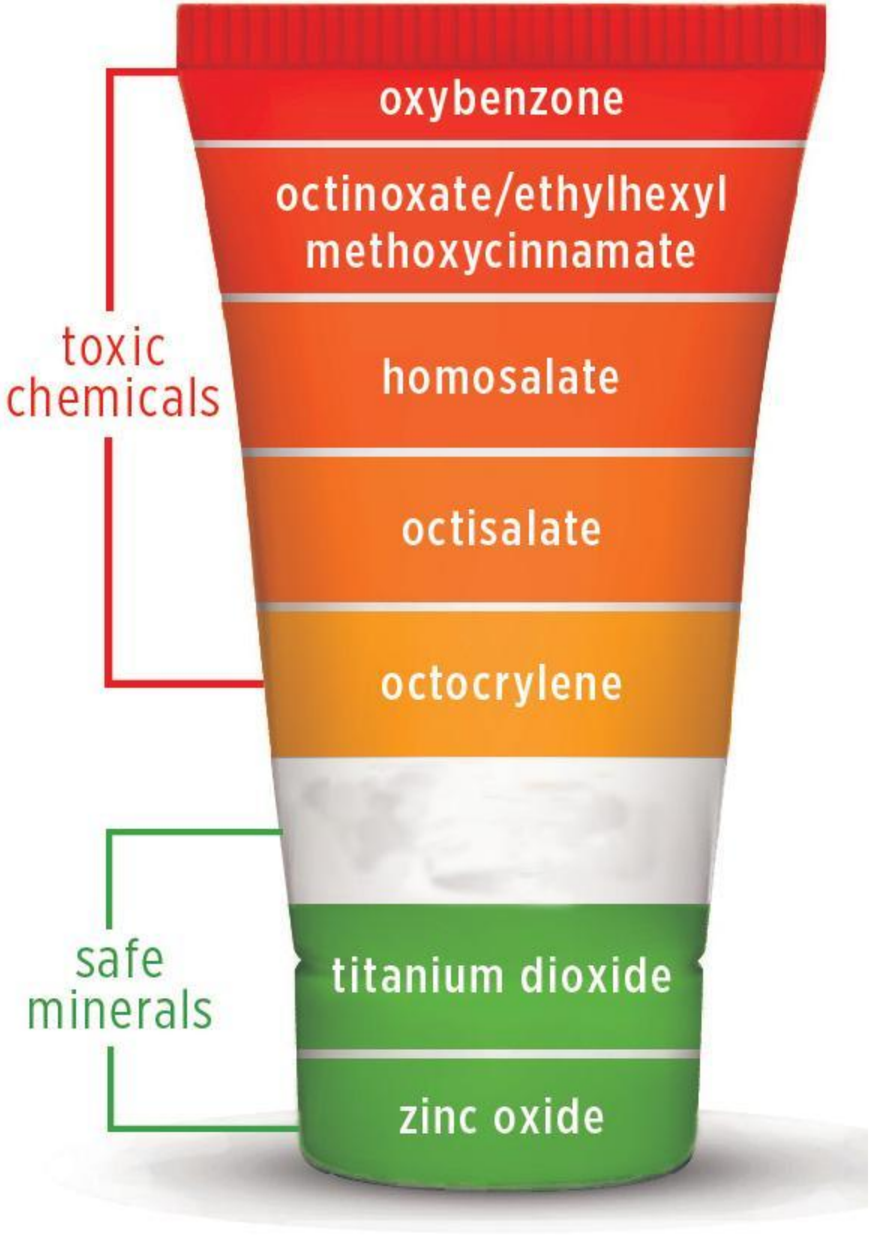




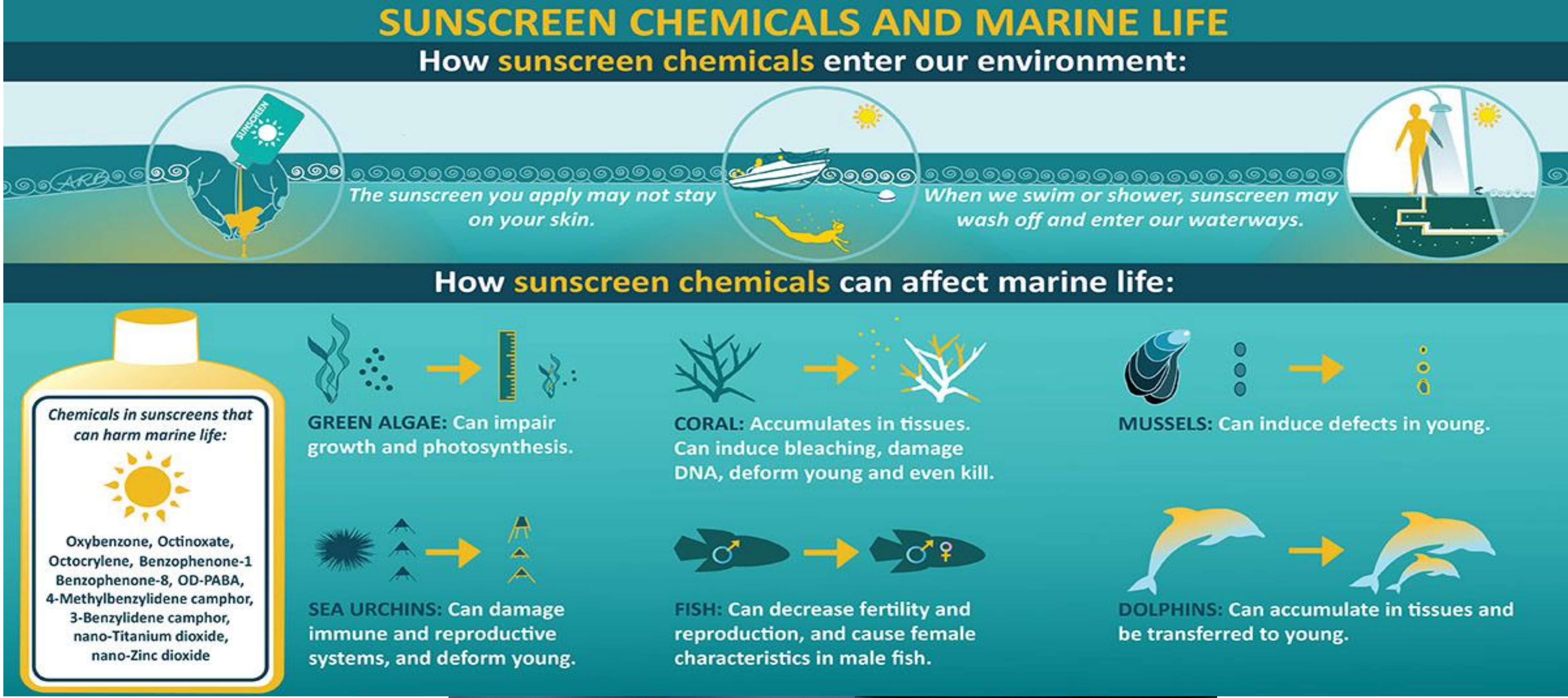


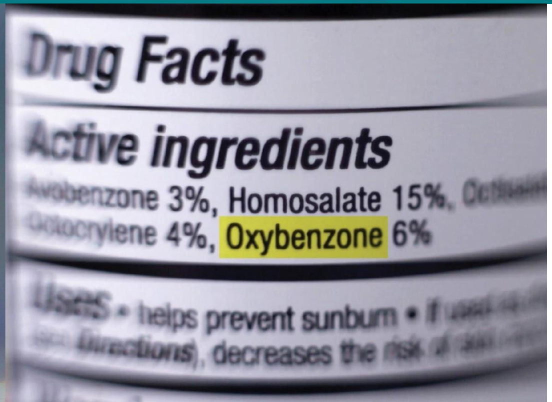
TESTIMONIAL DAY



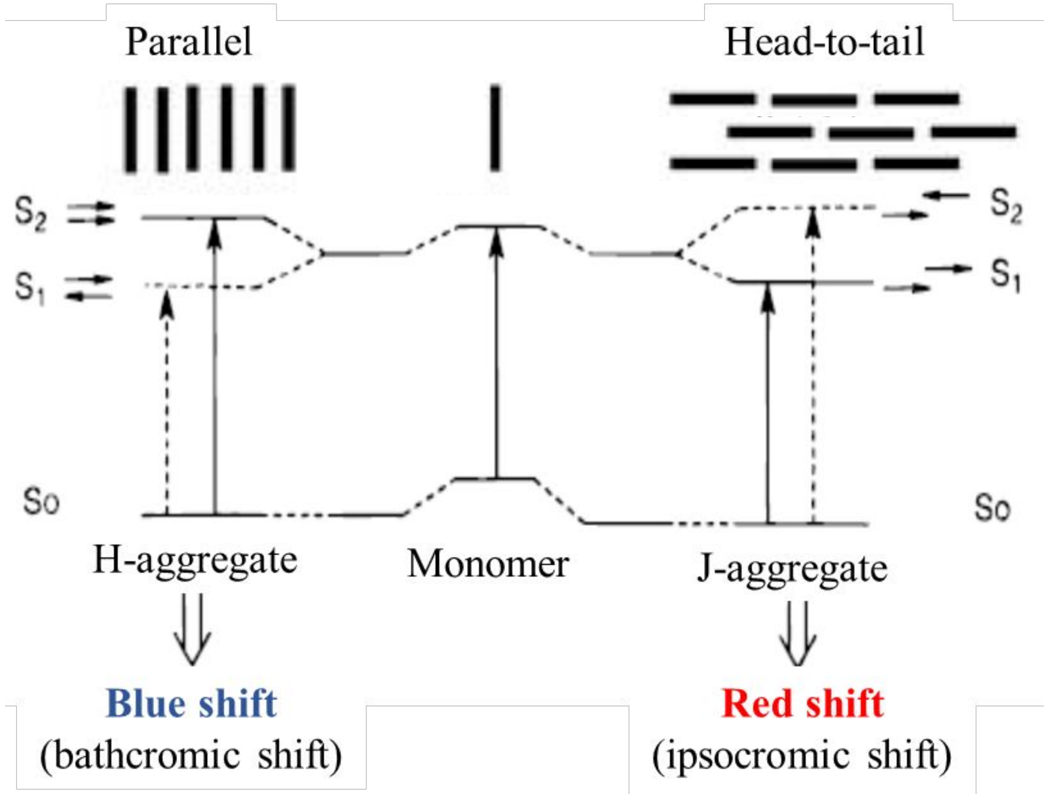


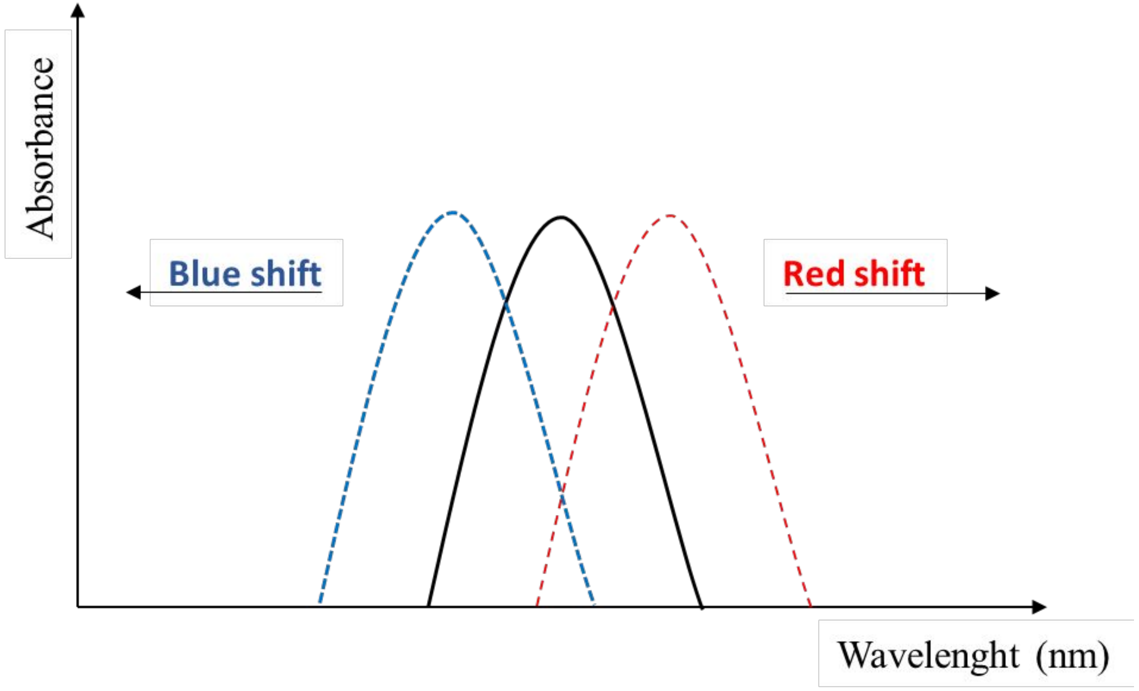
TESTIMONIAL DAY

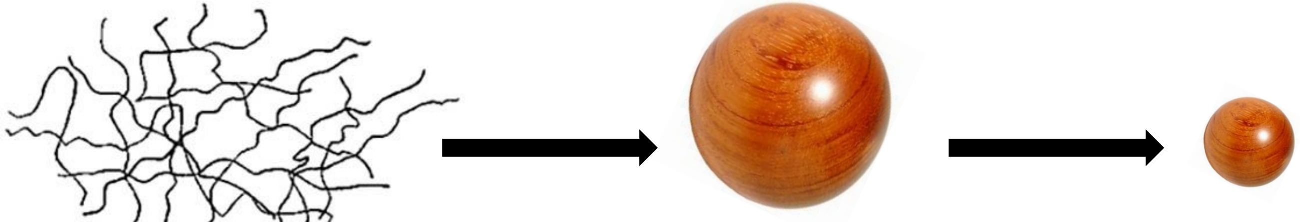




Structural exciton theory



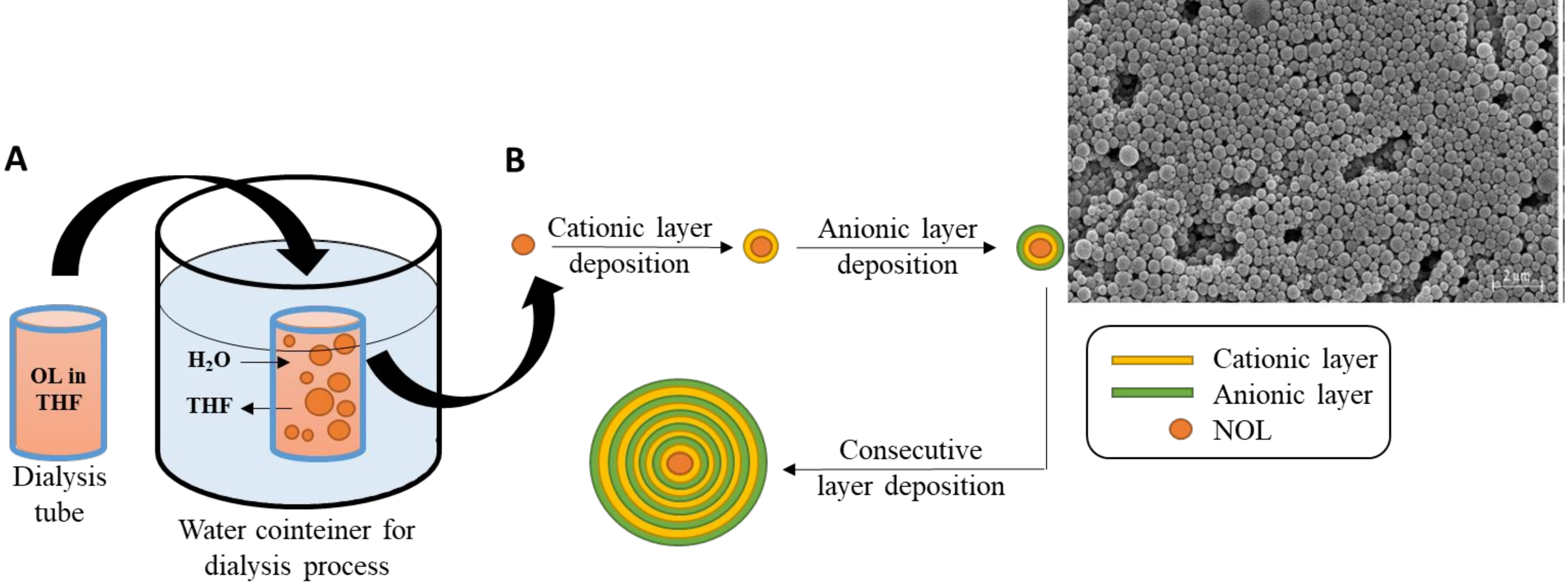




Amorphous state

μm size

nm-size



PATENTED No. 102018000006058

COFI GENTOXCHEM

"Micro- e nano- capsule o particelle a base di polifenoli e loro uso in campo cosmetico e come inchiostro".

BioMACROMOLECULES

Subscriber access provided by UNIV OF DURHAM

Article

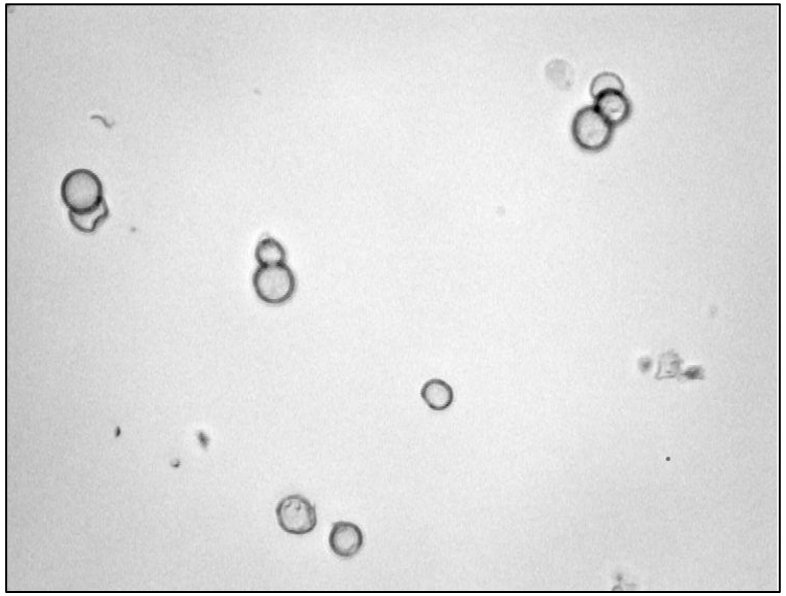
Layer-by-layer preparation of microcapsules and nanocapsules of mixed polyphenols with high antioxidant and UV-shielding properties.

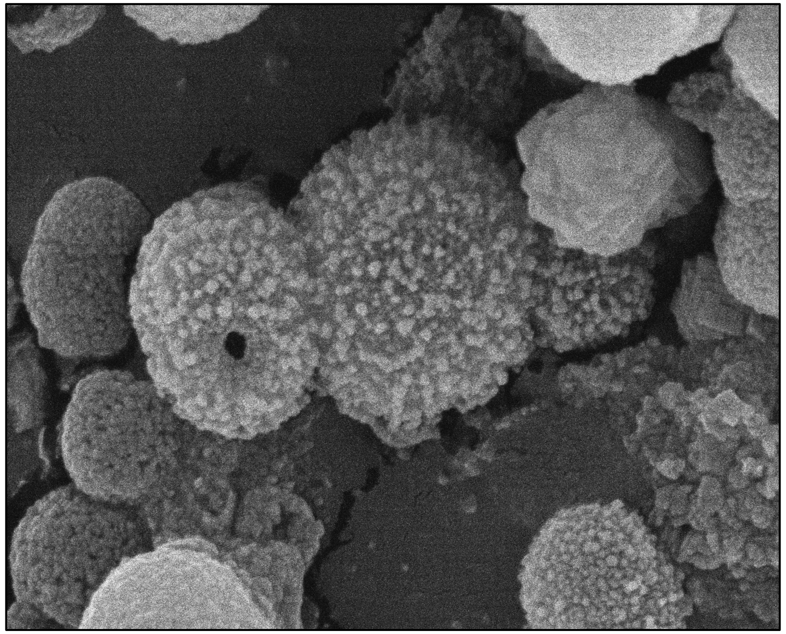
Davide Piccinino, Eliana Capecchi, Lorenzo Botta, Bruno Mattia Bizzarri, Paolo Bollella, Riccarda Antiochia, and Raffaele Saladino

Biomacromolecules, **Just Accepted Manuscript** • DOI: 10.1021/acs.biomac.8b01006 • Publication Date (Web): 08 Aug 2018

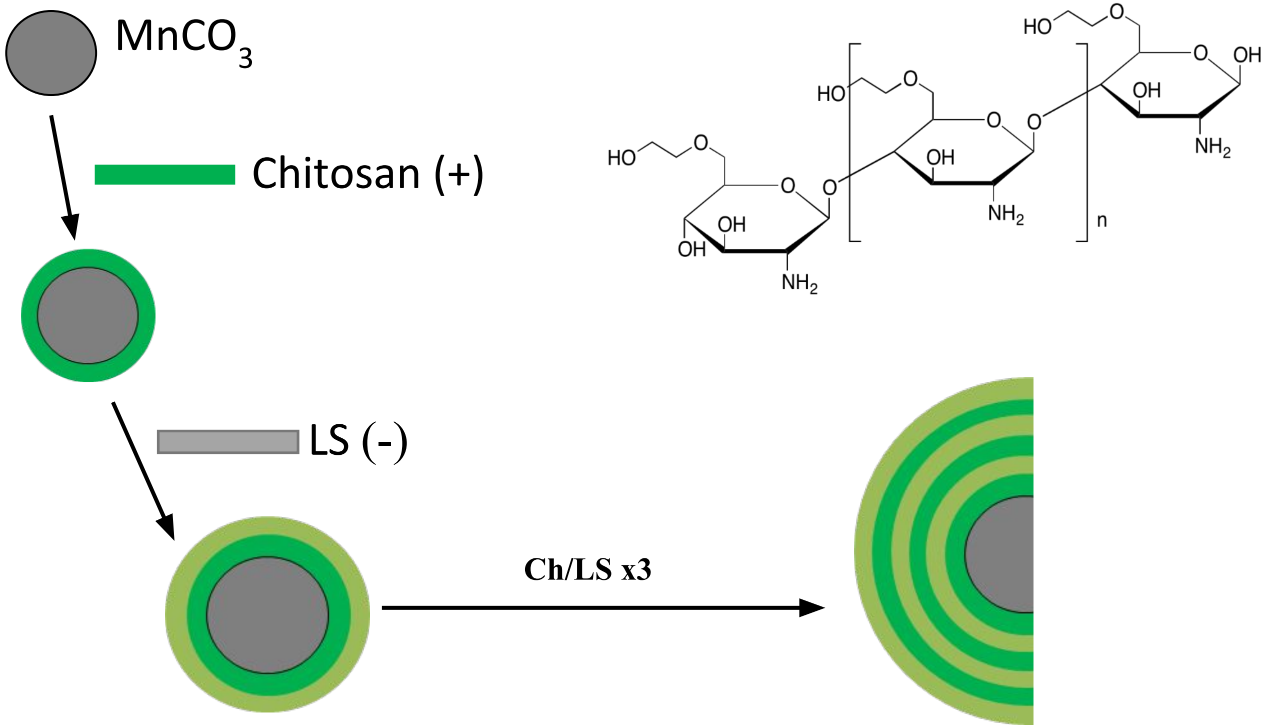
Downloaded from http://pubs.acs.org on August 9, 2018

Lignin nanocapsule obtained by LbL method

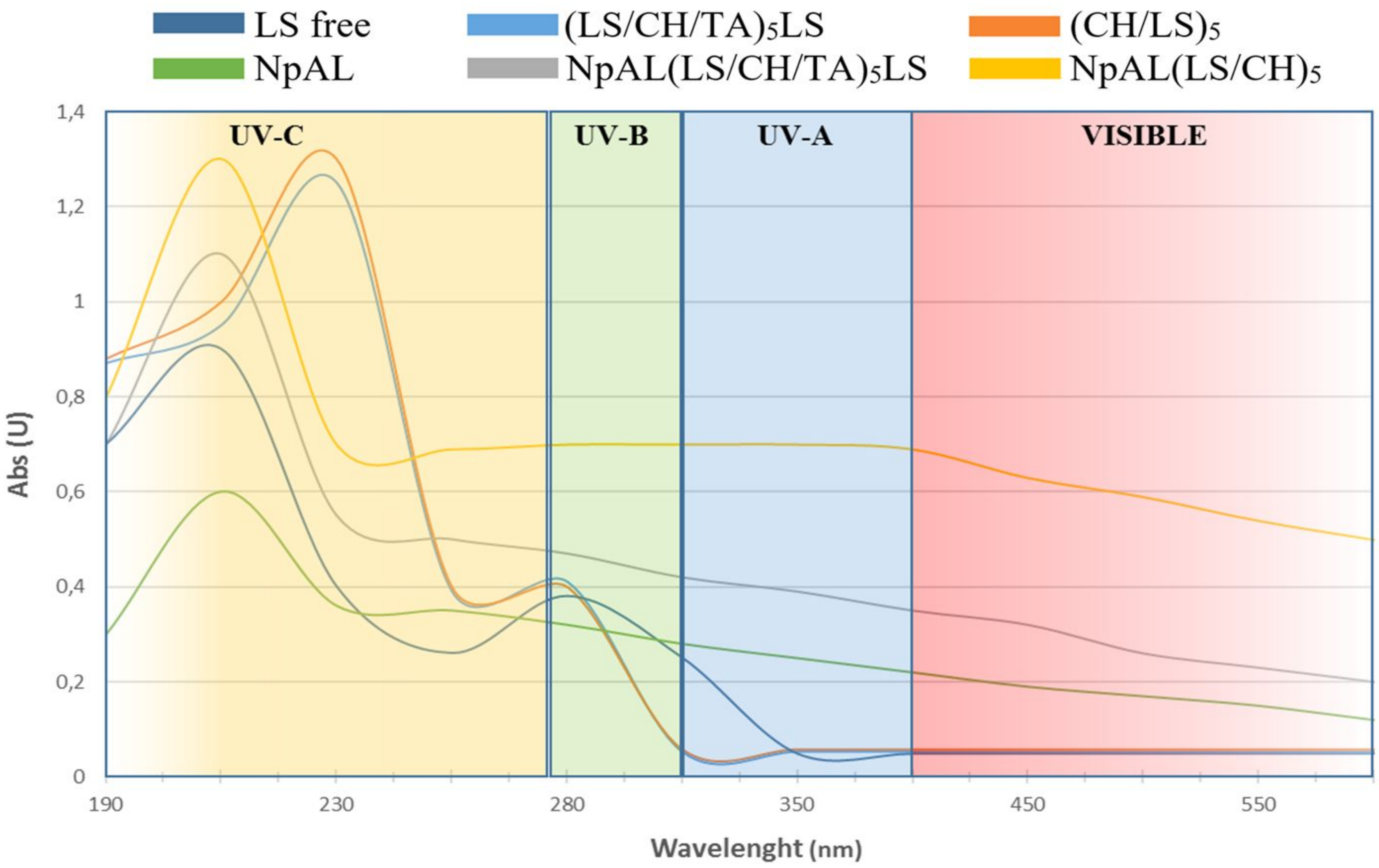




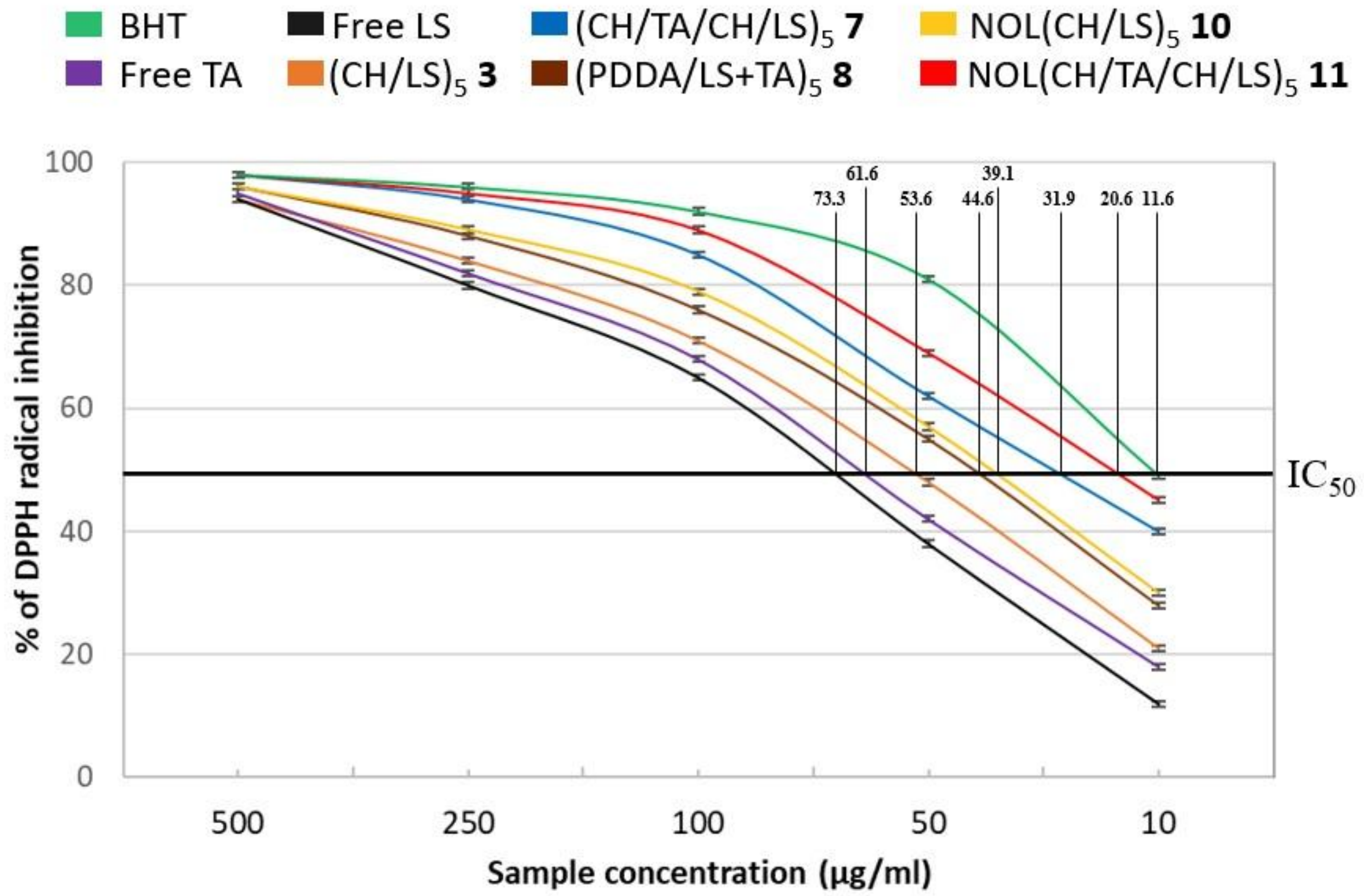
$[Ch/LS]_3$



POTERE ASSORBENTE UV-VISIBILE



POTERE ANTI-RADICALE TRAMITE SAGGIO DPPH



TESTIMONIAL DAY

1	campione **A**	**GEL BASE A**	**g 100**	glicerina 5 g	etanolo g 5			110
2	campione **B**	**IDI-OLS**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE A**	**g 100**	116
3	campione **C**	**IDI-OLSC**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE A**	**g 100**	116
4	campione **D**	**IDI-OLT**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE A**	**g 100**	116
5	campione **E**	**IDI-OLTC**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE A**	**g 100**	116
6	campione **1**	**IDI-OLS**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE A**	**g 100**	130
7	campione **2**	**IDI-OLSC**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE A**	**g 100**	130
8	campione **3**	**IDI-OLT**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE A**	**g 100**	130
9	campione **4**	**IDI-OLTC**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE A**	**g 100**	130
10	campione **1A**	**GEL BASE 1A**	**g 10(**	glicerina 5 g	etanolo g 5			110
11	campione **1B**	**IDI-OLS**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE 1A**	**g 100**	116
12	campione **1C**	**IDI-OLSC**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE 1A**	**g 100**	116
13	campione **1D**	**IDI-OLT**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE 1A**	**g 100**	116
14	campione **1E**	**IDI-OLTC**	**g 1**	glicerina 5 g	etanolo g 5	**GEL BASE 1A**	**g 100**	116
15	campione **1-1**	**IDI-OLS**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE 1A**	**g 100**	130
16	campione **1-2**	**IDI-OLSC**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE 1A**	**g 100**	130
17	campione **1-3**	**IDI-OLT**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE 1A**	**g 100**	130
18	campione **1-4**	**IDI-OLTC**	**g 5**	glicerina 10 g	etanolo g 5	**GEL BASE 1A**	**g 100**	130

Calculation of sun protection factor (SPF)

TESTIMONIAL DAY

+

4%

SPF
12

UVA/UVB unique filter !

+

2%

SPF
52

Booster effect at low concentration!

Bio-based packaging products that are biodegradable/compostable and/or recyclable

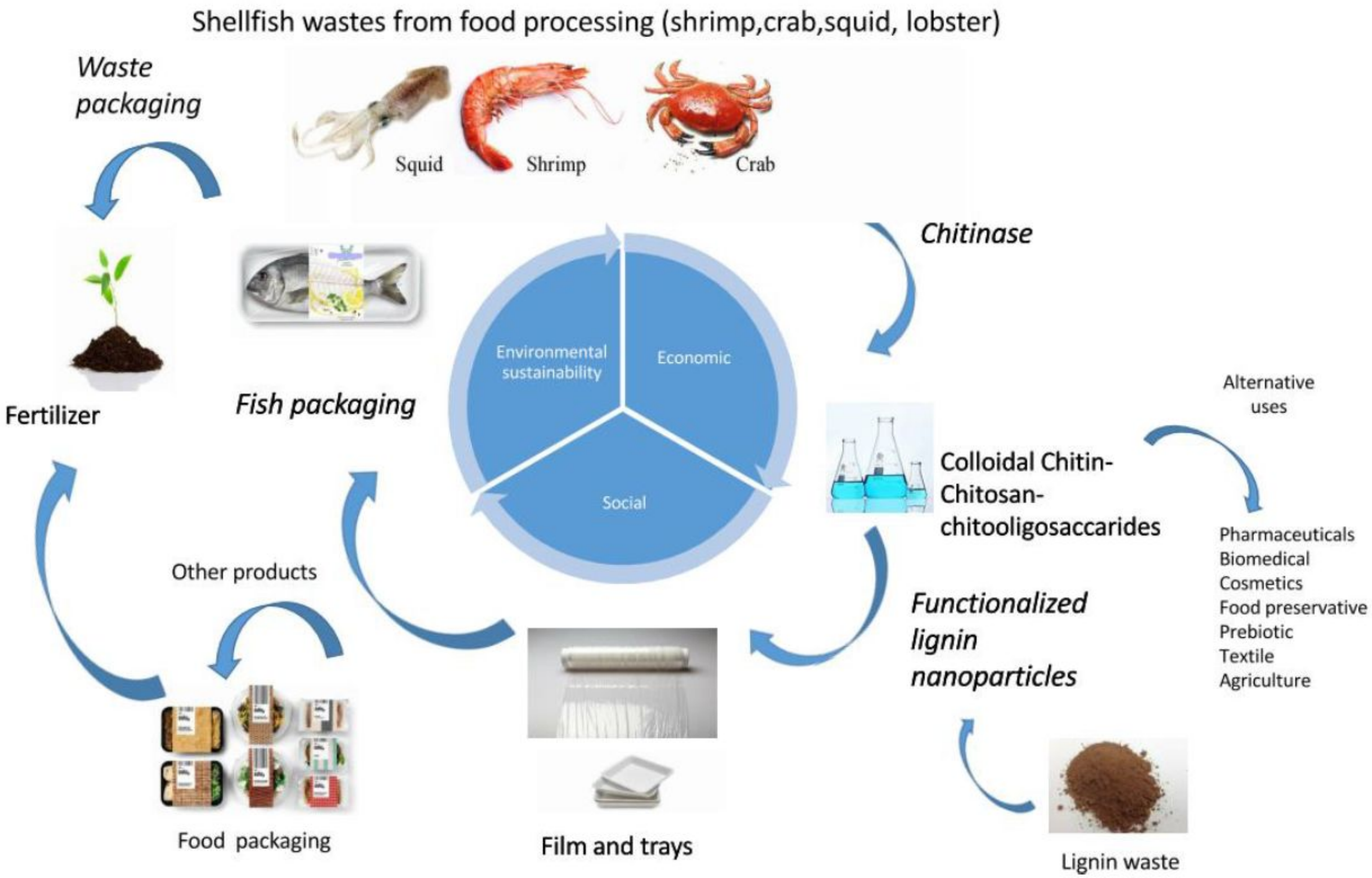
Proposal number: 863697

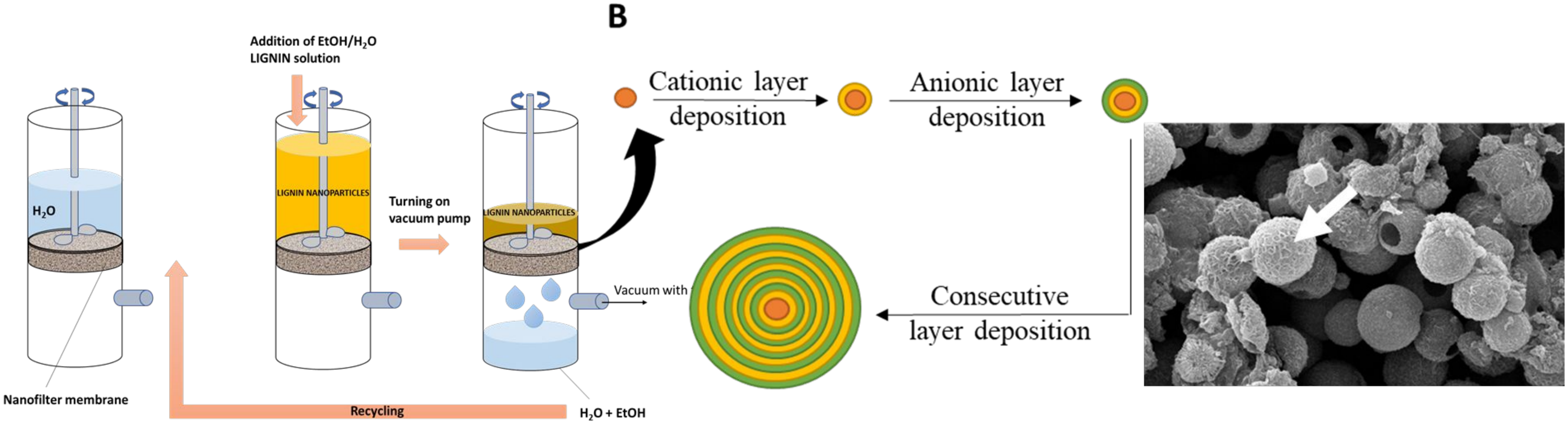
Proposal acronym: FISH4FISH

Il progetto europeo“**FISH4FISH**” integra competenze in ambito chimico ed industriale per la realizzazione di un innovativo blend realizzato con bioplastiche e **lignina**, un componente del legno non tossico a basso costo ed ecocompatibile, in grado di aumentare le proprietà reologiche e chimico fisiche delle bioplastiche attualmente in commercio.

L'obiettivo del progetto è quello di ottenere un materiale attivo a basso costo da sfruttare per le applicazioni industriali di Imballaggi alimentari.

The FISH4FISH concept is reported in the following scheme:





No. 102018000008001
submitted

Preparazione di nanoparticelle e sistemi colloidali per la produzione di bioplastiche

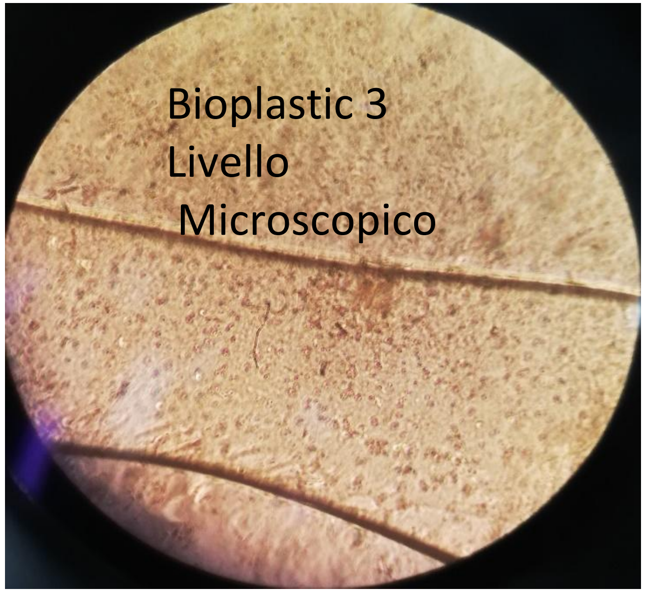
UNIVERSITÀ DEGLI STUDI DELLA Tuscia

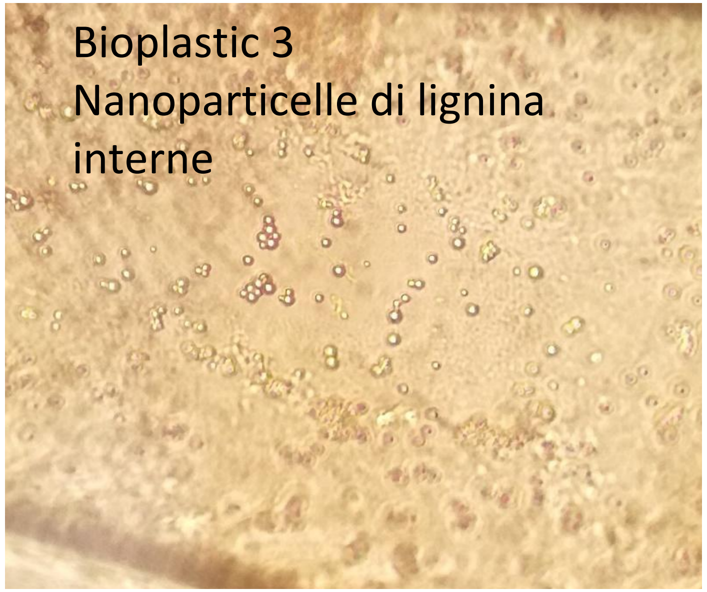
COFI GENTOXCHEM

FISH 4 FISH

UNIVERSITÀ DI SIENA 1240

NEXT TECHNOLOGY TECNOTESSILE





European Union
European Maritime and Fisheries Fund

HEALTH & FOOD / PROJECT

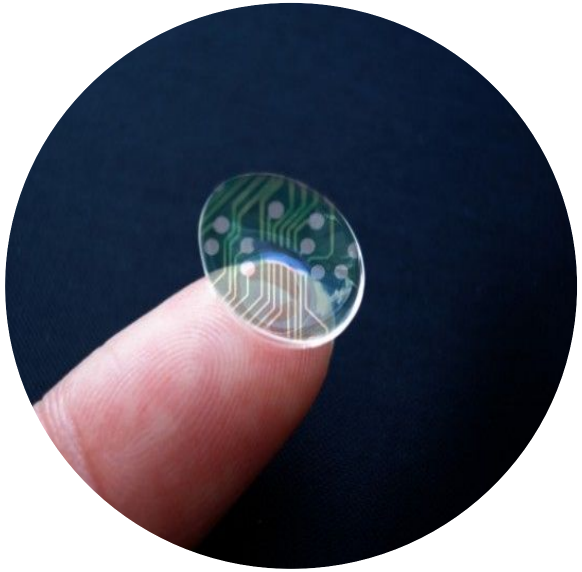
EU-IBISBA

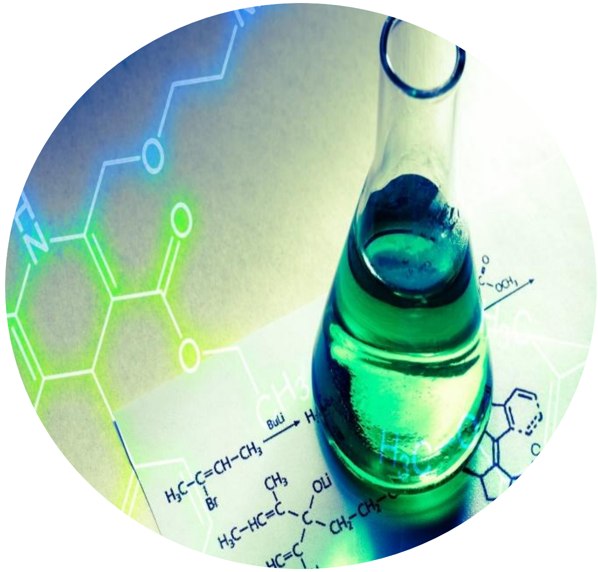
European Industrial Biotechnology Innovation and Synthetic Biology Accelerator

An accelerator for research and innovation in Industrial Biotechnology and Synthetic Biology

IBISBA 1.0

Design of bioinks





PhD Student Eliana Capecchi

Mail: e.capecchi@unitus.it

INKs GLOBAL ISSUES

Health, Environmental and Regulamentation Concerns


ORIGINAL RESEARCH

TATTOOS: What Do People Really Know About the Medical Risks of Body Ink?

by ILIANA A. RAHIMI, BSc; IGOR EBERHARD, PhD; and ERICH KASTEN, PhD

Mrs. Rahimi and Professor Kasten are with the Medical School hamburg in Hamburg, Germany. Dr. Eberhard is with the Department of Social and Cultural Anthropology at the University of Vienna in Vienna, Austria.

J Clin Aesthet Dermatol. 2018;11(3):30–35

ABSTRACT

21% **Malignant melanoma**

- Use of toxic phenol-formaldehyde resins
- Can contain PAH (*polycyclic aromatic hydrocarbons)*
- Photosensitivity
- Enhanced psoriasis and autoimmune problems

INK'S ENVIRONMENTAL FOOTPRINT

Decomposition time
450 to 1000 Years

- VOC (Volatile Organic Compounds)
- Energy demanding

Regulamentation

EuPIA European Printing Ink Association
A sector of CEPE aisbl

ABOUT INKs

How ink is made

Physical and stability Properties

Specific guidelines for the inks

Viscosity

Surface Tension

Light Fastness

Complex Composition

Additive 0.1-10%

Vehicle or Binders 6-7%

Pigments 33-34%

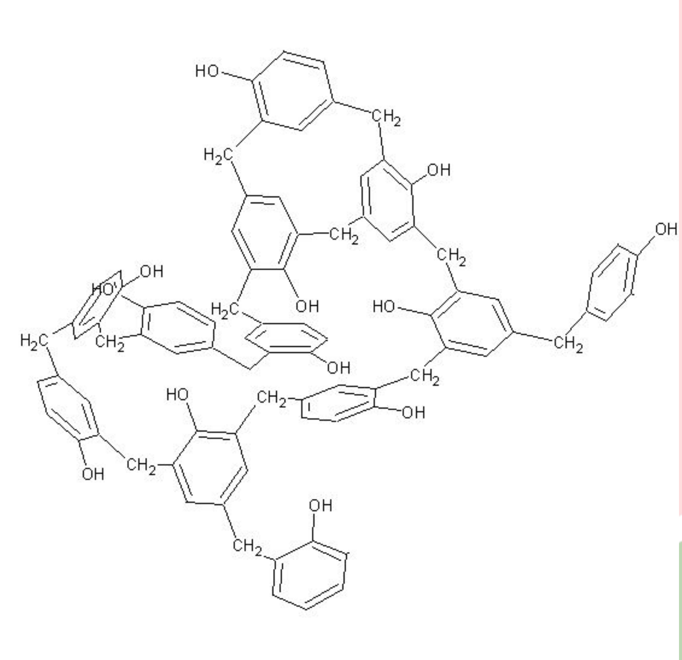
Solvent 60%

Chemistry Formulation

ECO FRIENDLY BINDER

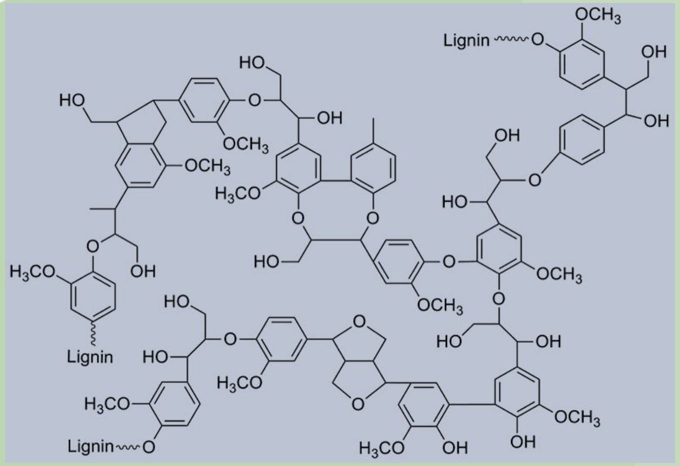
- Synthetic polymers obtained by the reaction of phenol or substituted phenol with formaldehyde.
- Carcinogenic formaldehyde (Toxicity) High Environmental impact for air pollutants emitted

Phenol formaldehyde resins



VS

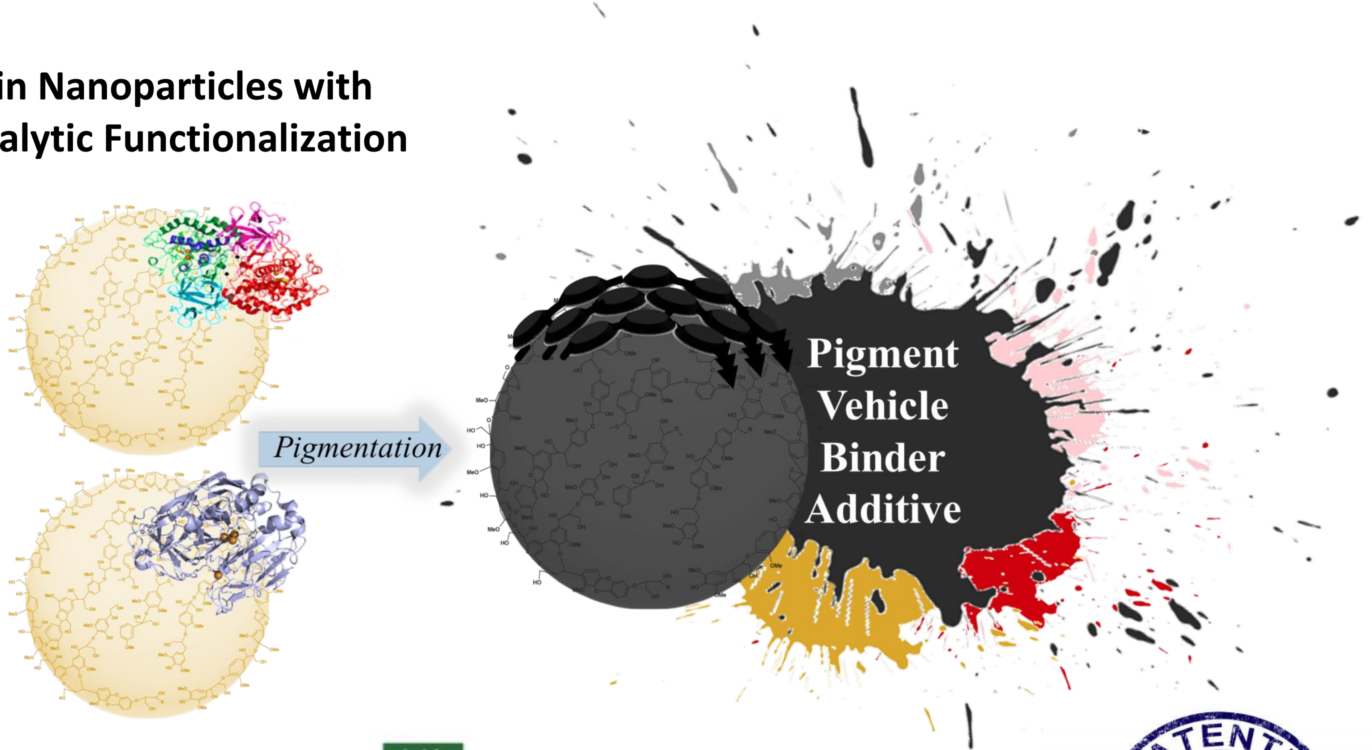
Lignin Based Binders



- The actual structure of the lignin molecule it is similar of a fully set formaldehyde polymer.
- Lignin based binders allow for raw materials cost savings
- Lignin as a raw material is non toxic and easy to handle.
- improving the viscosity of the medium

Our technology for an innovative Bioink

Lignin Nanoparticles with Biocatalytic Functionalization



Biomacromolecules

Article

Cite This: Biomacromolecules XXXX, XXX, XXX−XXX

pubs.acs.org/Biomac

Enzyme-Lignin Nanocapsules Are Sustainable Catalysts and Vehicles for the Preparation of Unique Polyvalent Bioinks

Eliana Capecchi,[†] Davide Piccinino,[†] Bruno Mattia Bizzarri,[†] Daniele Avitabile,[‡] Claudia Pelosi,[§] Claudia Colantonio,[§] Giuseppe Calabrò,[§] and Raffaele Saladino*[,†]

[†]Department of Biological and Ecological Sciences (DEB), Tuscia University, Via S. Camillo de Lellis snc, 01100 Viterbo, Italy
[‡]IDI Farmaceutici srl, Via dei Castelli Romani 83/85, Pomezia, 00040 Rome, Italy
[§]Department of Economics, Engineering, Society and Business Organization (DEIM), Tuscia University, 01100 Viterbo, Italy

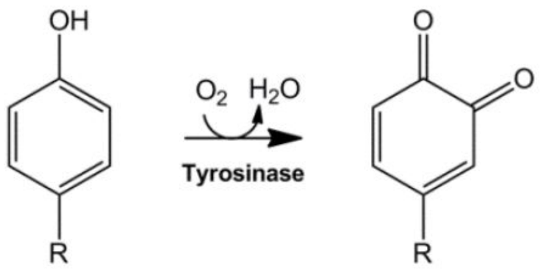
No. 102018000006058

“Micro- e nano- capsule o particelle a base di polifenoli e loro uso in campo cosmetico e come inchiostro”.

THE BASES OF OUR TECHNOLOGY

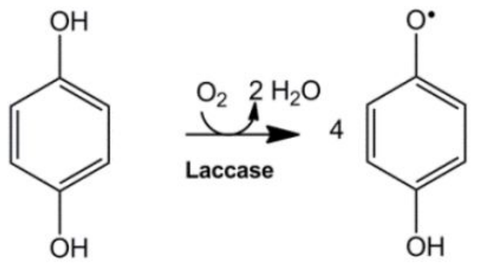
Biocatalytic Component
(From Mushroom)

TYROSINASE (EC 1.14.18.1)



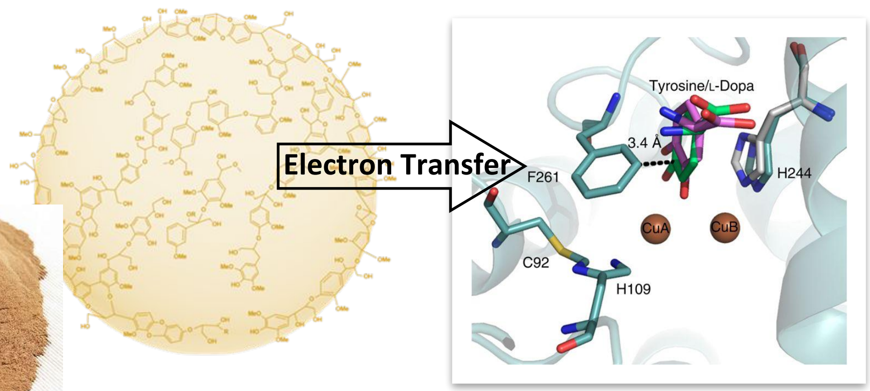
FUNGI EXTRACTION

LACCASE (EC 1.10.3.2)



Electro Active support For Enzymatic Immobilization

LIGNIN NANOPARTICLES



LIGNIN

nanomaterials MDPI

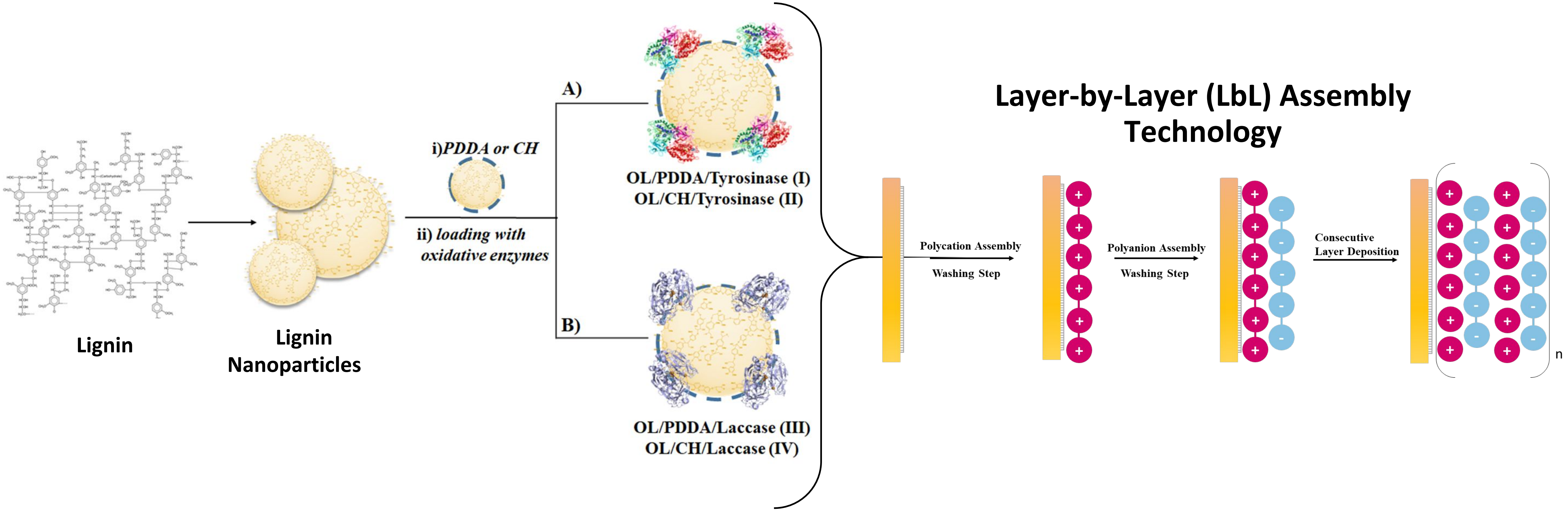
Article

Functionalized Tyrosinase-Lignin Nanoparticles as Sustainable Catalysts for the Oxidation of Phenols

Eliana Capecchi [1], Davide Piccinino [1], Ines Delfino [1], Paolo Bollella [2], Riccarda Antiochia [2] and Raffaele Saladino [1,*]

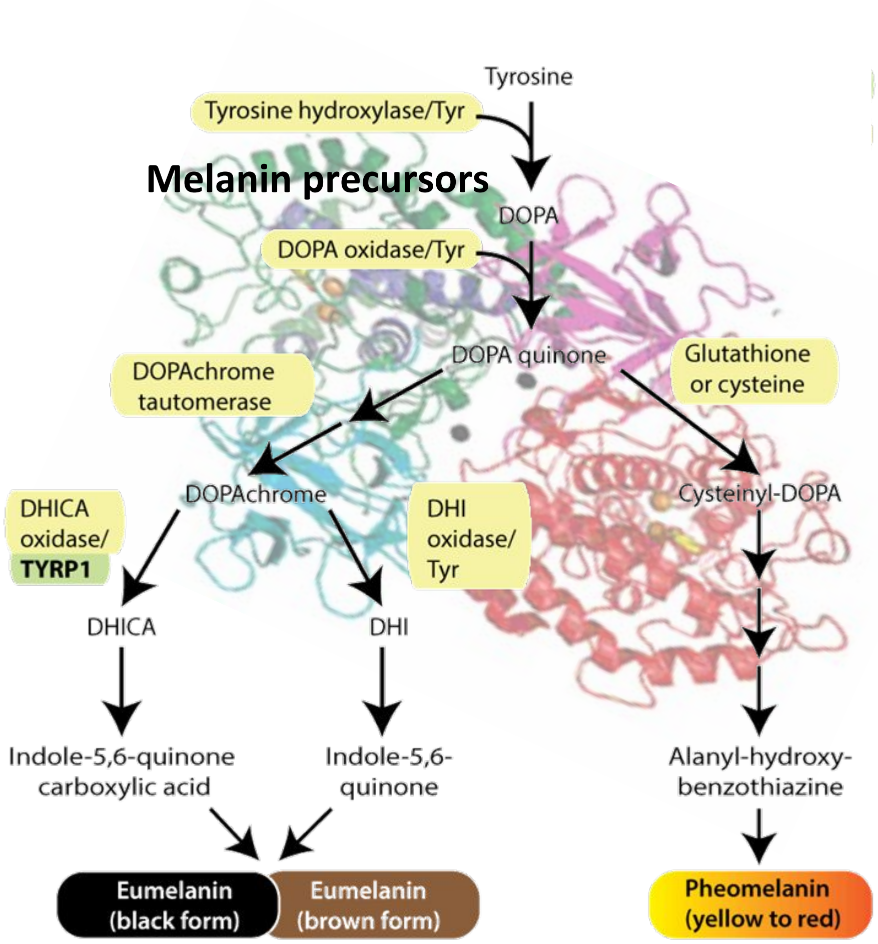
BIOTECHNOLOGY APPROACH

Layer by Layer Assembly Technology for the enzymatic functionalization of Lignin nanoparticles

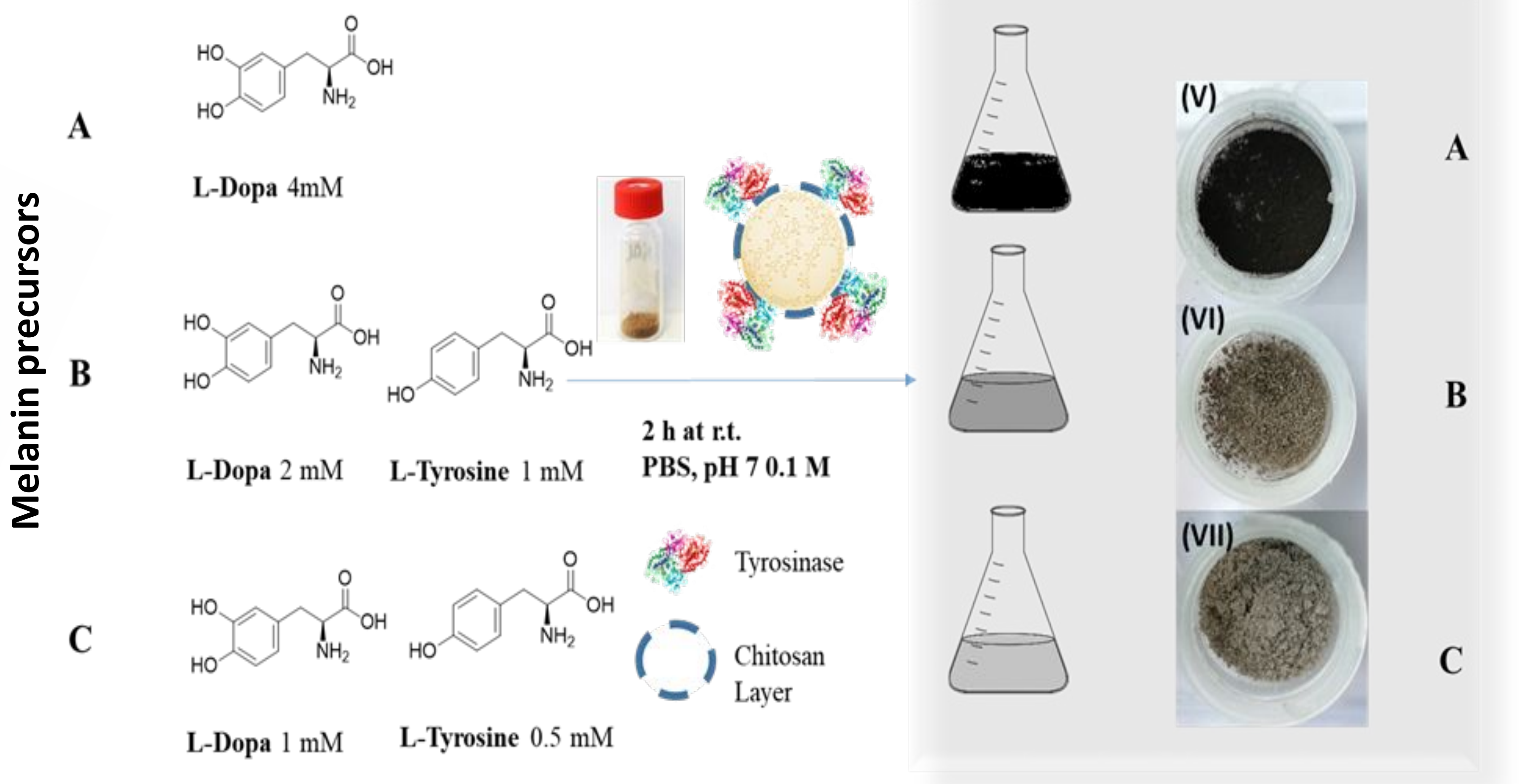


BIOINKS PRODUCTION

Tyrosinase in melanin pathway

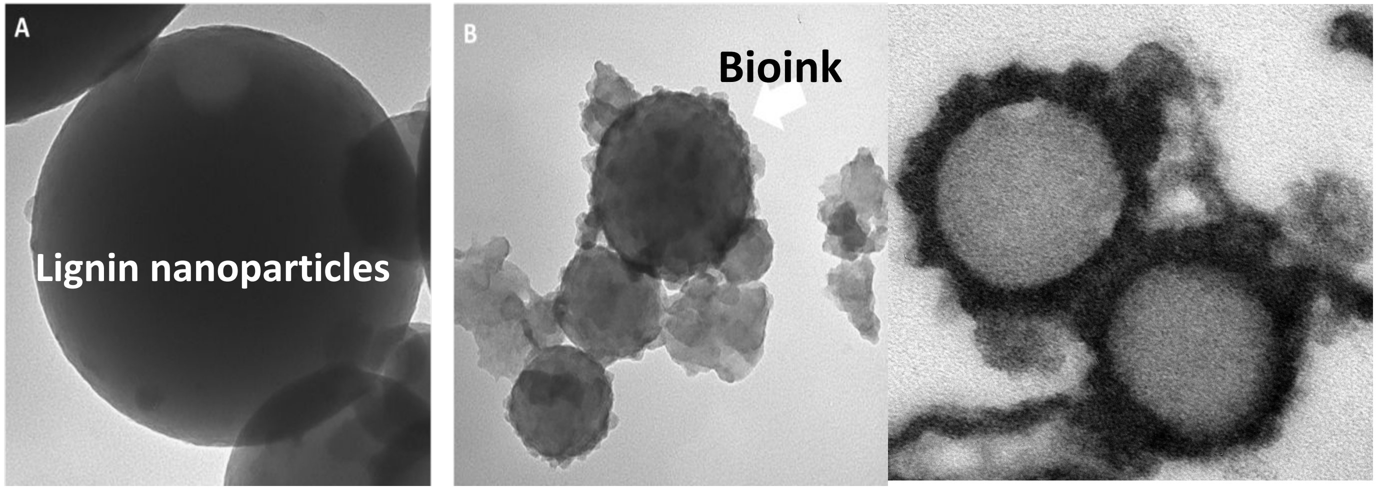


Immobilized Tyrosinase in Bioink Technology

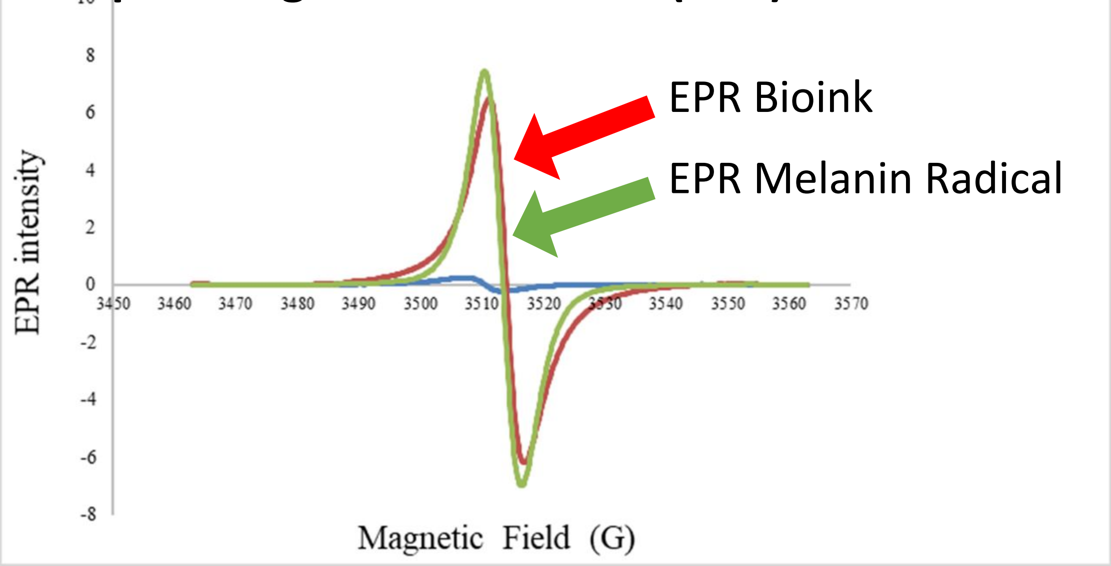


BIOINKS CHARACTERIZATION

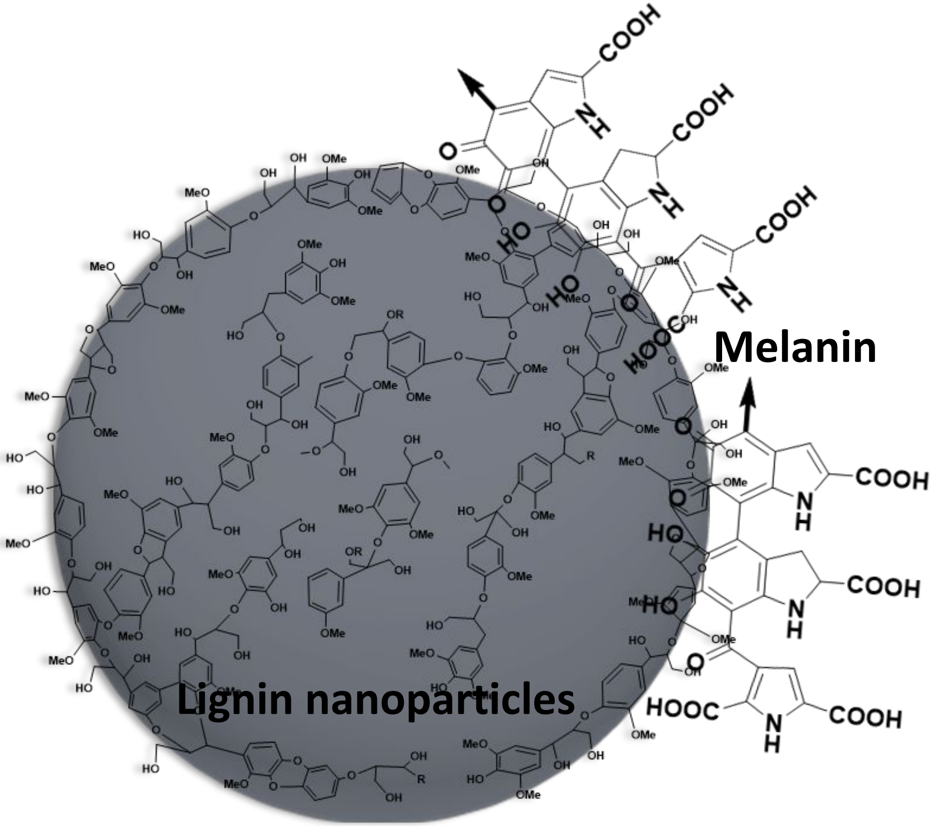
Transmission Electron Microscopy (TEM)



Electronic paramagnetic resonance (EPR)

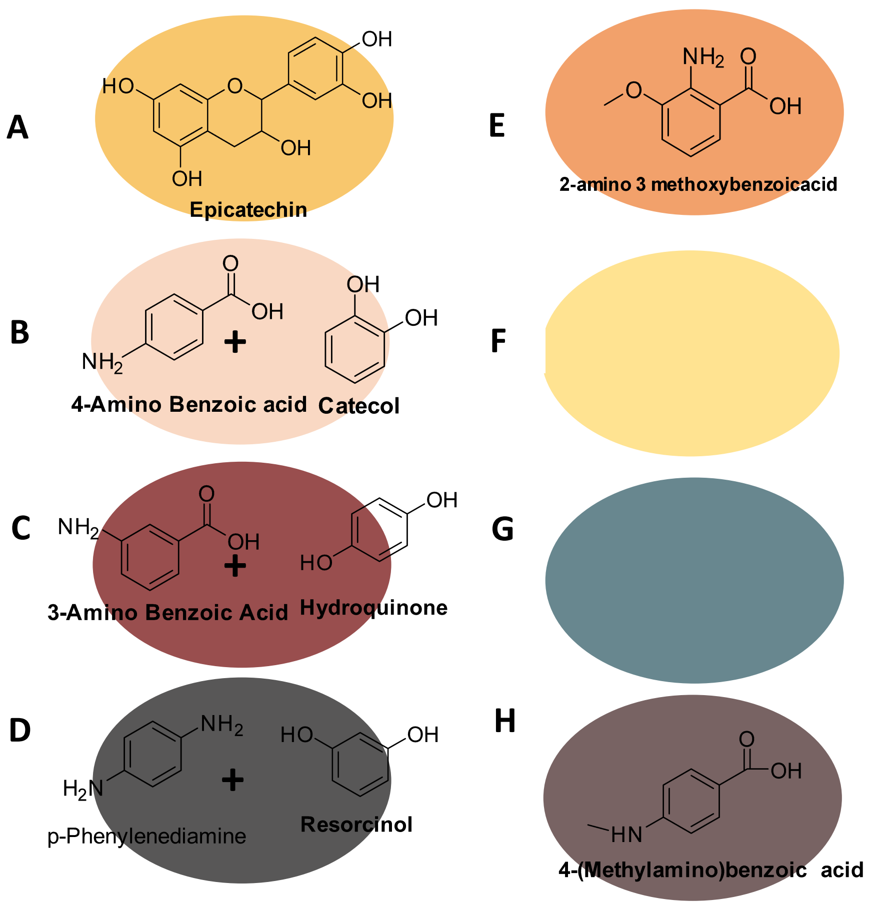


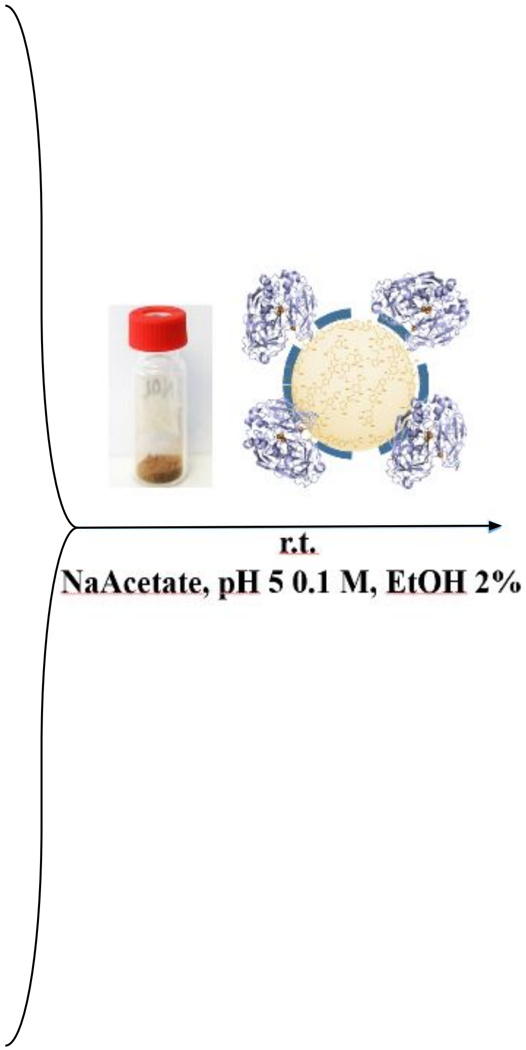
BioInk Chemical Structure



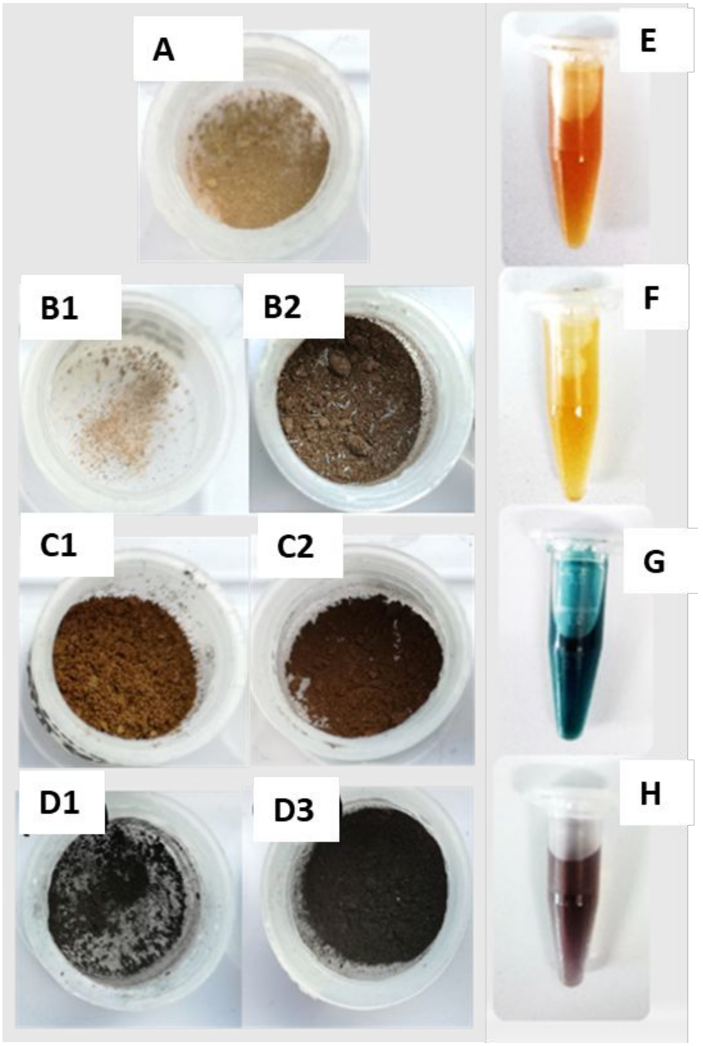
BIOINKS PRODUCTION

Laccase Chromogenic Substrates





Immobilized Laccase in Bioink Technology



PHYSICAL PROPERTIES OF BIOINKS

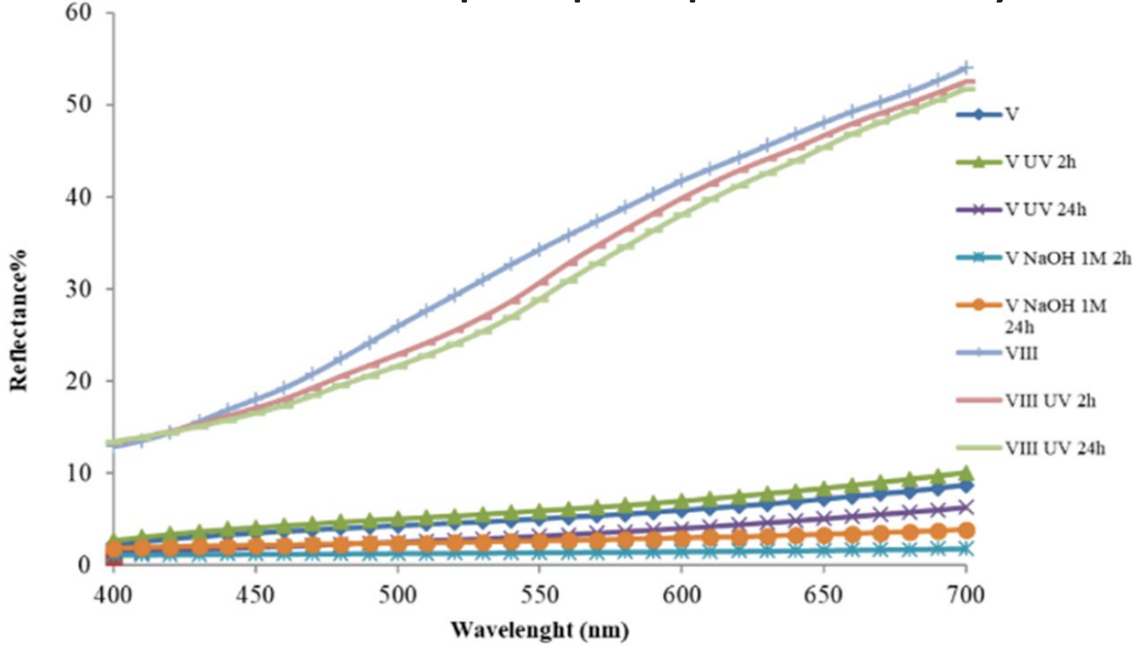
LIGHT FASTNESS STABILITY TEST

Color strength and light fastness are important physical properties for the quality, weather resistance, and applications of the inks. Alkaline medium and artificial and natural light may cause most pigments to degrade resulting in color change.

Bio-Ink

-Alkaline medium
-Artificial light

CIE L*a*b* Color Space Spectrophotometer Analysis



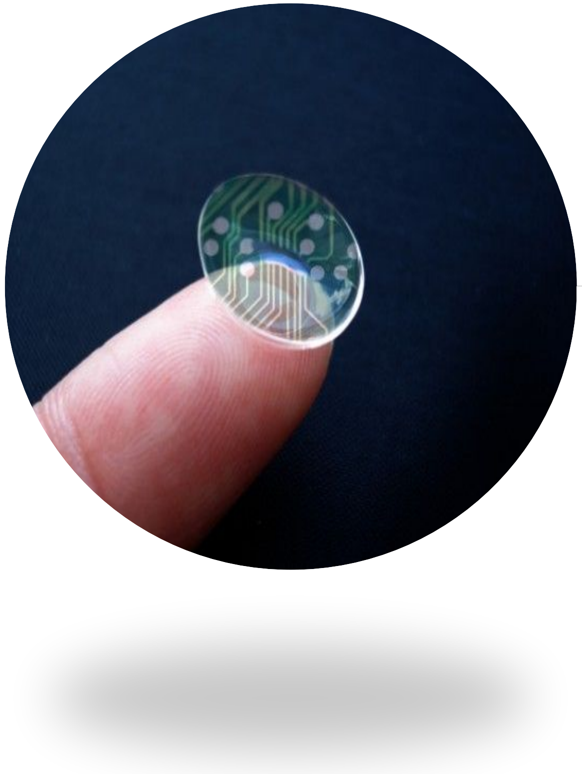
Results

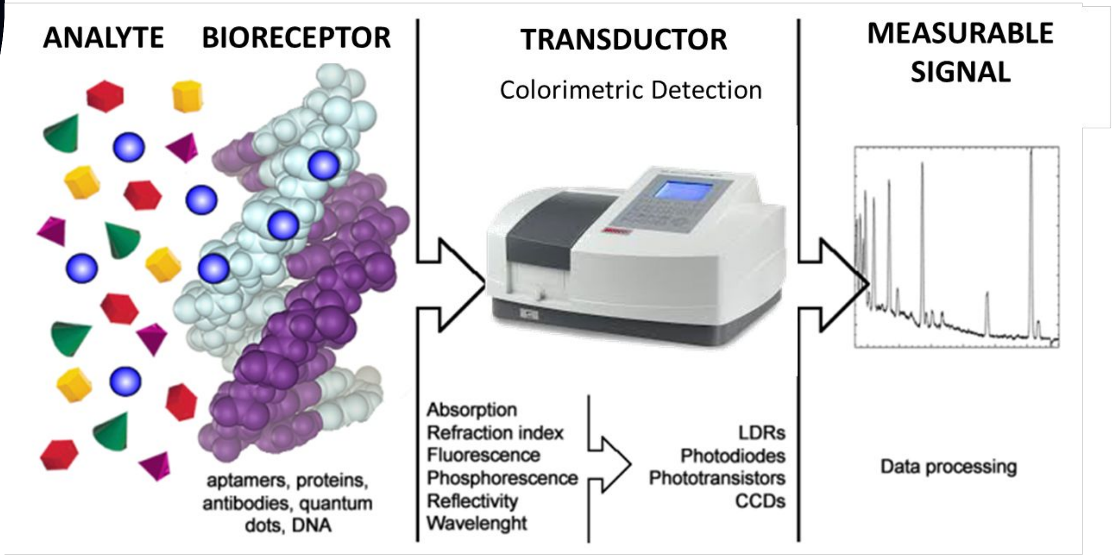
1.No Colour Changes

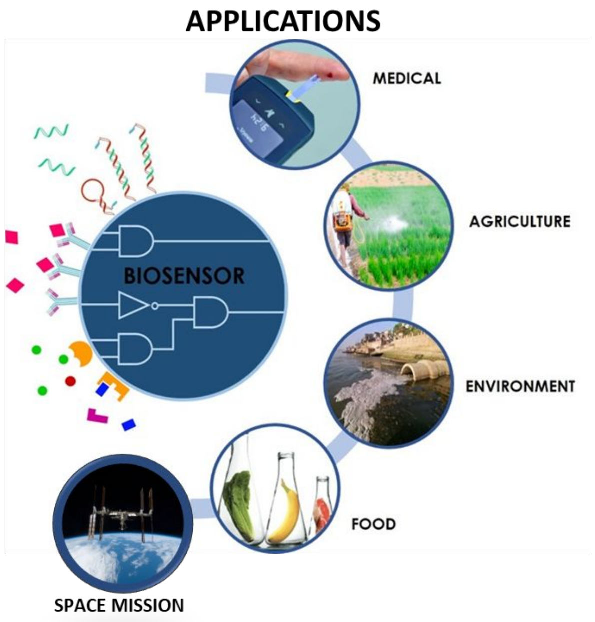
2.Pigments not degraded

3.Bio-Ink stable

Design of colorimetric biosensors

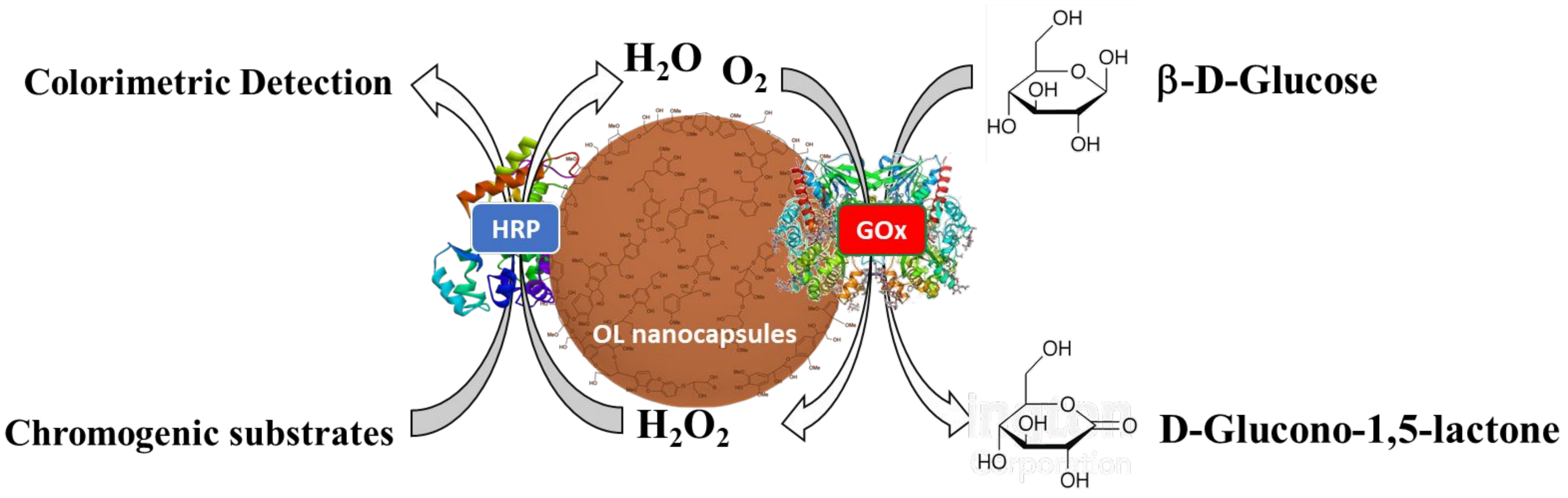




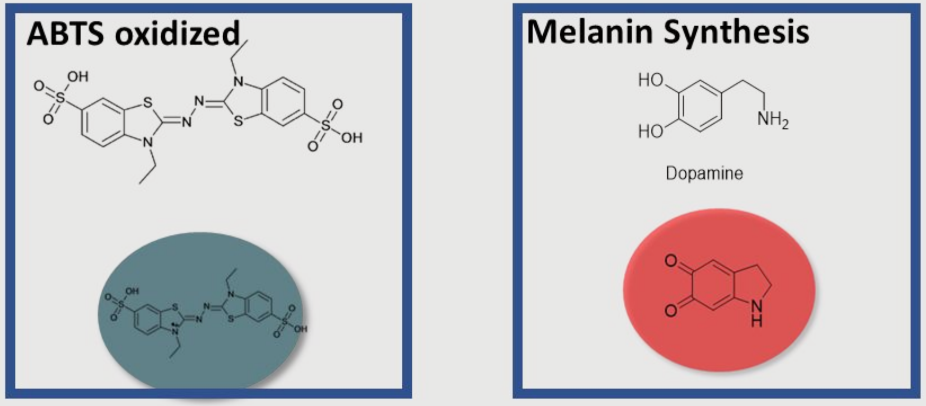


Design of colorimetric biosensors

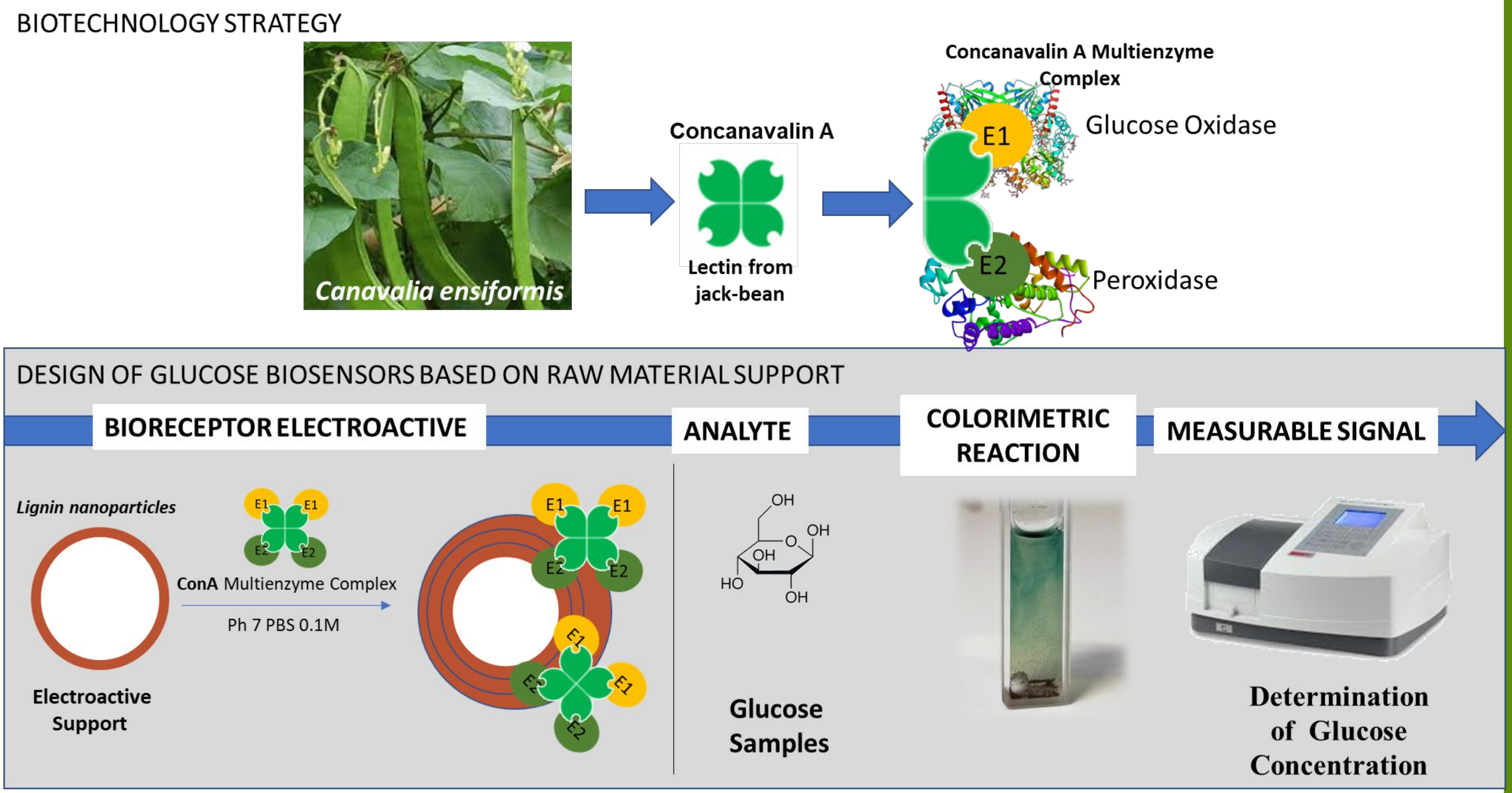
A novel Biosensors that combining colorimetric and Electrochemical detection



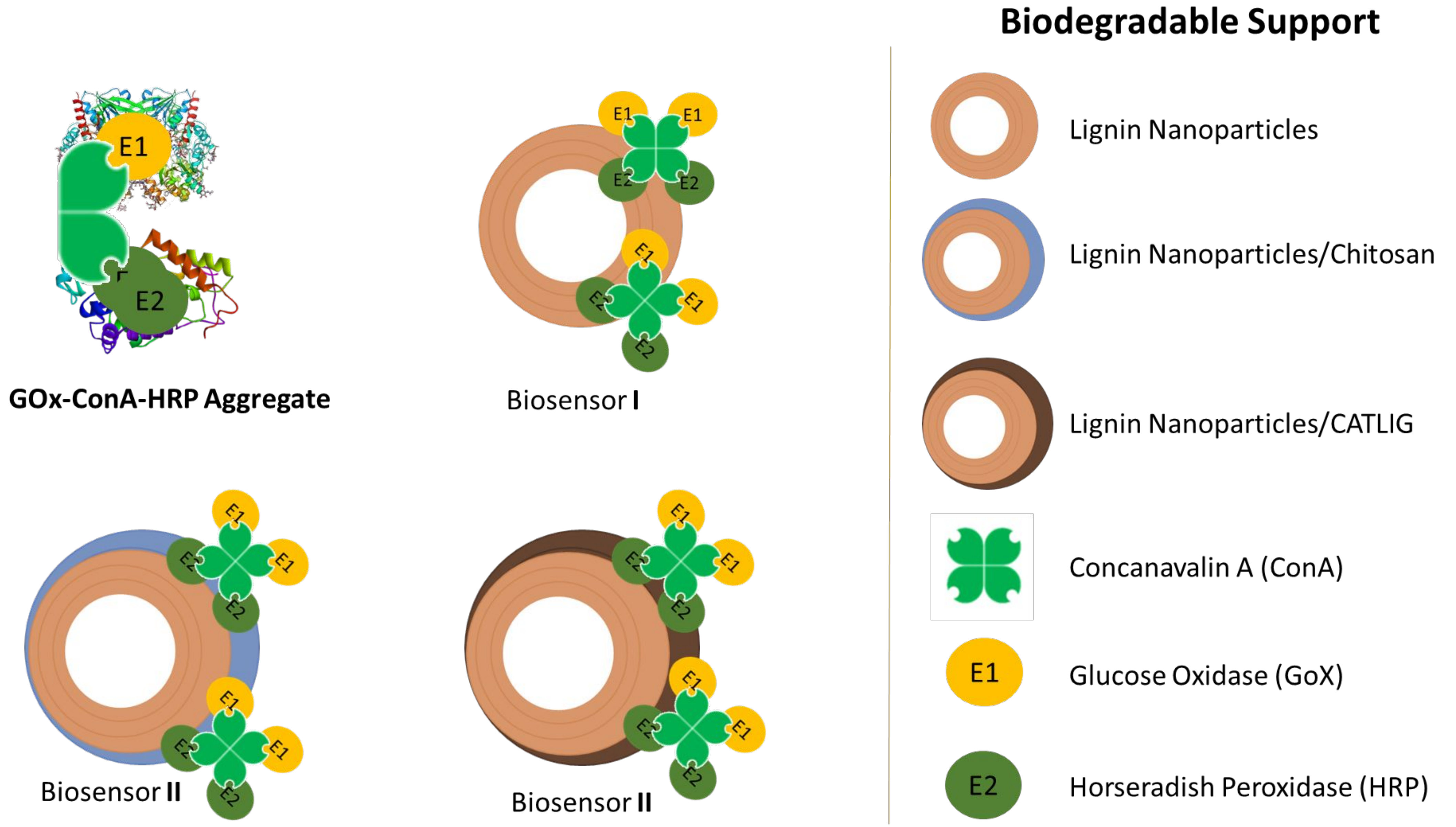
Chromogenic Substrates



Design of colorimetric biosensors



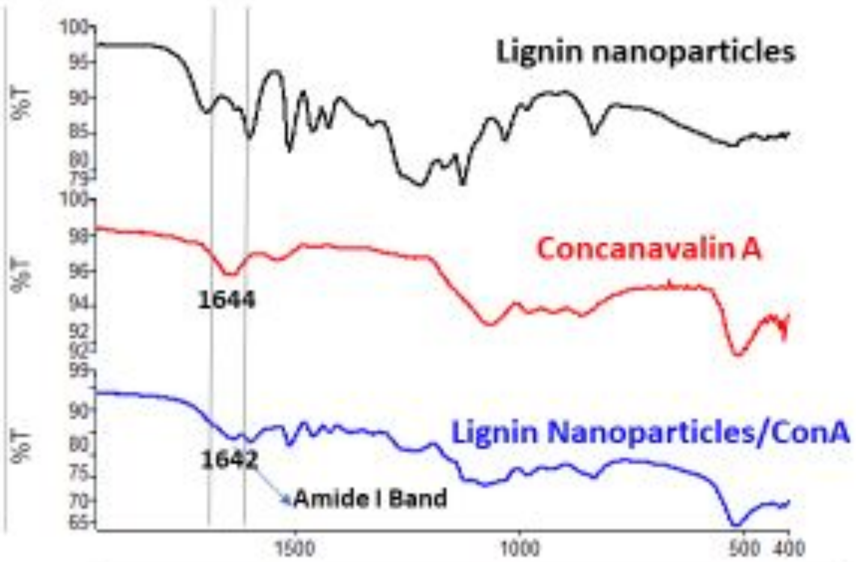
BIORECEPTOR ELECTROACTIVE



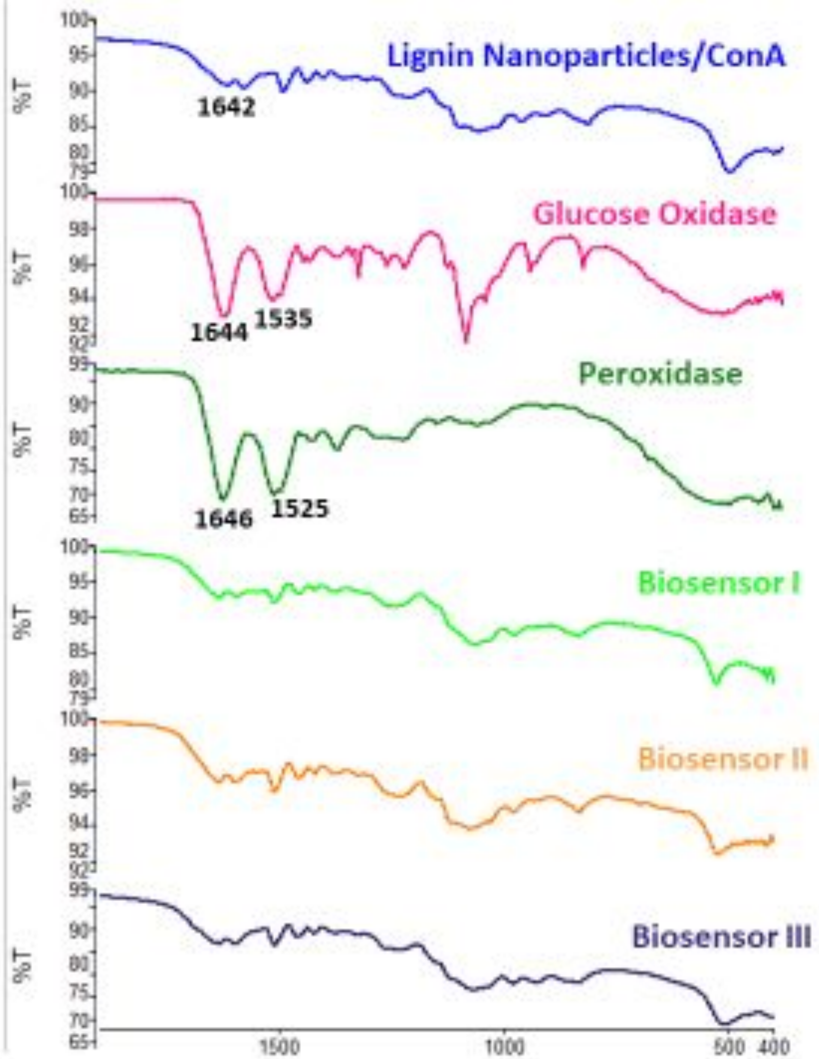
BIORECEPTOR ELECTROACTIVE

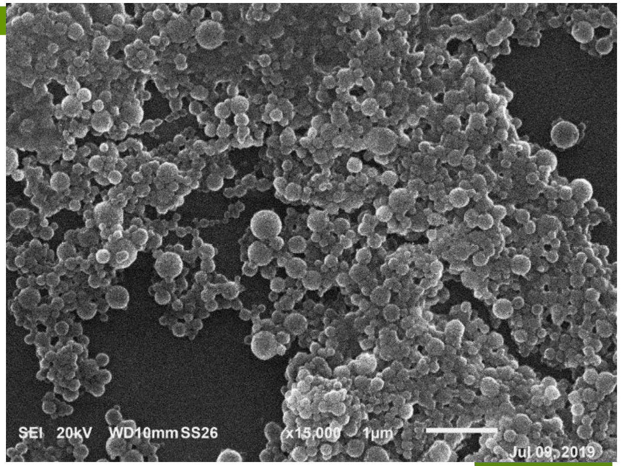
Fourier transform infrared spectra (FTIR) in ATR mode

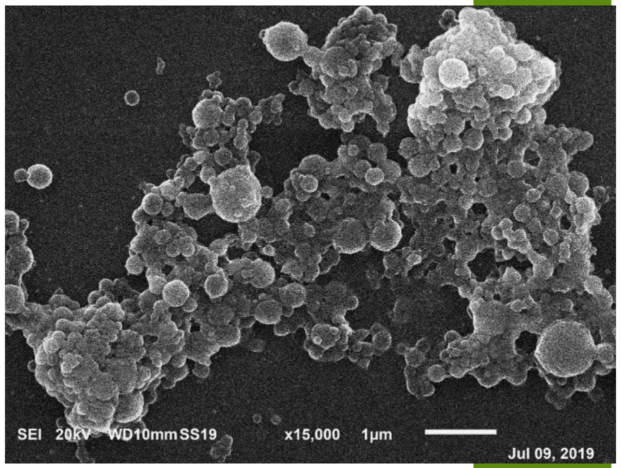
A)

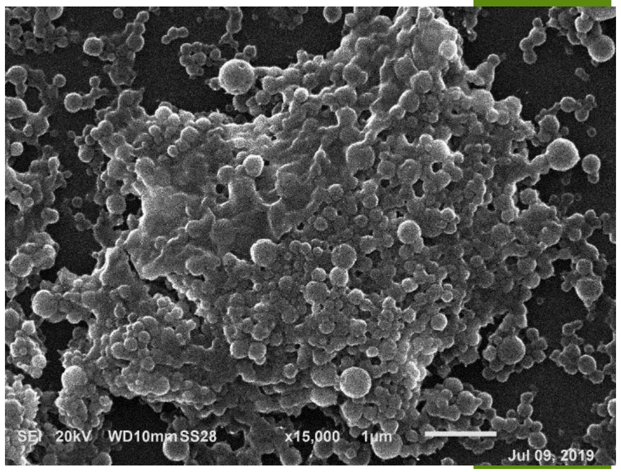


Fourier transform infrared spectra (FTIR) of Lignin Nanoparticles, ConA and ConA-Lignin Nanoparticles, showing a typical C=O peak at 1600 cm-1 for Lignin Nanoparticles with ConA, a similar trend is reported in previous work.[ref]







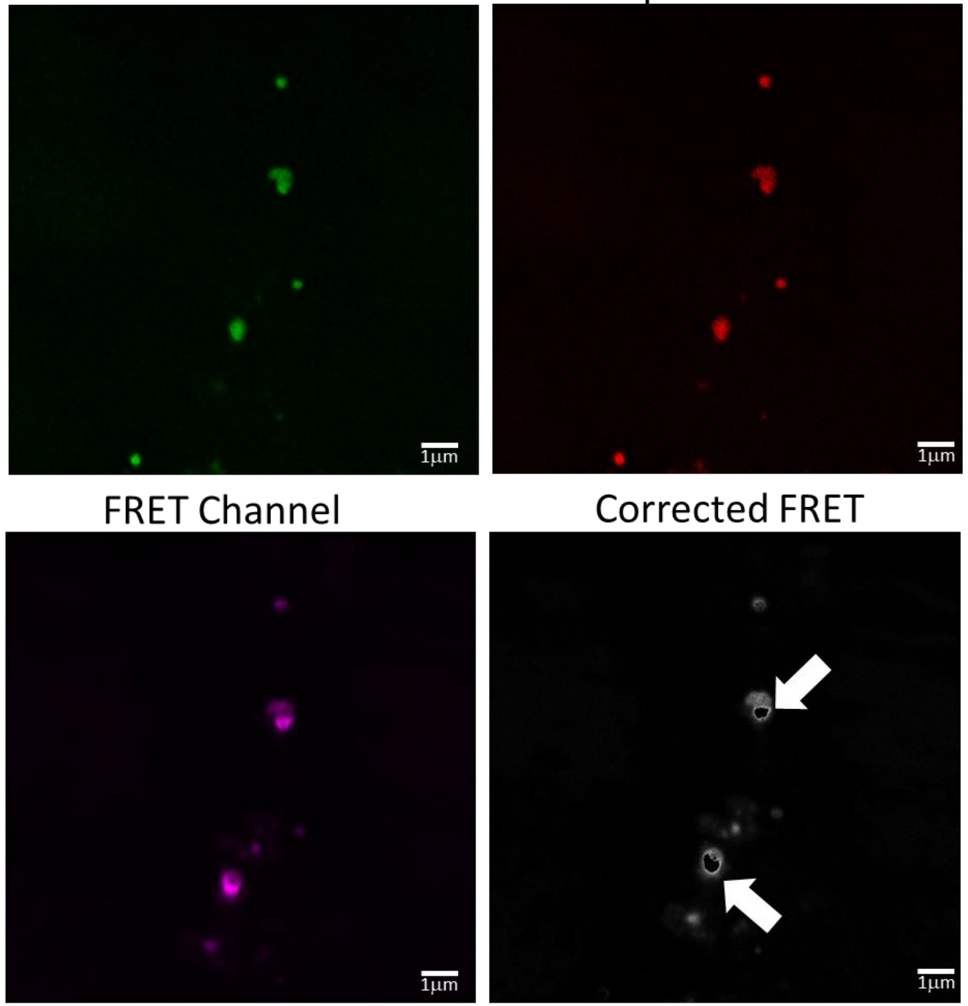


Design of colorimetric biosensors

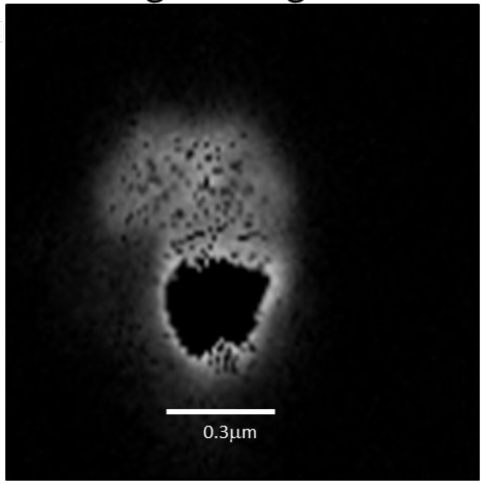
BIORECEPTOR ELECTROACTIVE

FITC donatore
GOX

Donor Channel | Accepted Channel | FRET Channel | Corrected FRET

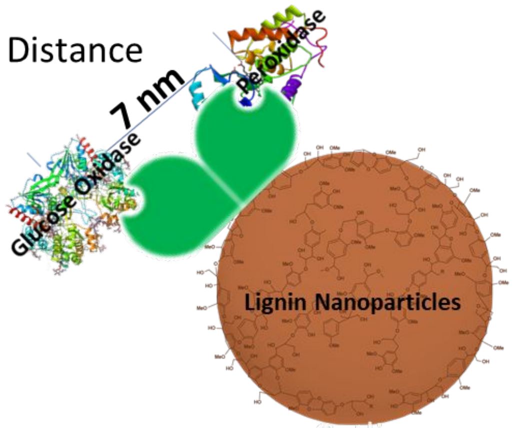


FRET signal Magnification



RESULTS
R=7nm

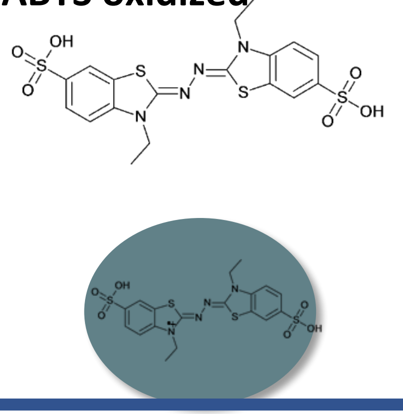
La distanza ottimale tra GOX-HRP è circa 6-10nm

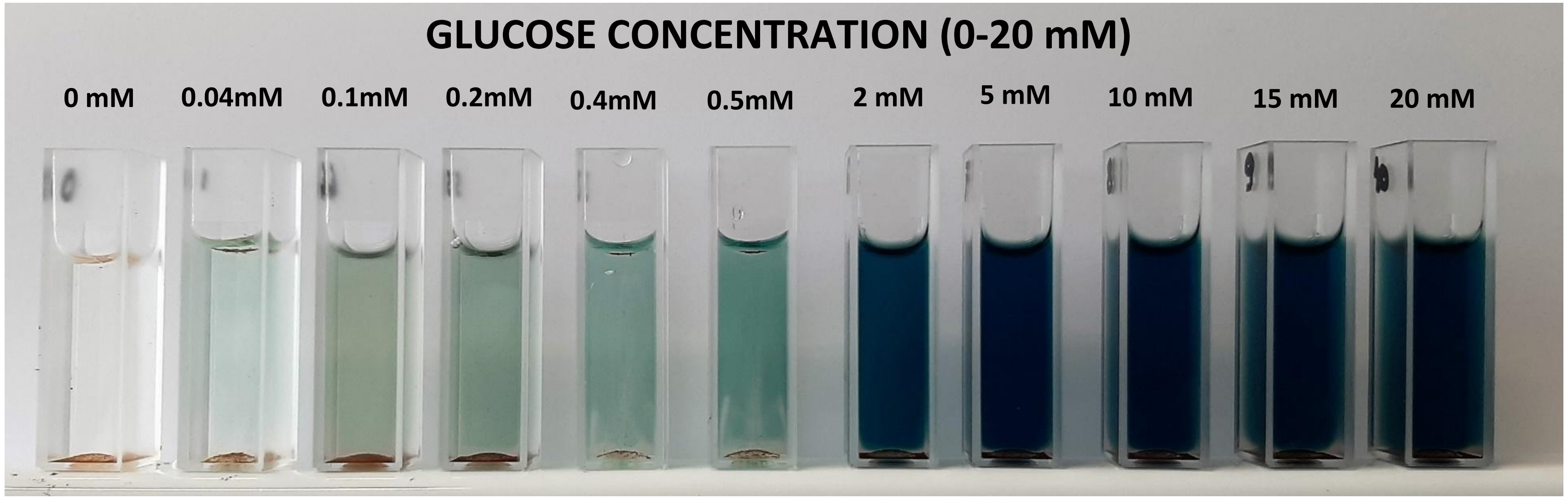


ANALYTE → COLORIMETRIC REACTION → MEASURABLE SIGNAL

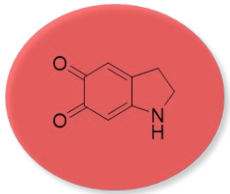
BIOSENSOR SENSITIVITY (LOD)

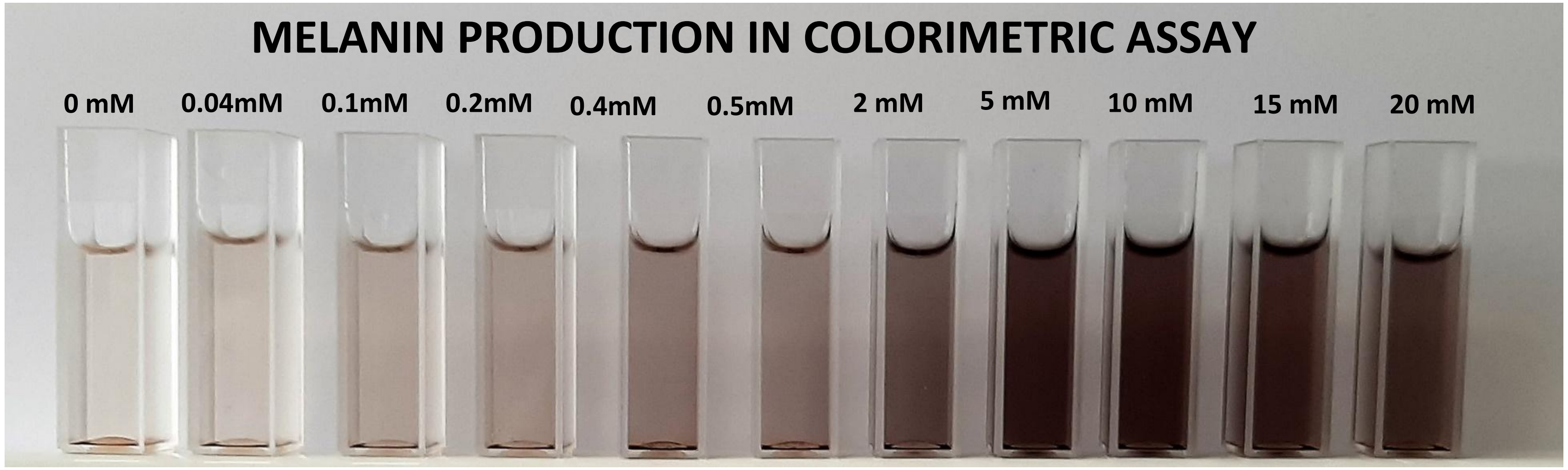
ABTS oxidized





Melanin Synthesis

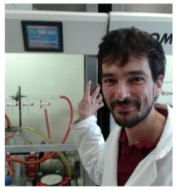




COFI

Raffaele Saladino

Bruno M Bizzarri



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THANK YOU

FOR YOUR ATTENTION