Sustainable production of Cellulose-based products and additives to be used in SMEs and rural areas
Funded from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 101007733.

I am CELISE

Valorization of lignocellulosic biomass: nanomaterials for advanced applications

Juan Carlos Colmenares

CELISE Med Term Meeting
24th-25th of July-2023, Warsaw, POLAND

IChF Institute of Physical Chemistry PAS

Instituto de Investigación en Ingeniería
UNIVERSIDAD COOPERATIVA DE COLOMBIA

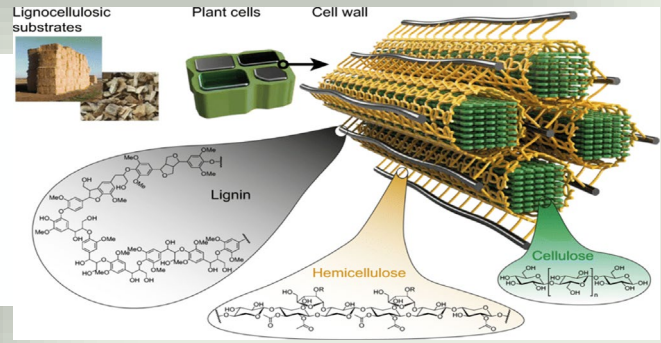
Engineering Research Institute
Universidad Cooperativa de Colombia

I am CELISE

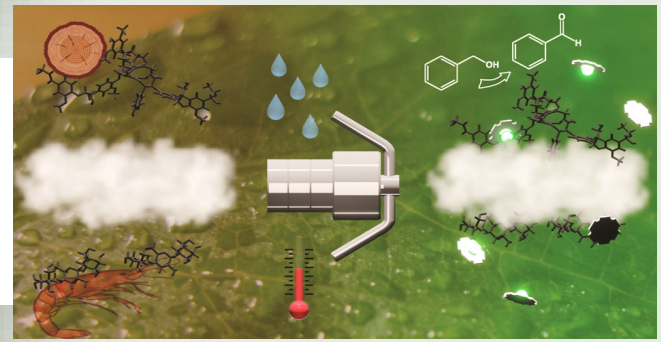
Outlines

Colombia-Poland, Process intensification, Photocatalysis, Sustainability, TiO_2/carbon-based materials, Lignin valorization, Nanomaterials, SDGs, Water purification,…,

1. Generalities of Colombia-Poland Cooperation and the possibilities of using lignin for photocatalysts' fabrication

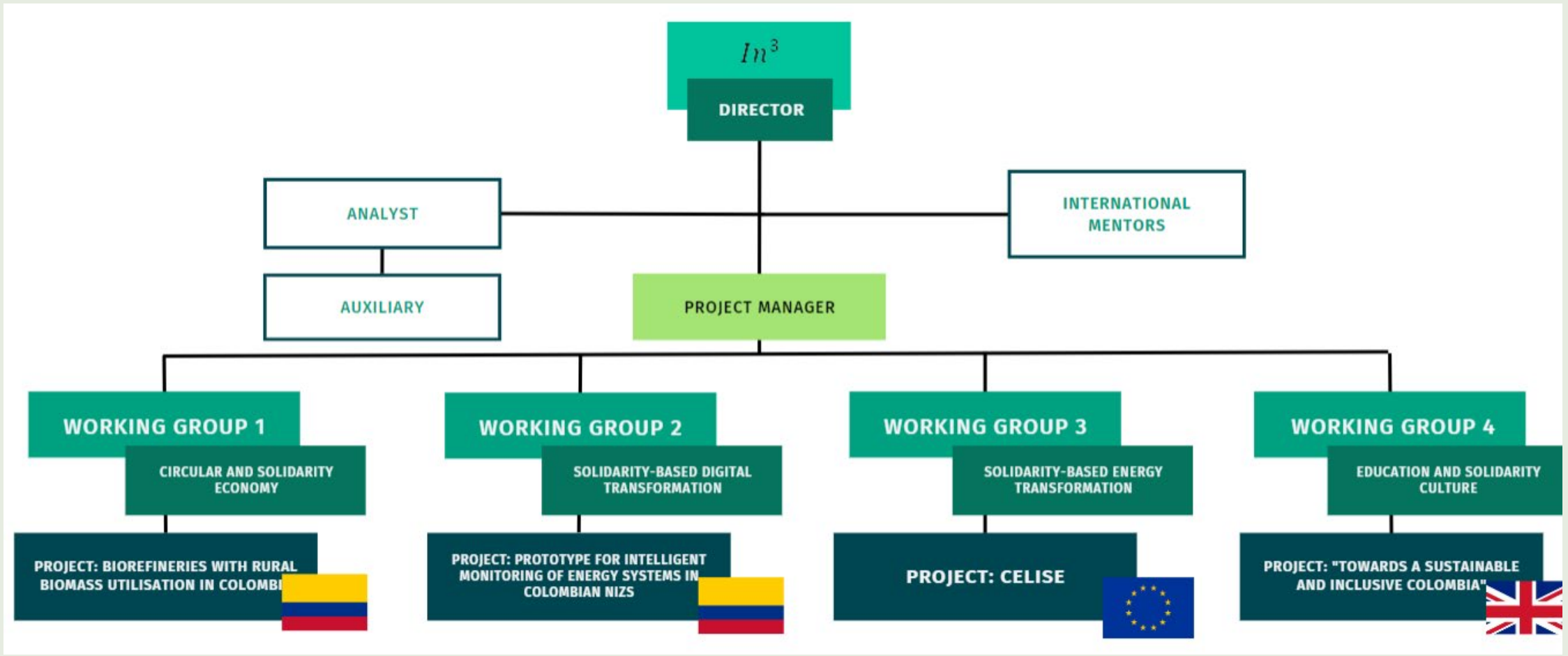


2. Titania/Chitosan-Lignin nanocomposite as an efficient photocatalyst for the selective oxidation of benzyl alcohol under UV and visible light.



I am CELISE

Engineering Research Institute
Universidad Cooperativa de Colombia



I am CELISE

Projects in execution through the Network: BERSTIC

https://berstic.edu.co/

BERSTIC –Co-creation Network

Dissemination of research results Design of project proposals

Transfer of Knowledge and Technology Directorate

- Incubation of technology-based companies
- Prototype development

Laboratories and Capacities

Universidad Cooperativa de Colombia

VoCATE (UK)

Aquiatera Ltd (UK)

Ghent University (Belgium)

Institute of Sciences and Technologies for Sustainable Energy and Mobility (STEMS)(Italy)

AgroSavia Research Centre (Colombia)

Institute of Physical Chemistry (Poland)

Business models

Industry

Academy

Communities

Government

- Customised training
- Advisor work
- Monitoring Centre
- Surveillance of calls

Tools:

QFD (Quality Function Deployment) System Thinking

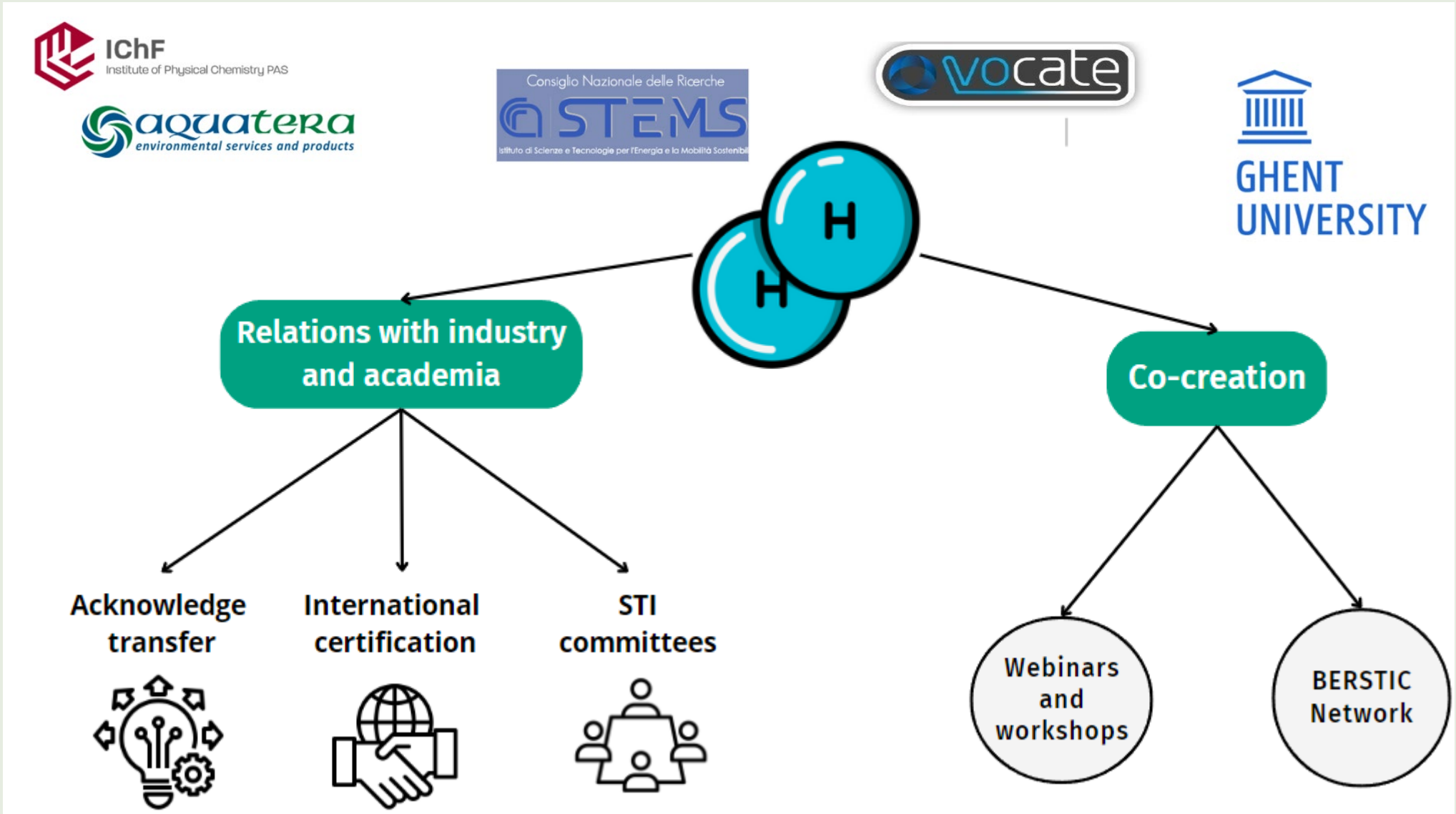
Life Cycle Analysis Data Processing Virtual and Expanded Reality

Science, Technology and Innovation Committees

- Management Team - Project Managers - International Mentors and Advisors

I am CELISE

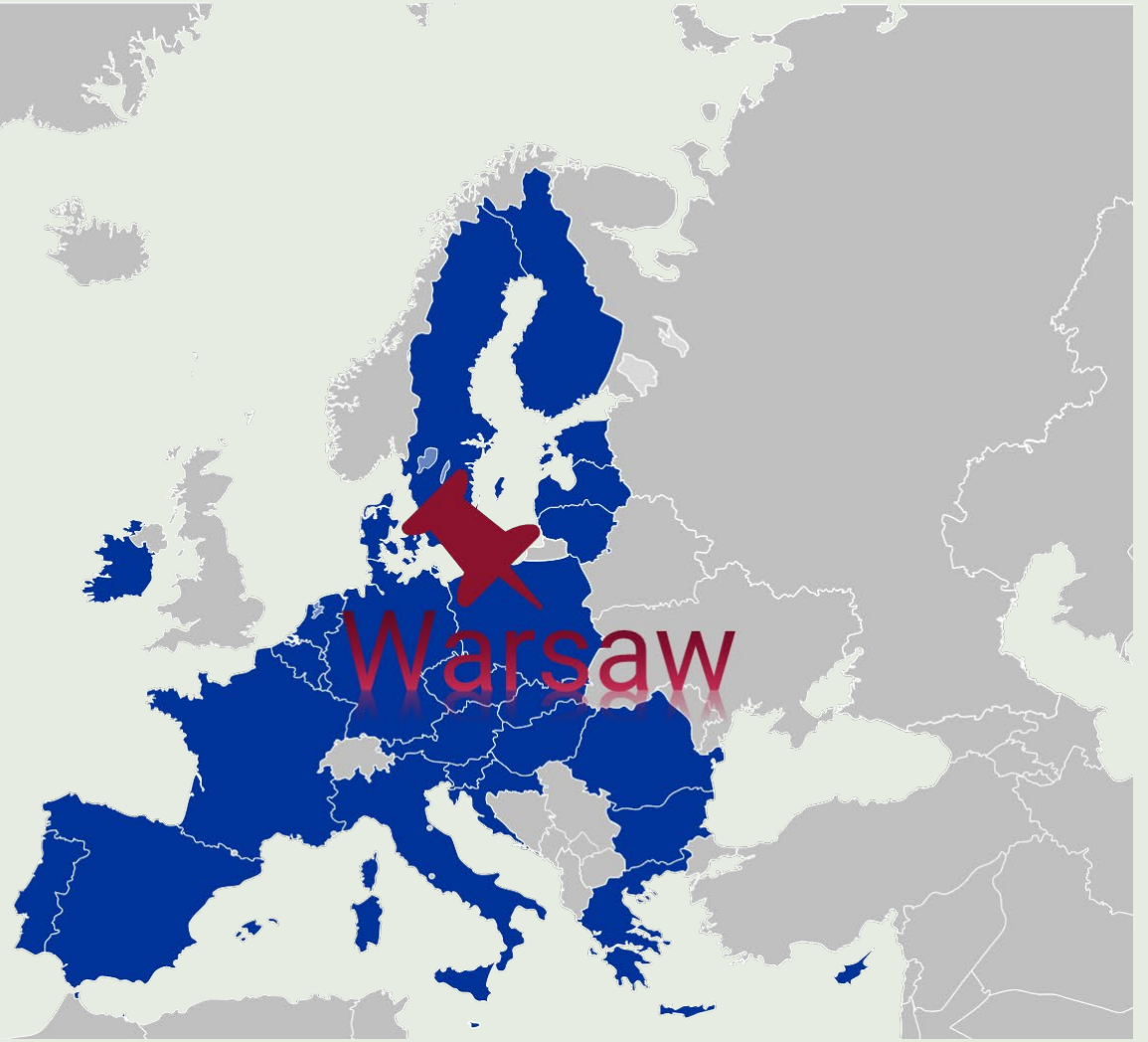
Network of International Collaborators



I am CELISE

IChF
Institute of Physical Chemistry PAS

Where to find us?



I am CELISE

IChF
Institute of Physical Chemistry PAS

Our mission

Research
- ~250 research papers / year
- 70 running projects funded externally

Innovations
- ~15 patents / year
- Spin-offs

Education
- Doctoral School
- Science promotion

I am CELISE

IChF
Institute of Physical Chemistry PAS

Our approach

- >200 scientists
- PIs are free to choose research topic
- Education through research

- Support in grant writing
- Accounting
- Legal support

Emerging topics get funded

I am CELISE

IChF
Institute of Physical Chemistry PAS

Our spin-offs/outs

SCOPE fluidics

Fluence .technology

CURIOSITY DIAGNOSTICS

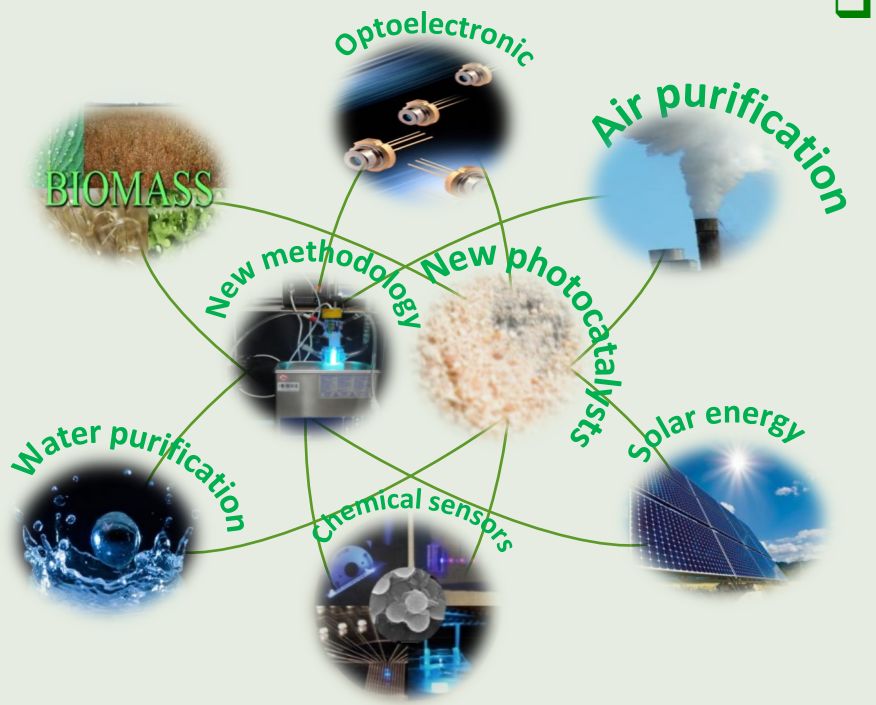
BACTEROMIC

NANOXO

I am CELISE

Colmenares's research group at IChF-Warsaw

❑ Rational design of functionalized nanosized catalysts using unconventional methodologies (e.g., sonication, photo-assisted methodologies).



❑ Sonocatalytic and photocatalytic green pathways in organic synthesis.

❑ Catalytically harvesting of solar energy in the shape of chemical energy.

❑ Development of novel proof of concepts of catalytic processes for the treatment and purification of water and air.

❑ Catalyst preparation and optimization, surface chemistry, nanoengineering, catalyst poisoning/degradation, catalytic process design, chemical/reactor engineering and reaction kinetics.

❑ Thermo-catalytically, Sono-catalytically and Photo-catalytically valorization of any kind of organic wastes (CO_2 included) in aqueous and gaseous systems.

01/08/2023

I am CELISE

IChF Institute of Physical Chemistry PAS

Acknowledgments

Research group nr 28:

"Catalysis for sustainable energy production and environmental protection, CatSEE"

Visit our web site: **http://photo-catalysis.org/**

Hanggara

Juan Carlos

Swaraj

Nilesh

Dariusz

Behdokht

Abdul

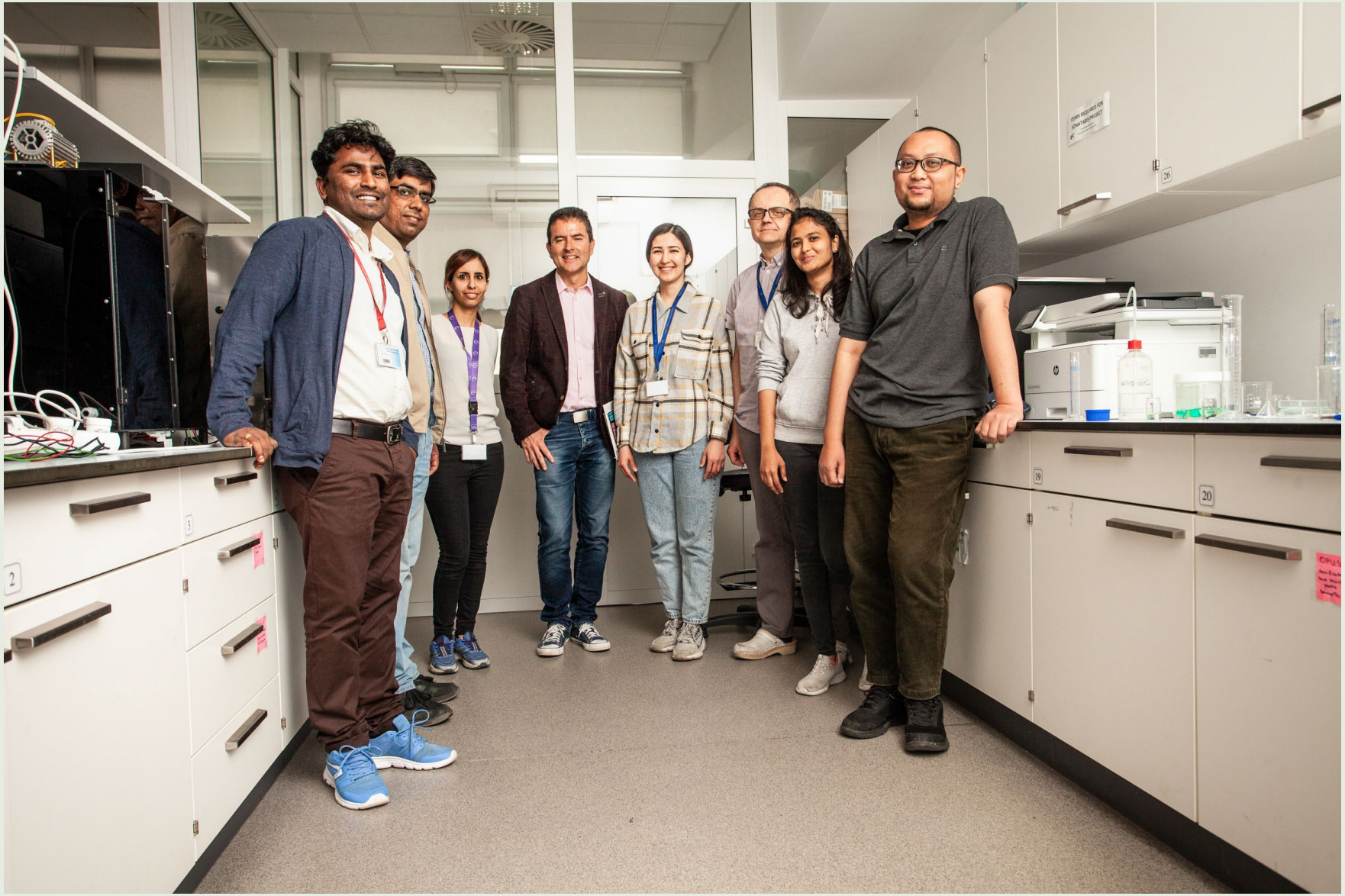
Maya

I am CELISE

IChF Institute of Physical Chemistry PAS

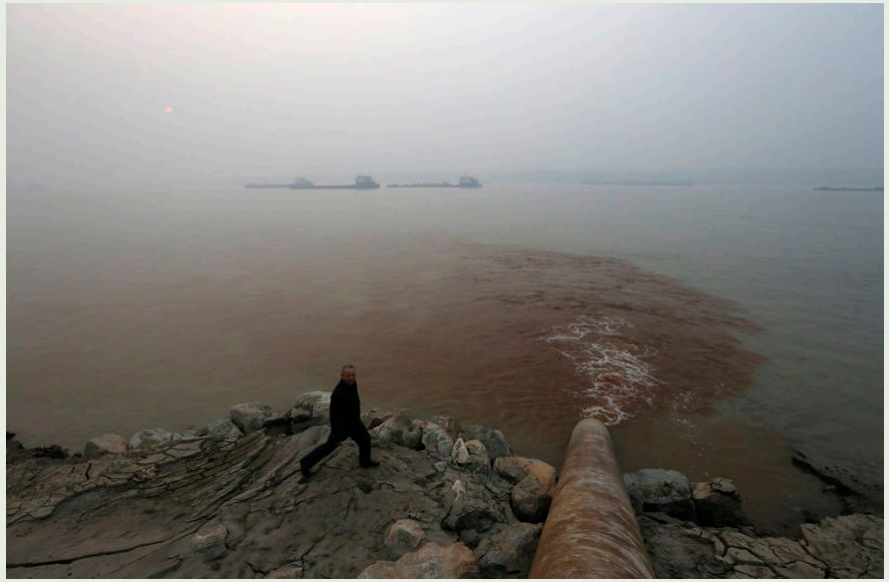
Research group 28:

"Catalysis for sustainable energy production and environmental protection, CatSEE



I am CELISE

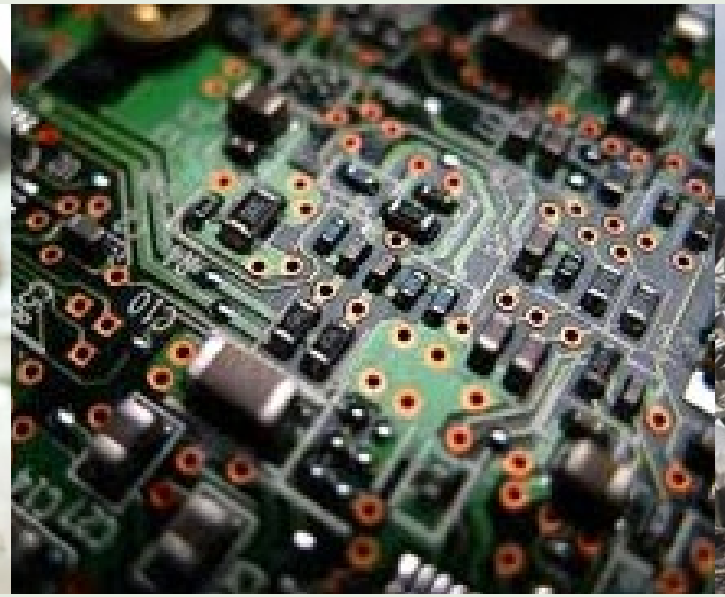
What do these images tell you?



I am CELISE

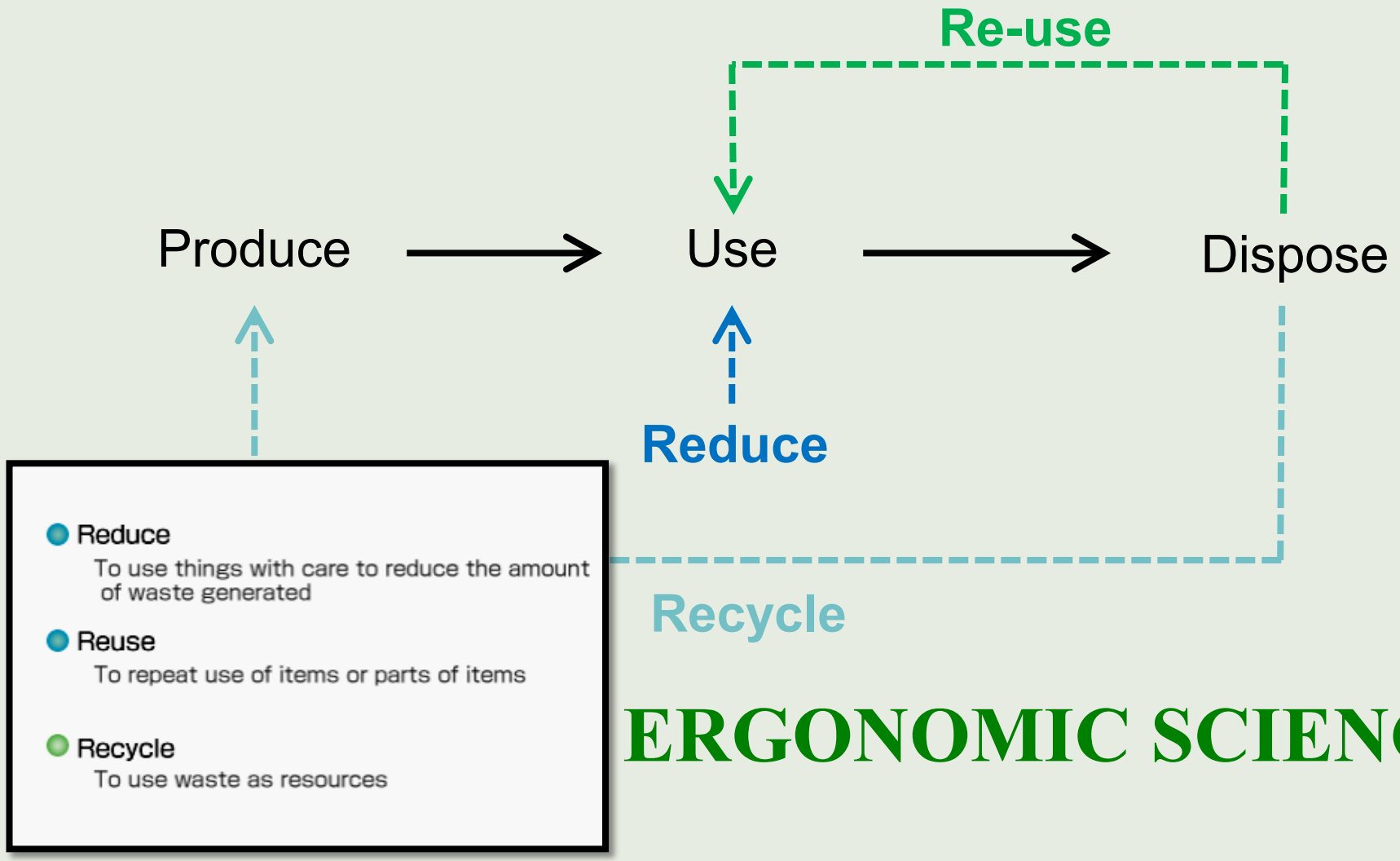
ITS ALWAYS THE SAME THING……

Produce ⟶ Use ⟶ Dispose



I am CELISE

We have to change our mindset!!!



ERGONOMIC SCIENCE!

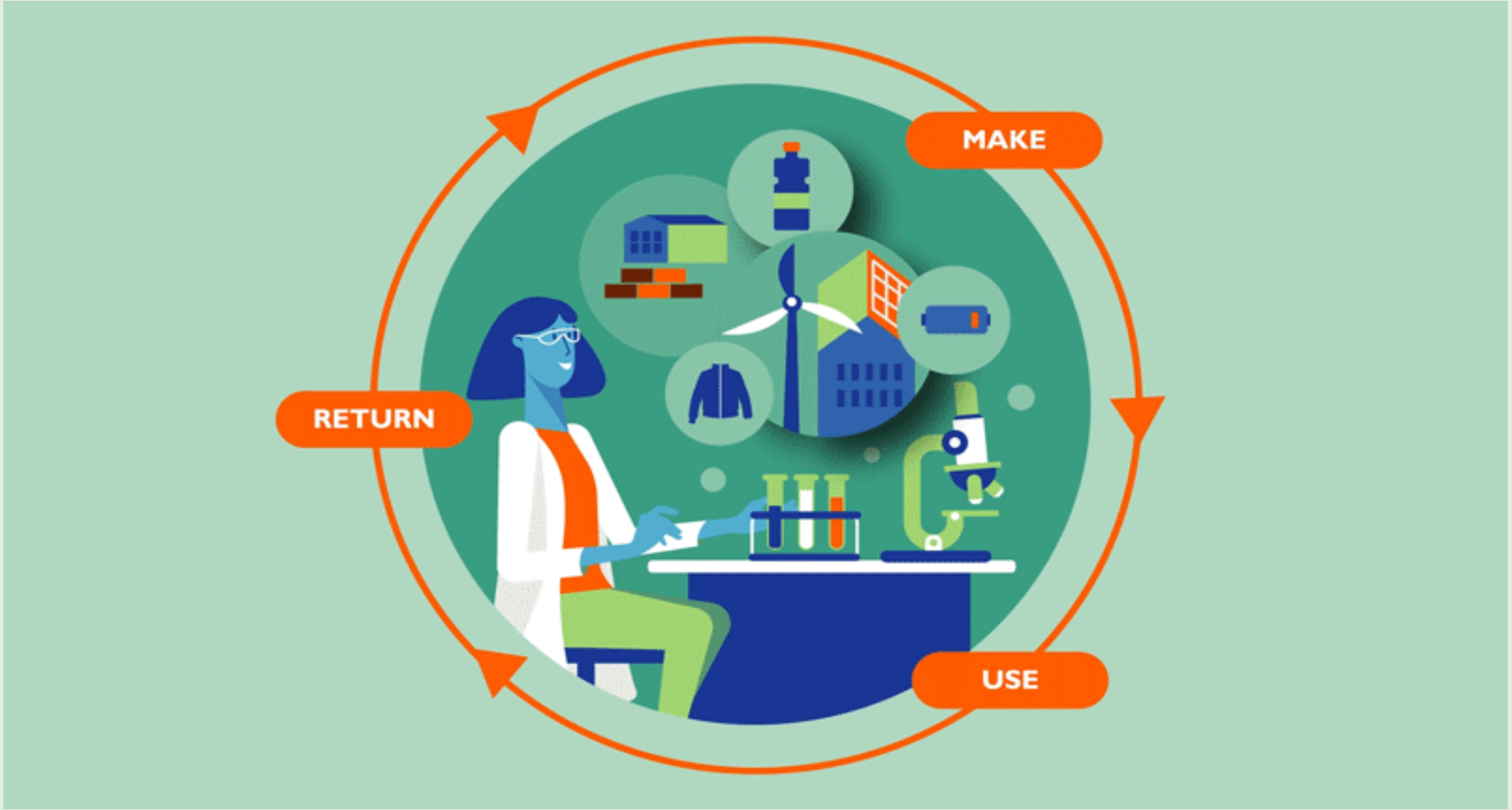
Green Technologies & Sustainability

I am CELISE

I am CELISE

CIRCULAR ECONOMY

Value of materials, products, and resources is sustained in the economy as much as possible with minimal generation of waste



I am CELISE

The resource transition: Towards a Sustainable, Circular Economy

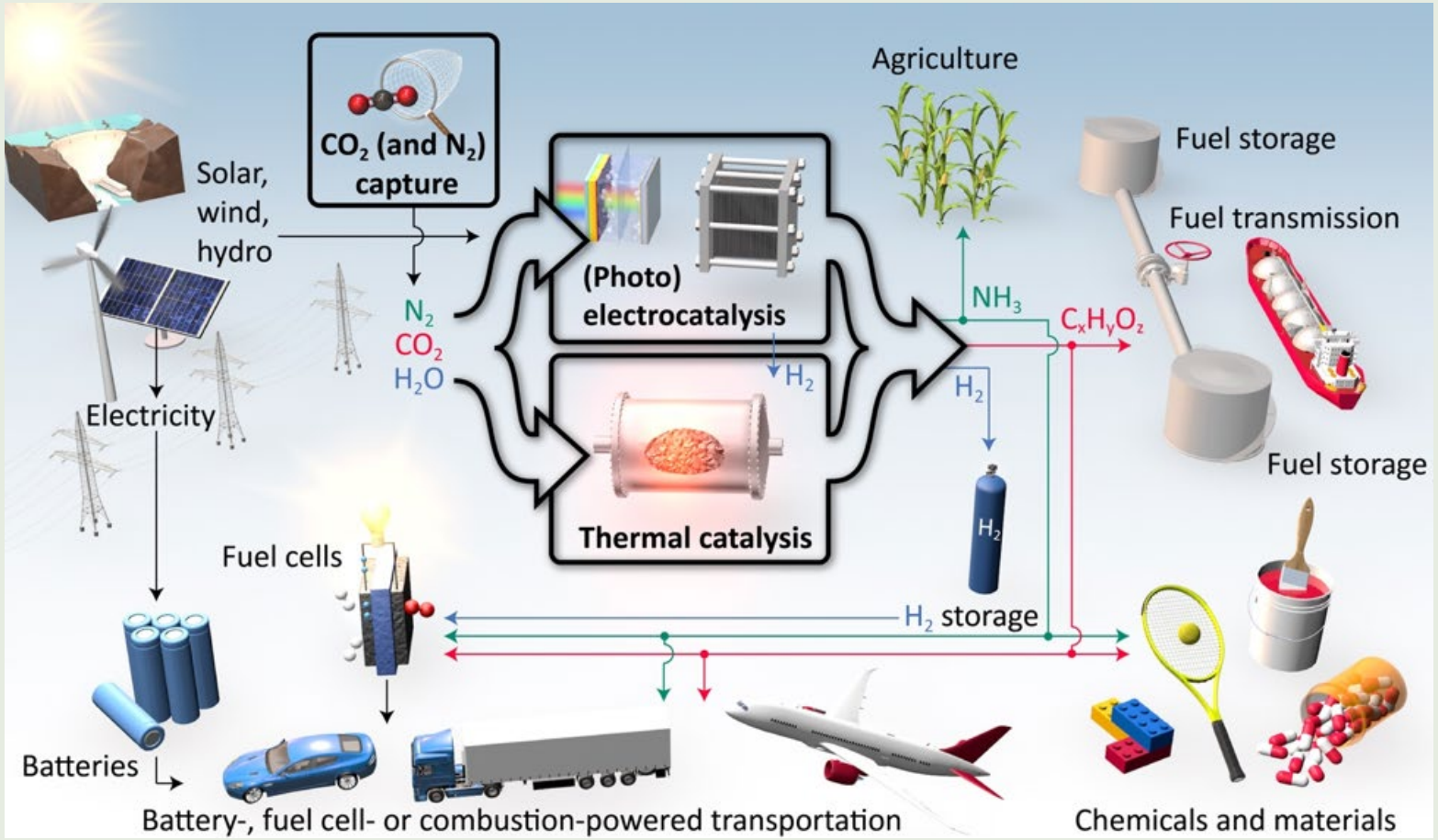
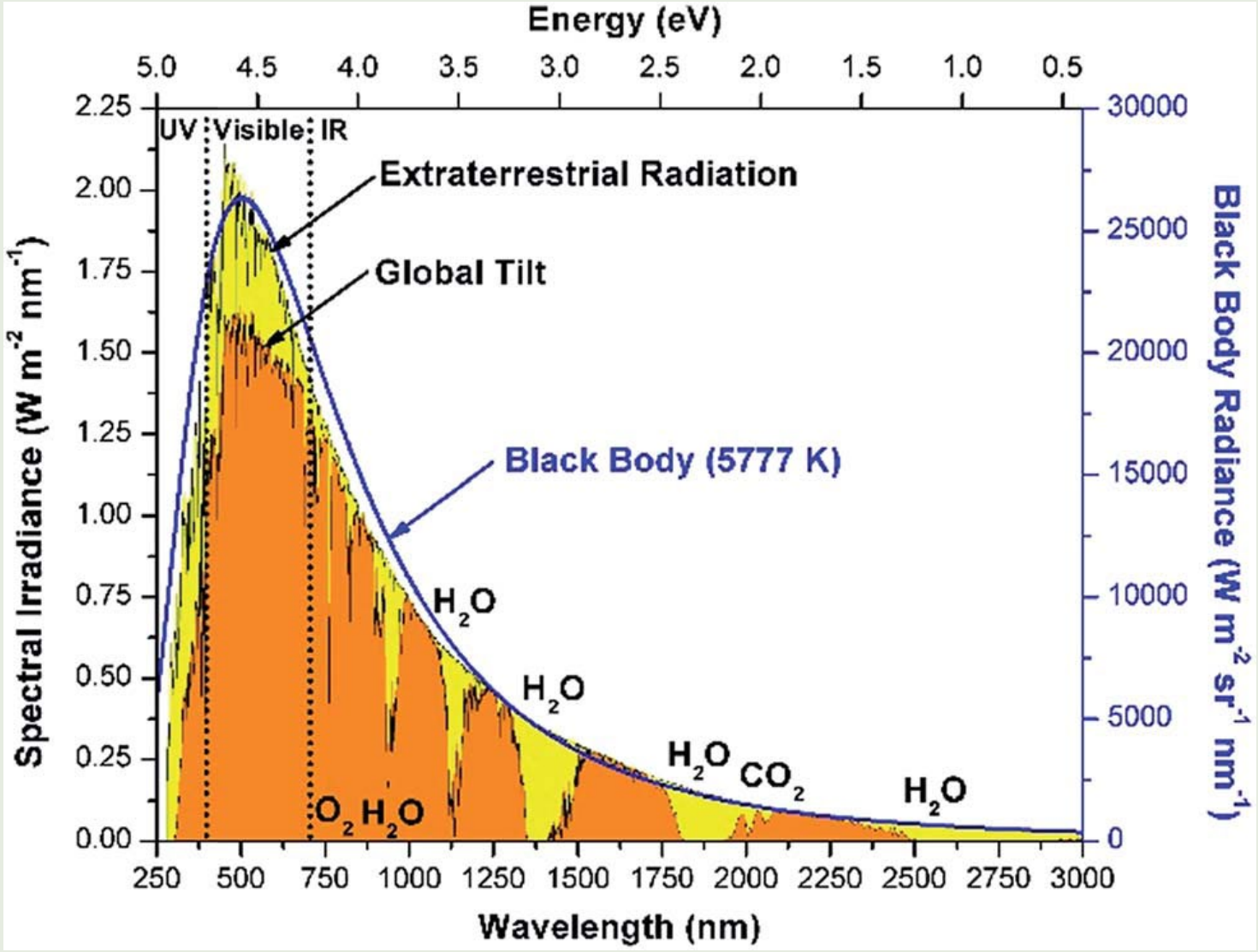


Illustration of a sustainable energy system: Key processes are: electrochemical water splitting and thermal and electrochemical CO_2 and N_2 reduction. (Graphics courtesy of Jakob Kibsgaard, DTU)

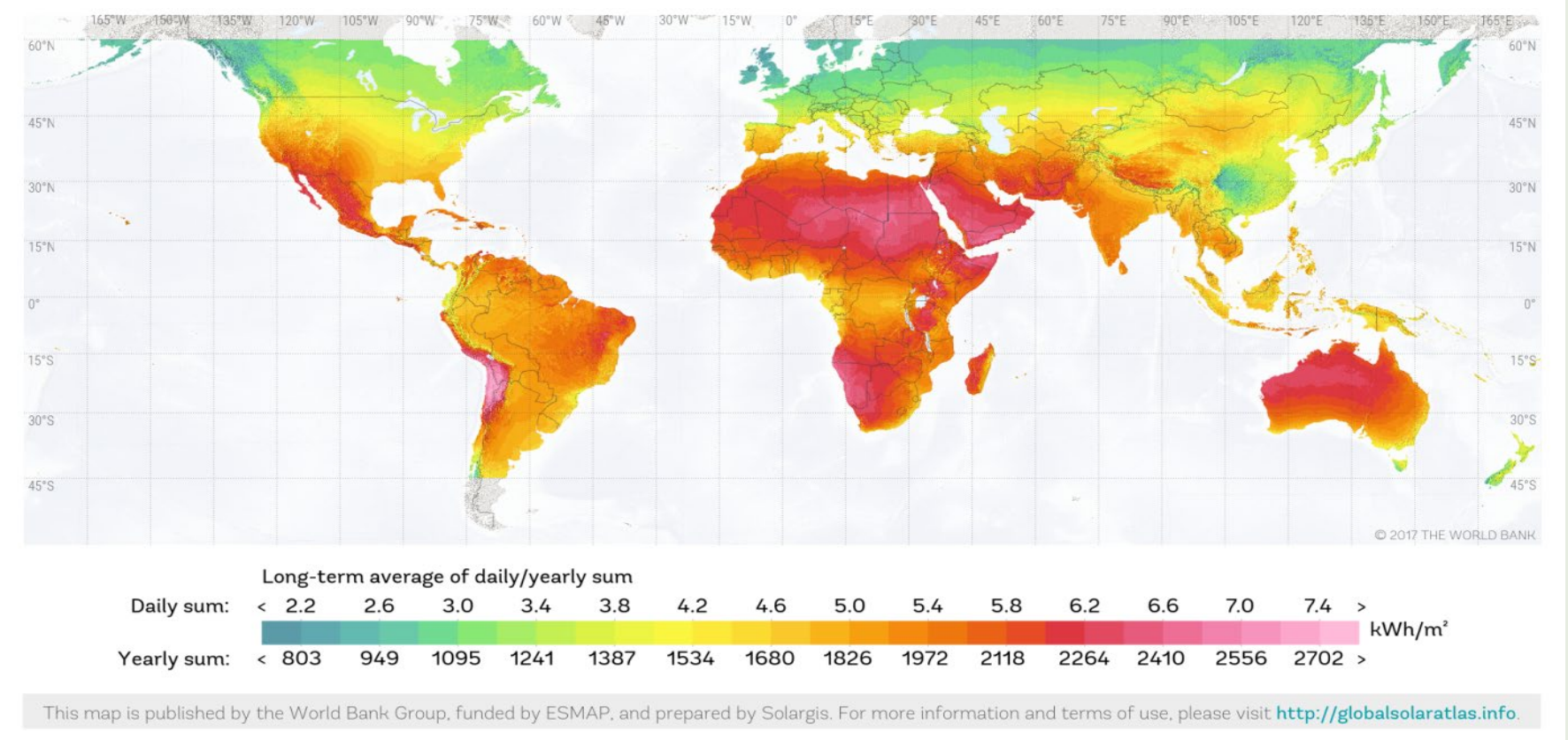
I am CELISE

Solar Spectral Irradiance: Air Mass 1.5



http://rredc.nrel.gov/solar/spectra/am1.5/, accessed June 2014.

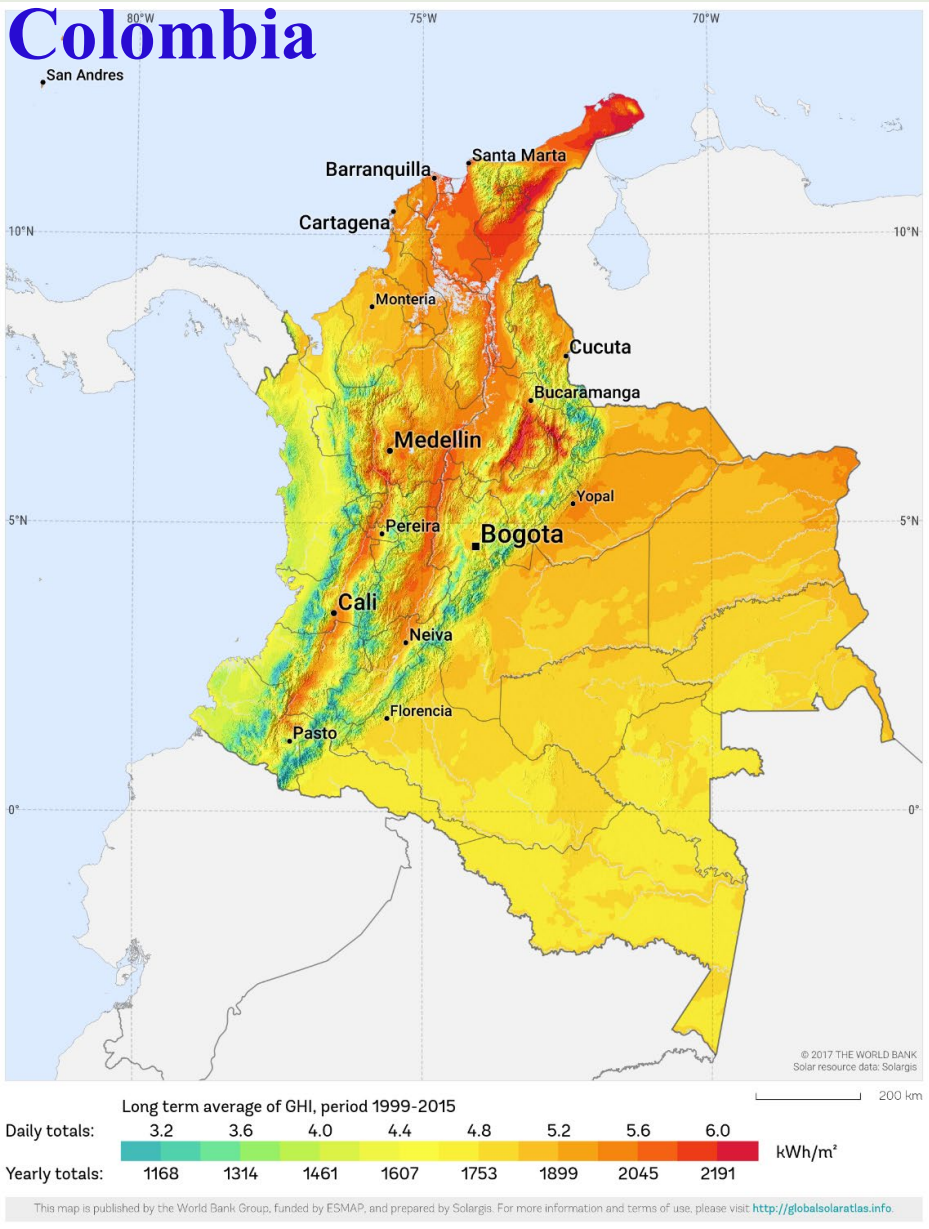
Global Horizontal Irradiation

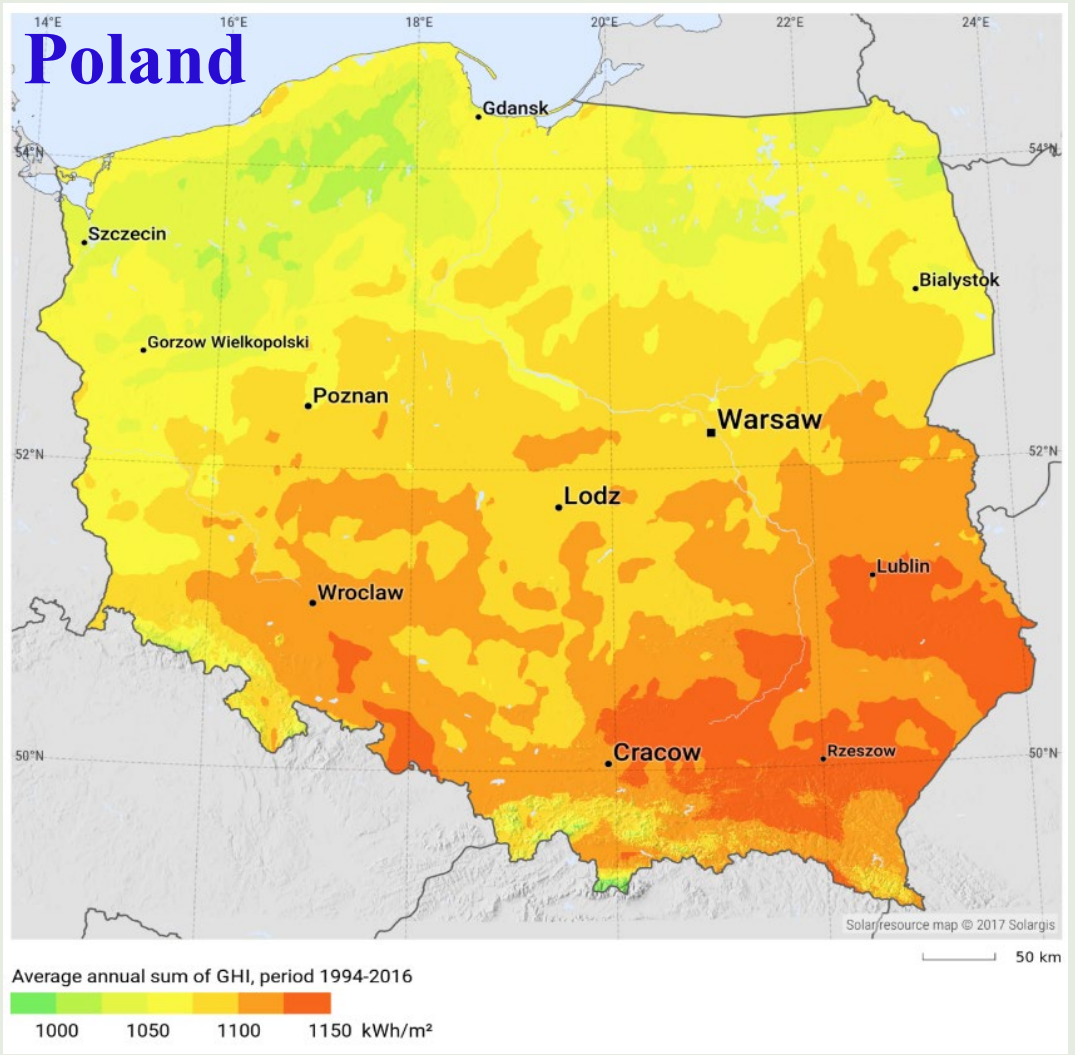


The quantity of radiation incident on our planet's surface depends on a good number of factors: **(1) location, (2) time of the day, (3) declination and inclination of the Earth's surface, (4) weather, among others.** The intermittent nature of solar radiation is one of the major and important challenges in designing solar fuels technologies. Thus, storing solar energy is very important for continuous processing at the time of these fluctuations

I am CELISE

Colombia and Poland Horizontal Irradiation

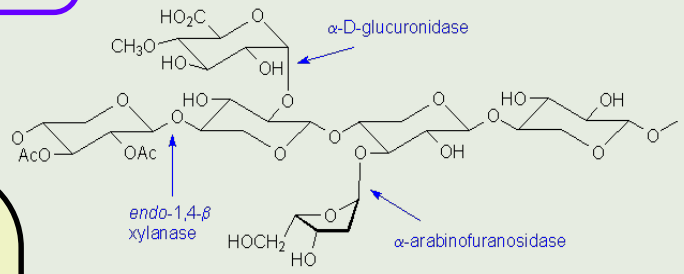




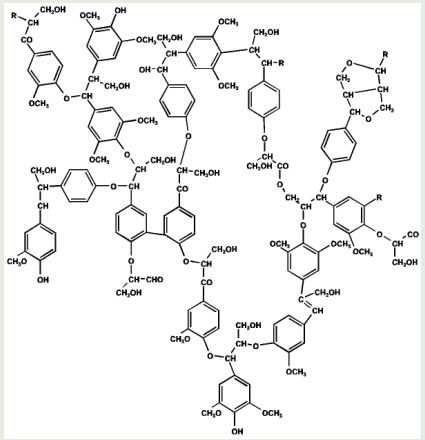
I am CELISE

Knowing chemical composition is the key to success!!!

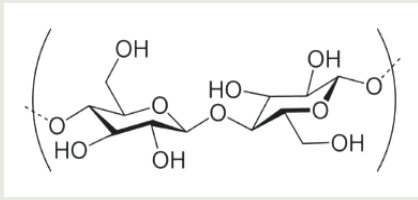
HEMICELLULOSE



LIGNIN



CELLULOSE



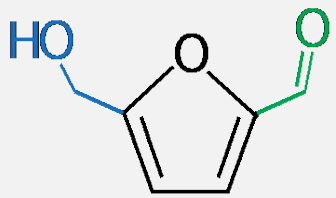
MINOR CONSTITUENTS

Image: Courtesy of Prof. Rafael Luque

Lignocellulose valorization

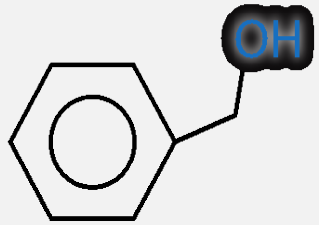
I am CELISE

Model compounds



HMF

5-hydroxymethylfurfural



BnOH

benzyl alcohol

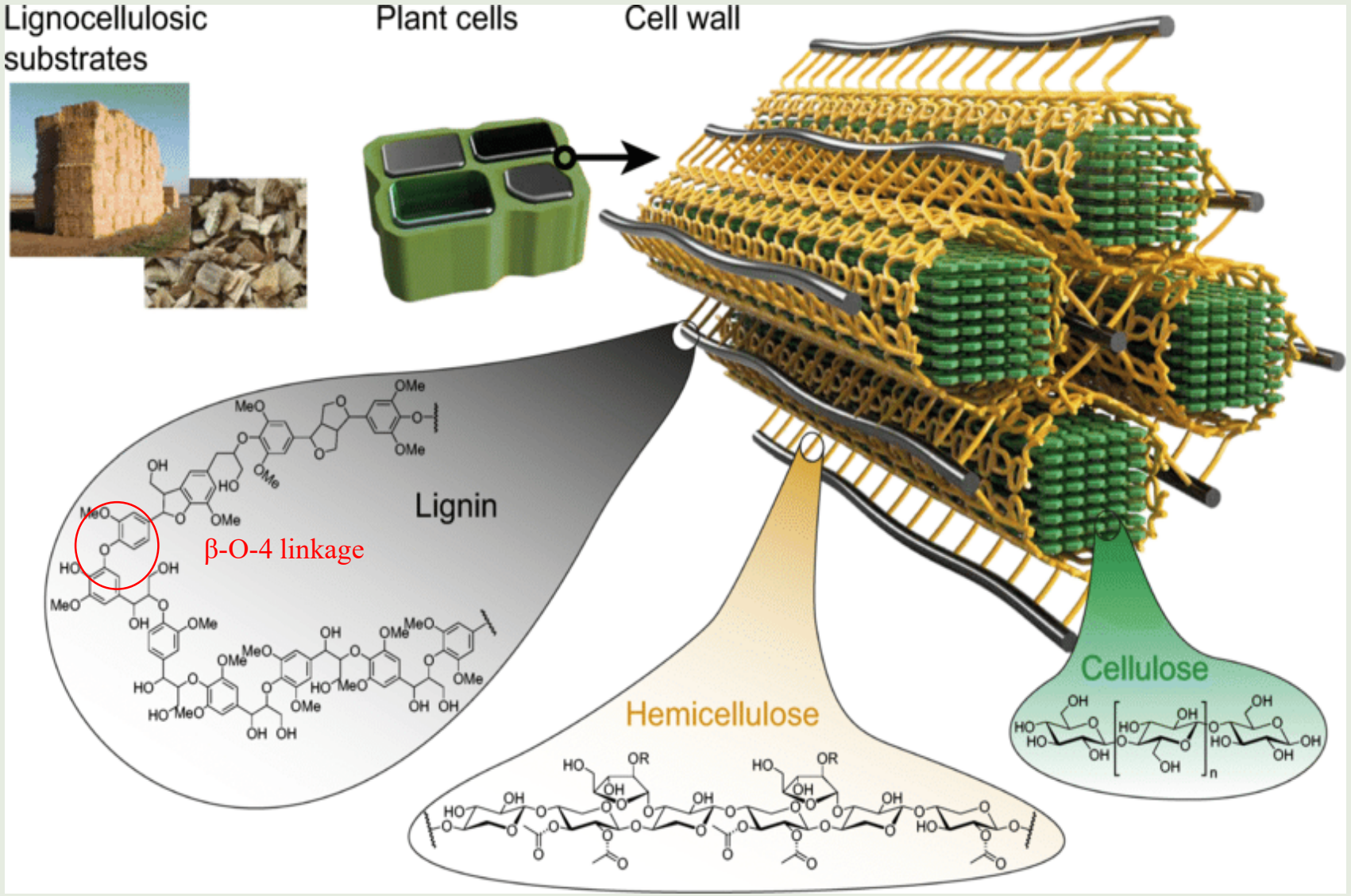
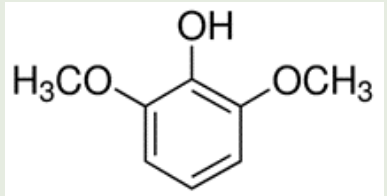


Image: Courtesy of Dr. D. Giannakoudakis

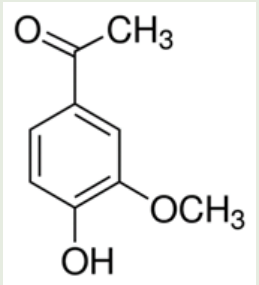
I am CELISE

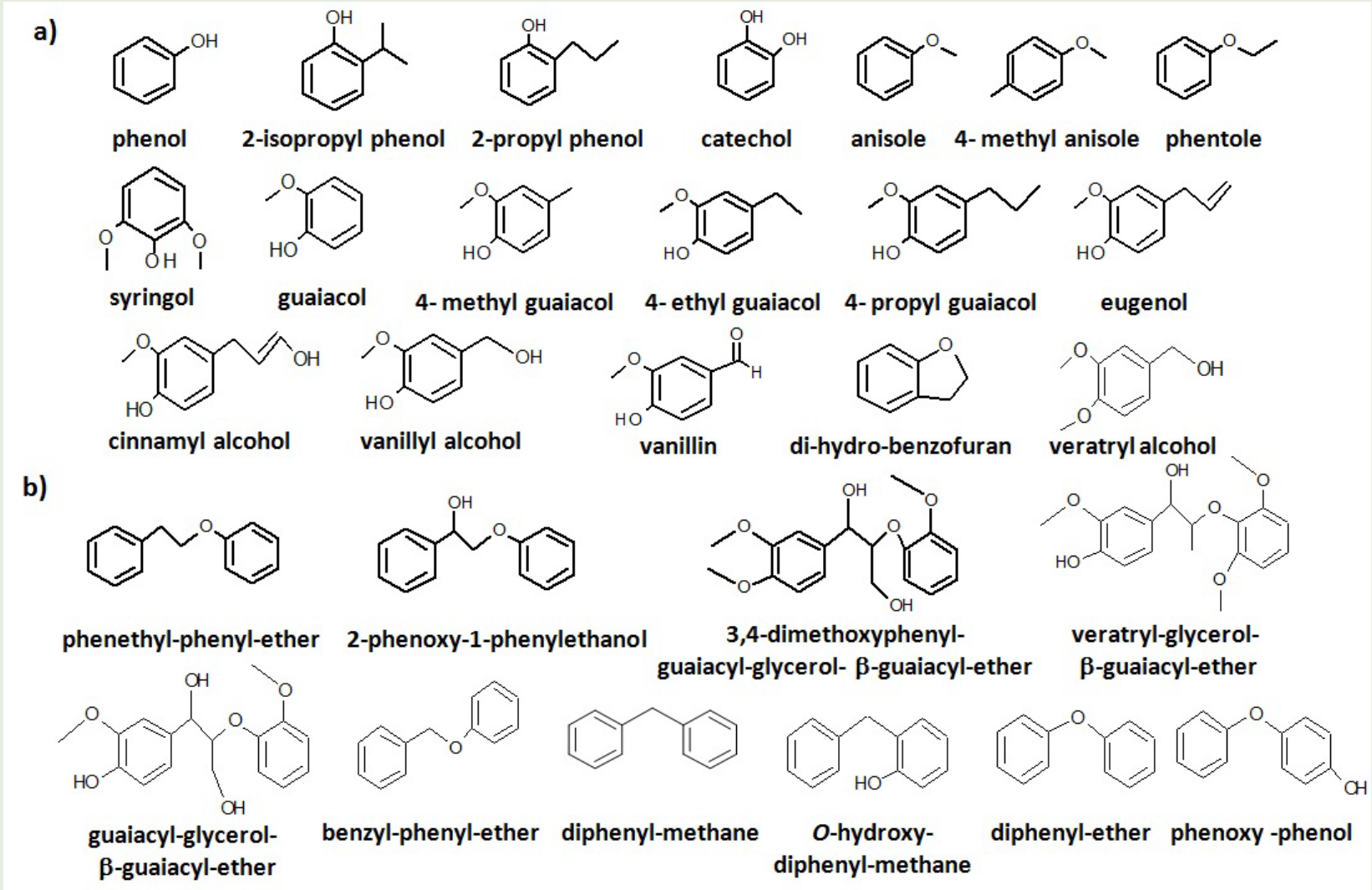
Lignin model compounds of (a) monomers (b) dimers

2,6-dimethoxyphenol



Acetovanillone

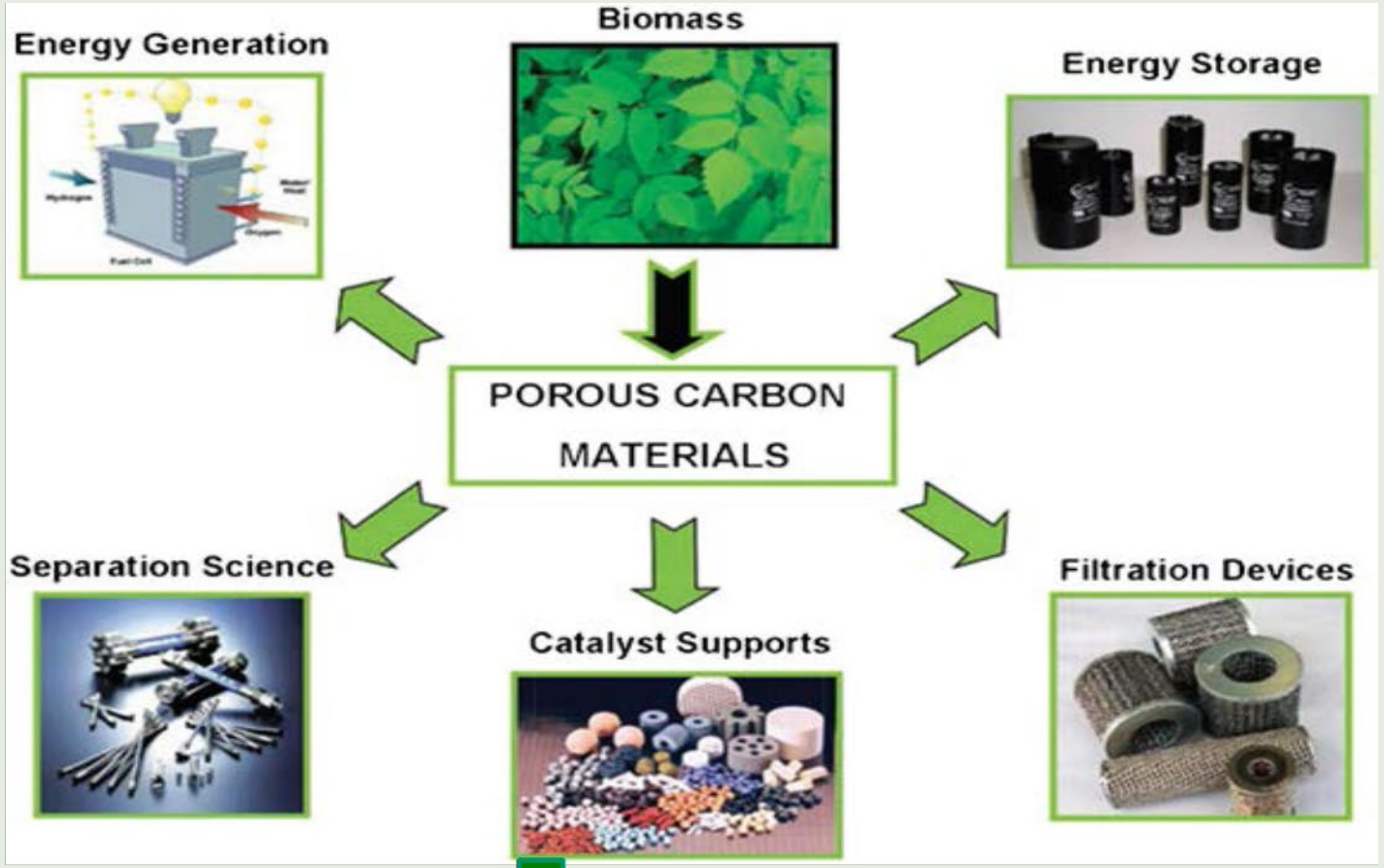


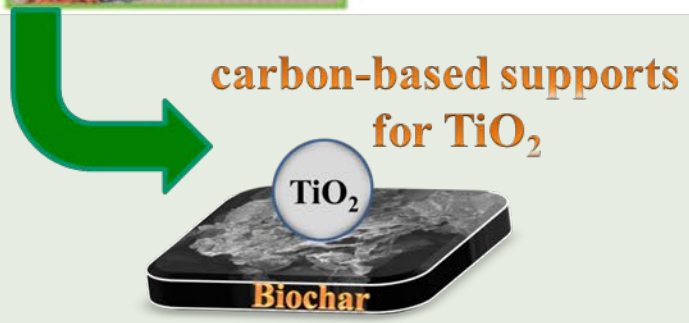


Reprinted from: L Yang, K. Seshan and Y. Li, Catal. Today, 2016,DOI: 10.1016/j.cattod.2016.11.030 (with permission from Elsevier B.V, Copyright 2016).

I am CELISE

Lignocellulose-based carbonaceous materials: countless possibilities for application



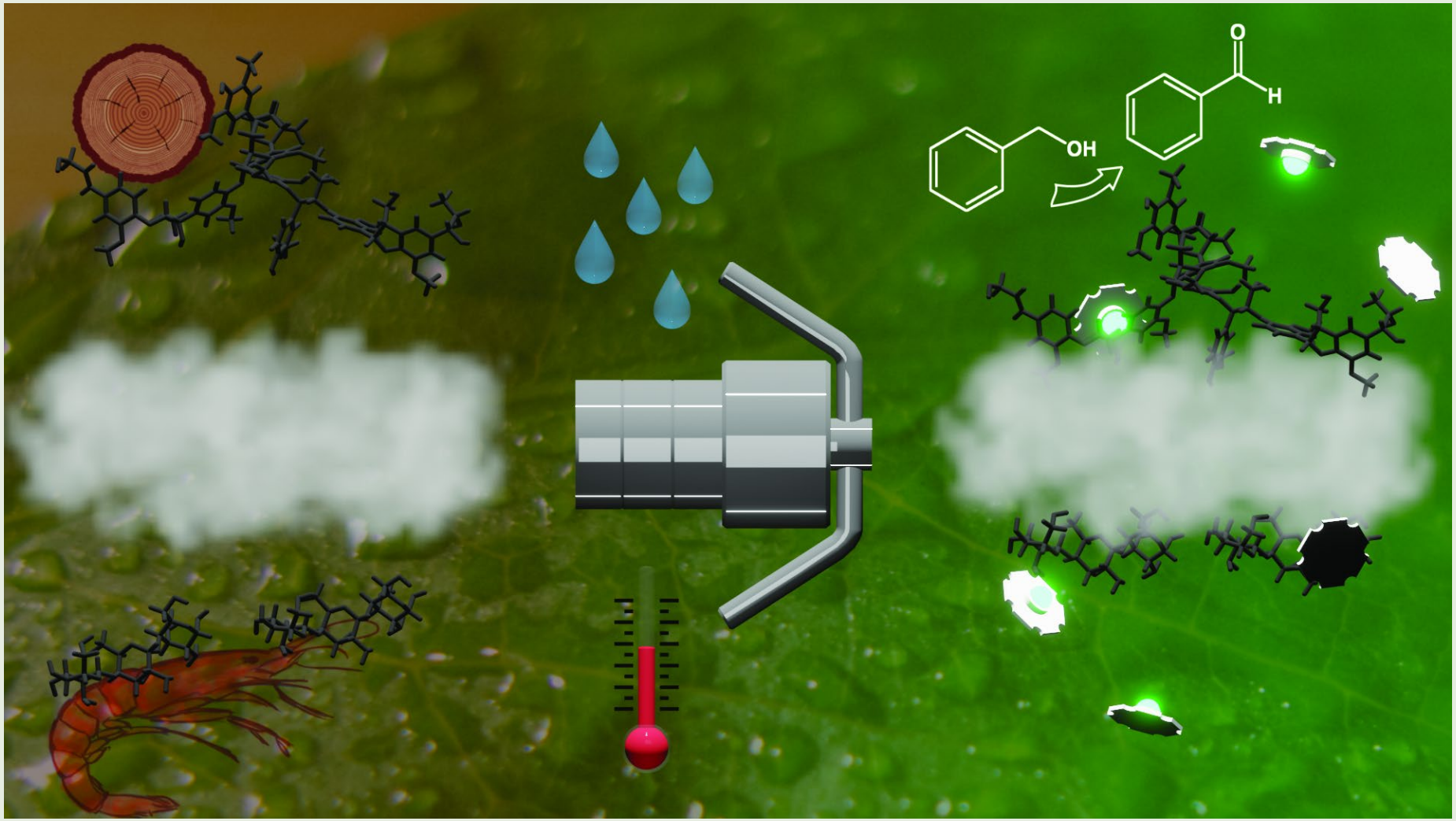


Adapted from *Chem. Soc. Rev.*, 38 (2009) 3401

I am
CELISE

I am CELISE

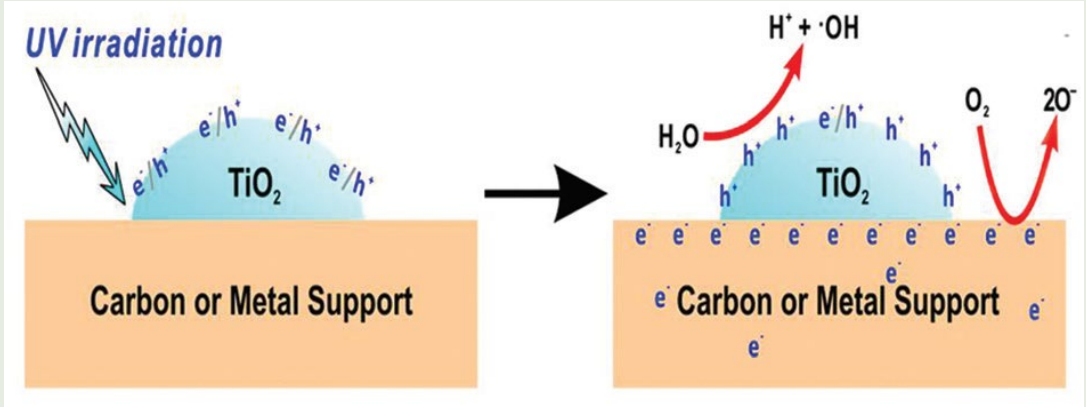
Titania/Chitosan-Lignin nanocomposite as an efficient photocatalyst for the selective oxidation of benzyl alcohol under UV and visible light



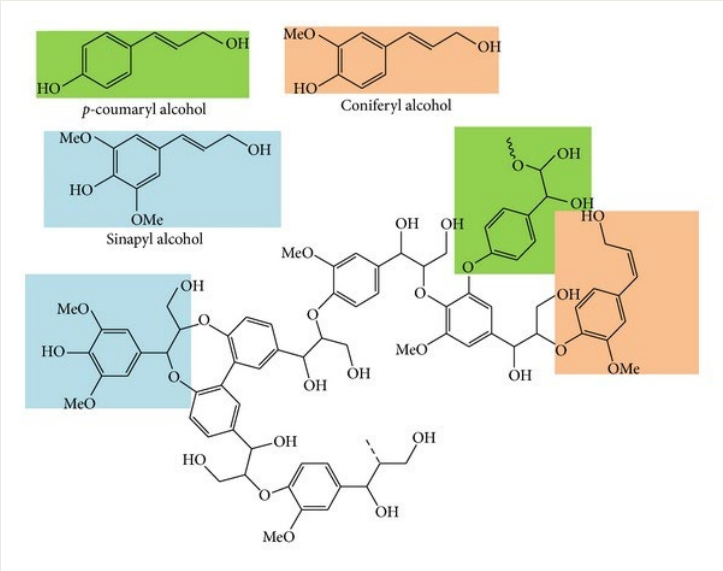
Colmenares, et al. RSC Adv., 11 (2021) 34996-35010

Titania-Carbon composite

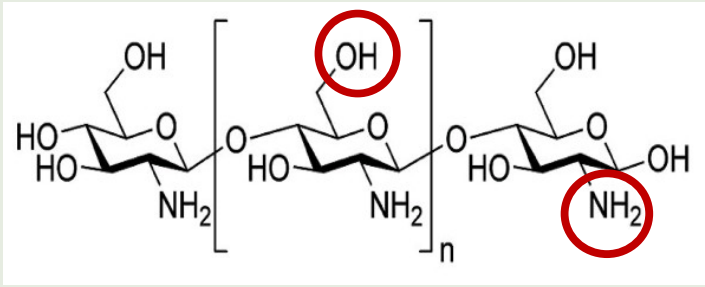
Synergetic photocatalytic effect of TiO_2/carbon support



J. Shi, Chem. Rev., 2013, 113, 2139–2181.



Lignin



Chitosan

I am CELISE

Nanocomposites of titania and carbon materials: Objectives

✓***Design a hydrothermal synthesis route for*** the preparation of chitosan-lignin (CL) composite.

✓***Develop a sol-gel and hydrothermal method*** to prepare titania/chitosan-lignin (T/CL) nanocomposite for the selective oxidation of benzyl alcohol (BnOH) to benzaldehyde (Bnald) under visible light (515 nm). ***Free of additives/oxidizing agents!!!***

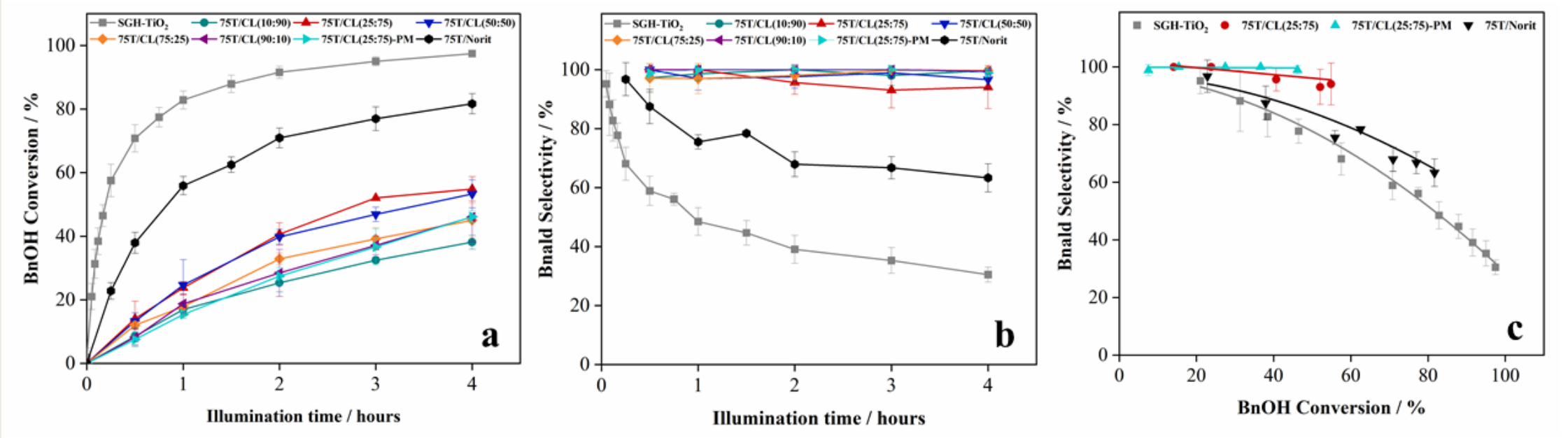
✓***Compare the activity of T/CL nanocomposite*** with Norit (activated carbon)-based nanocomposite (T/Norit).

✓***Understand the synergy of titania and chitosan-lignin composite in T/CL nanocomposite by characterizing them through wide range of techniques,*** e.g. X-ray diffraction (XRD), N_2 physisorption, FTIR spectroscopy, DRS UV-Visible spectroscopy, and X-ray photoelectron spectroscopy (XPS).

The PhotoCatalytic Results: under UV light (375 nm)

I am CELISE

(a) BnOH conversion profile of SGH-TiO_2, 75T/CL nanocomposites and 75T/Norit nanocomposite as a function of time under UV light (375 nm) **(b)** Bnald selectivity profile of SGH-TiO_2, 75T/CL nanocomposites and 75T/Norit nanocomposite as a function of time under UV light (375 nm) **(c)** BnOH conversion versus Bnald selectivity plot for SGH-TiO_2, 75T/CL(25 : 75) nanocomposite and 75T/Norit nanocomposite under UV light (375 nm).

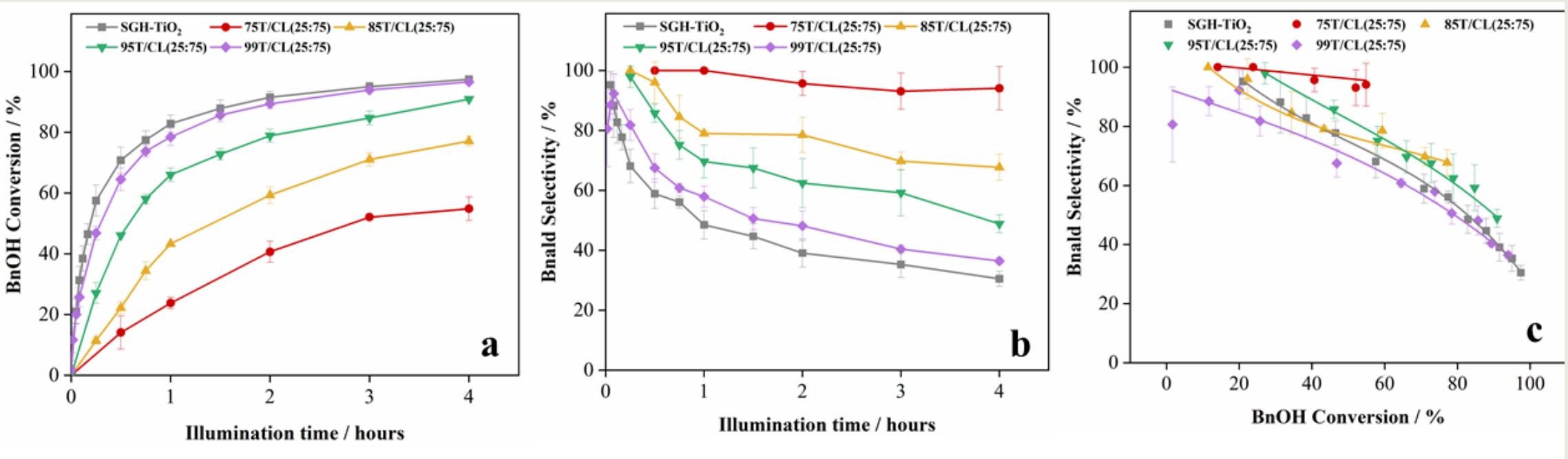


Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

The PhotoCatalytic Results: under UV light (375 nm)

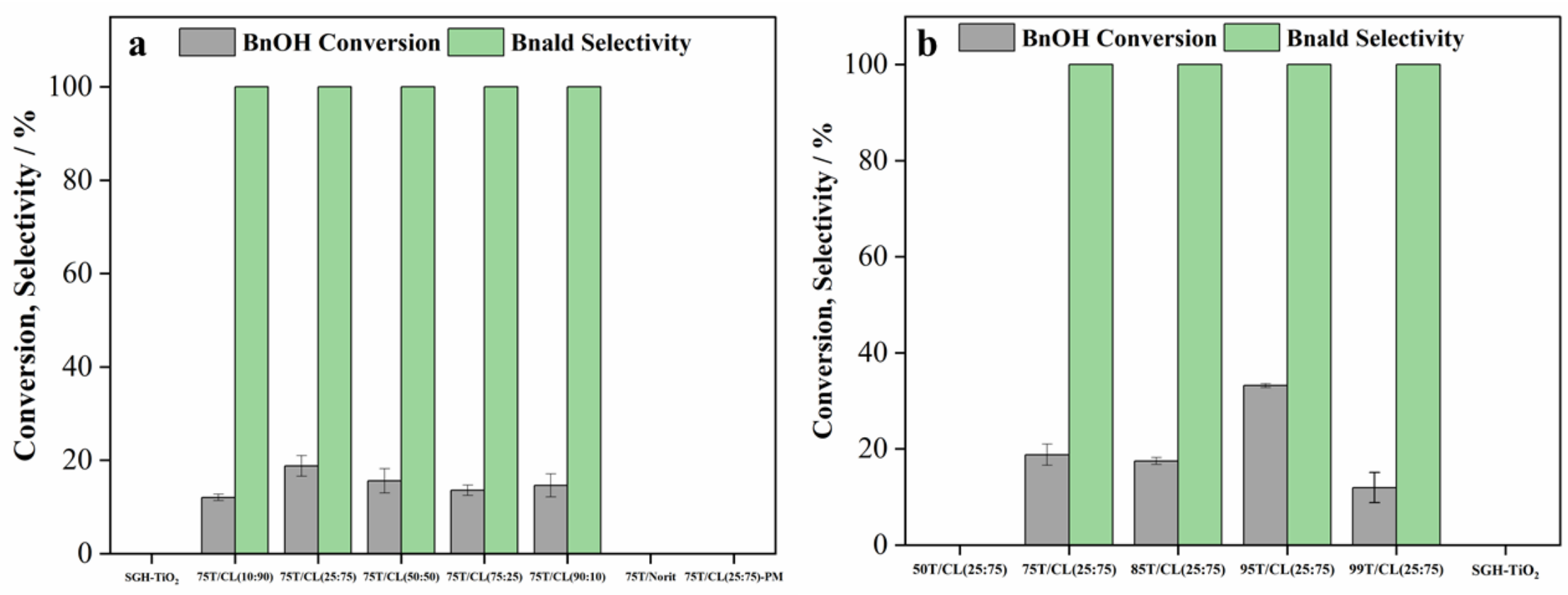
(a) Effect of titania content in nanocomposites on the BnOH conversion profile as a function of time under UV light (375 nm) **(b)** effect of titania content in nanocomposites on the Bnald selectivity profile as a function of time under UV light (375 nm) **(c)** effect of titania content in nanocomposites on BnOH conversion versus Bnald selectivity plot under UV light (375 nm).



I am CELISE

The PhotoCatalytic Results: under visible light (515 nm)

(a) Photocatalytic performance of SGH-TiO_2, 75T/CL nanocomposites, and 75T/Norit nanocomposite for the selective oxidation of BnOH under visible light (515 nm) **(b)** effect of titania content on the photocatalytic performance of nanocomposites for the selective oxidation of BnOH under visible light (515 nm).

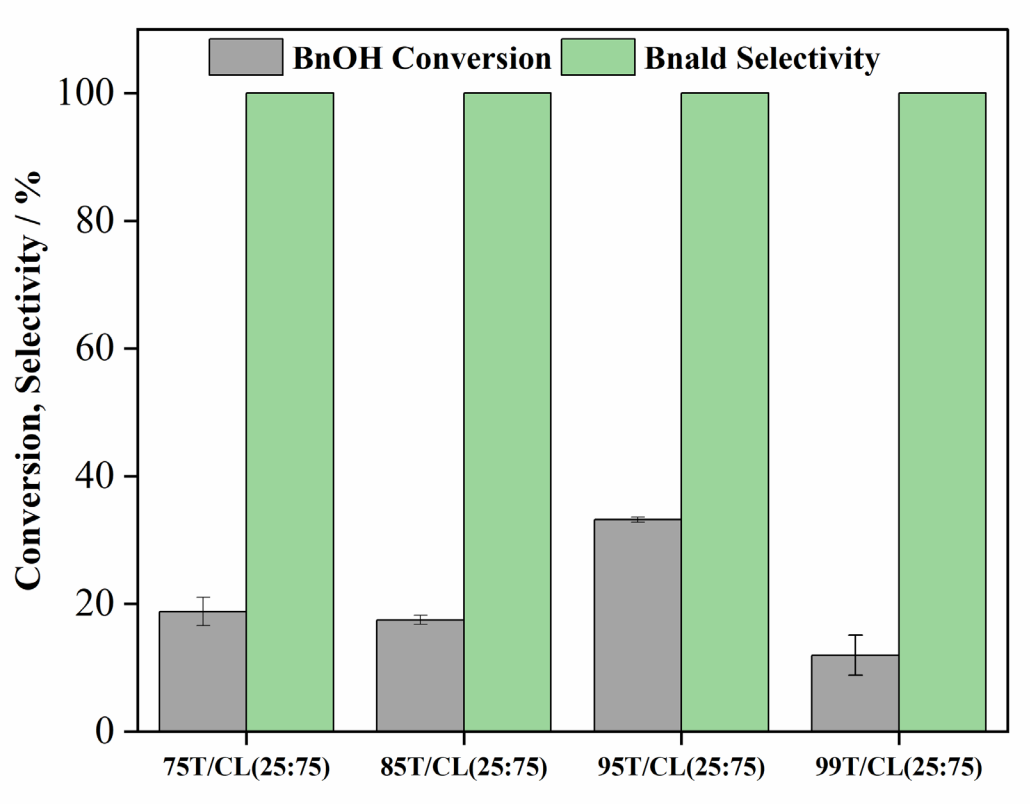


Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

The PhotoCatalytic Results: under visible light (515 nm)

Effect of titania content on the photocatalytic activity of nanocomposites for the selective oxidation of BnOH under visible light (515 nm)



Other photocatalysts	BnOH Conv. / %	Bnald Sel. / %
25T/CL(25:75)	✘	✘
50T/CL(25:75)	✘	✘

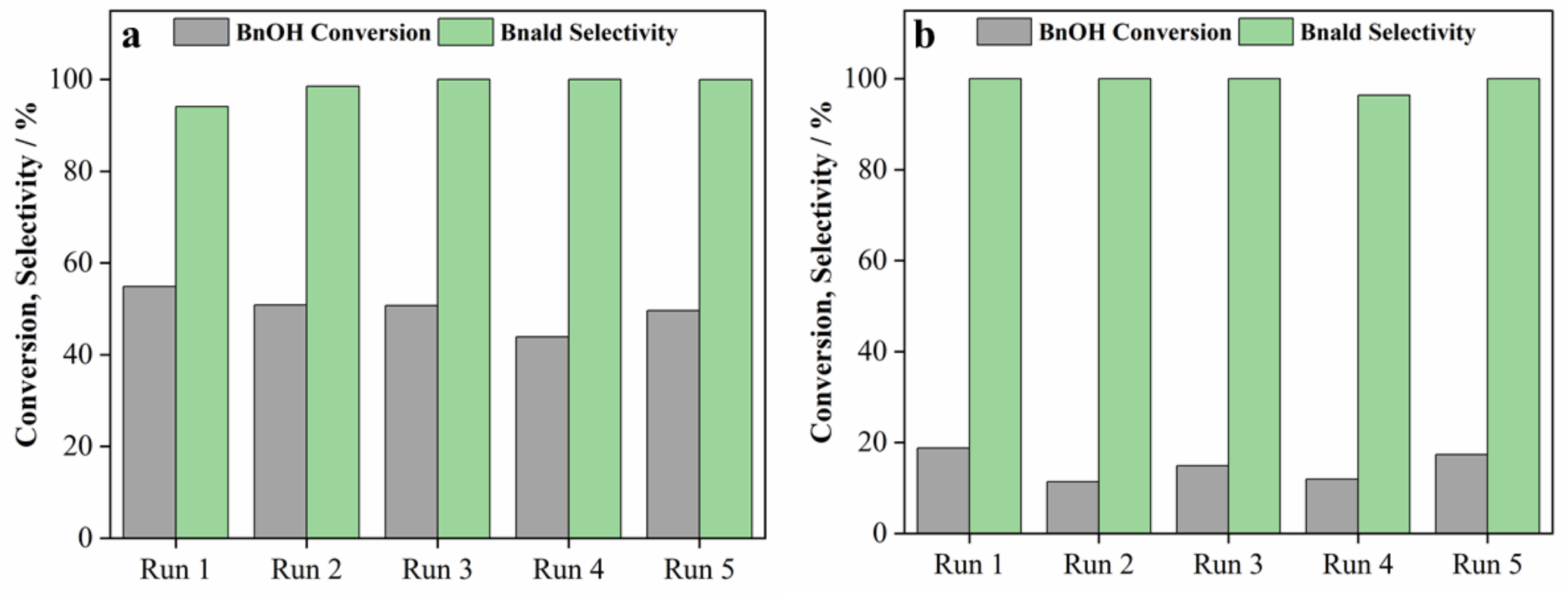
Colmenares et al., RSC Adv., 11 (2021) 34996-35010

- Increasing the titania content in the nanocomposite (95T/CL(25:75), increases the conversion of BnOH

The PhotoCatalytic Results: 75T/CL(25:75) stability

I am CELISE

The recycling of 75T/CL(25:75) nanocomposite for the selective oxidation of BnOH under **(a)** UV light (375 nm) irradiation **(b)** visible light (515 nm) irradiation

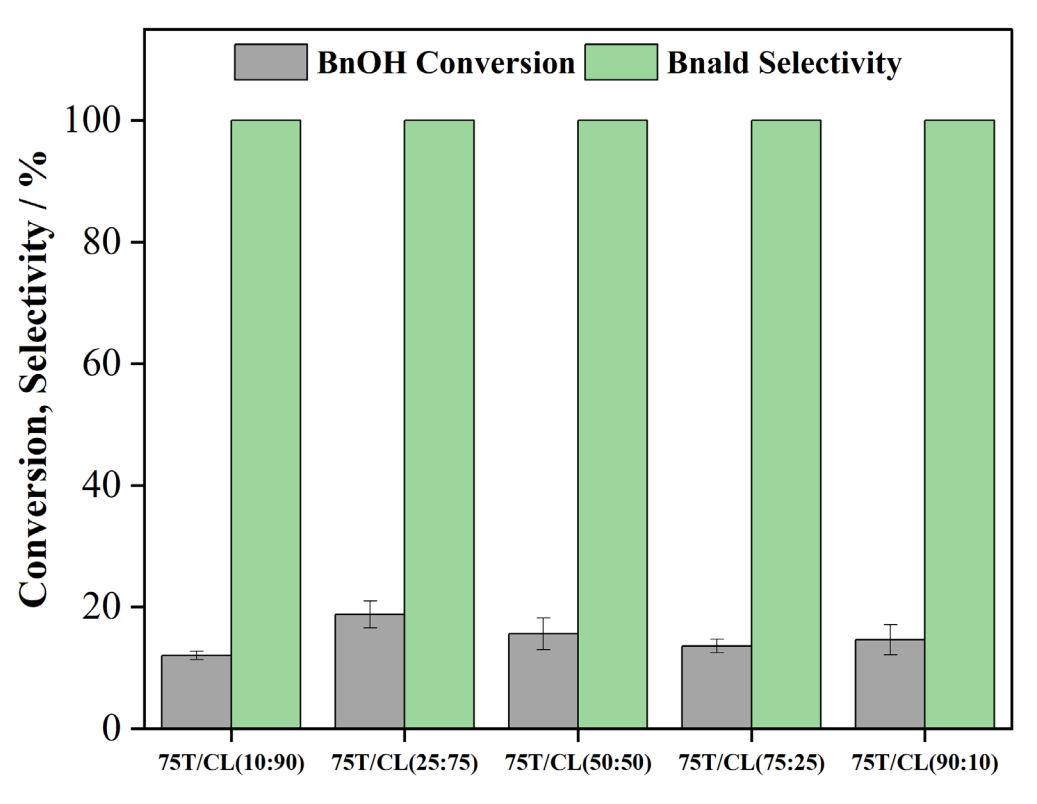


Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

The PhotoCatalytic Results: Short summary for 75T/CL(25:75)

Photocatalytic activity of 75T/CL nanocomposites, SGH-TiO_2 and 75T/Norit nanocomposite for the selective oxidation of BnOH to Bnald under visible light (515 nm)



Other photocatalysts	BnOH Conv. / %	Bnald Sel. / %
SGH-TiO_2	✘	✘
75T/Norit	✘	✘
75T/CL(25:75)-PM	✘	✘
75T/L	✘	✘
75T/C	14	100

Colmenares et al., RSC Adv., 11 (2021) 34996-35010

- **The photocatalytic activity of 75T/CL nanocomposites under visible light may attribute to the nitrogen doping of titania by chitosan**

I am CELISE

Textural and crystallographic features of nanocomposites

Entries	Samples	SSA/ (m^2g^{-1})	Ratio of crystalline phases	Crystal size	
			Anatase:Brookite / %	Anatase / nm	Brookite / nm
1	*Norit	558	NA	NA	NA
2	SGH-TiO_2	177	74:26	5	6
3	75T/CL(10:90)	162	83:17	5	6
4	75T/CL(25:75)	174	79:21	5	6
5	75T/CL(50:50)	170	78:22	5	6
6	75T/CL(75:25)	169	81:19	5	6
7	75T/CL(90:10)	164	74:26	5	5
8	*75T/Norit	239	66:30	6	8

Colmenares et al., RSC Adv., 11 (2021) 34996-35010

Sample contain traces of silica,

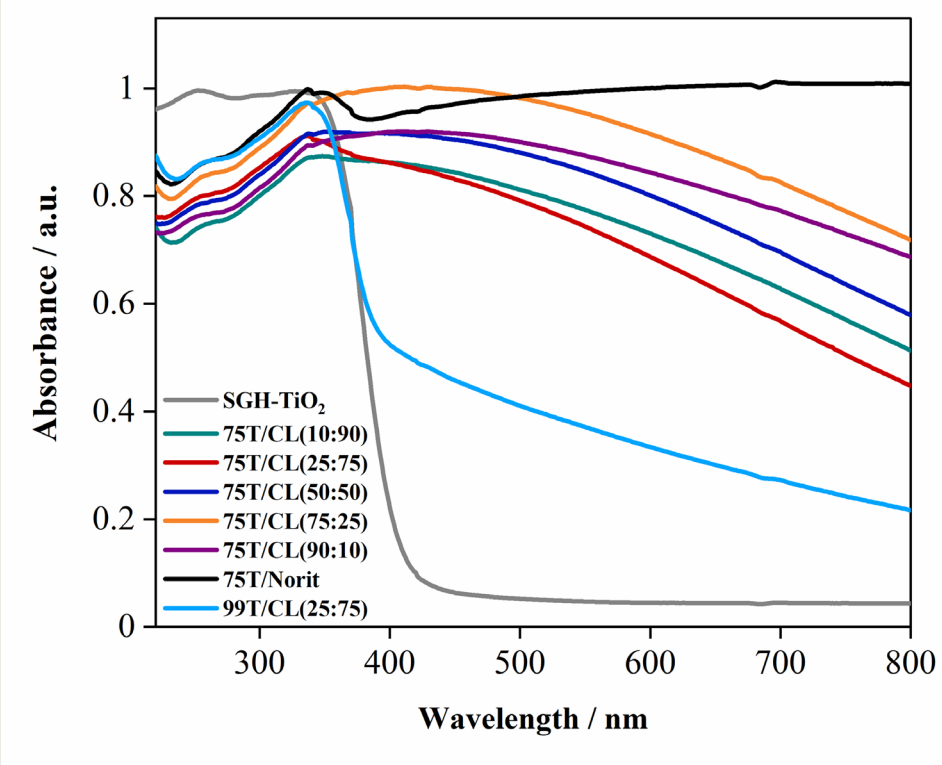
CL composites showed specific surface area (SSA) in the range of 10-16 m^2g^{-1}

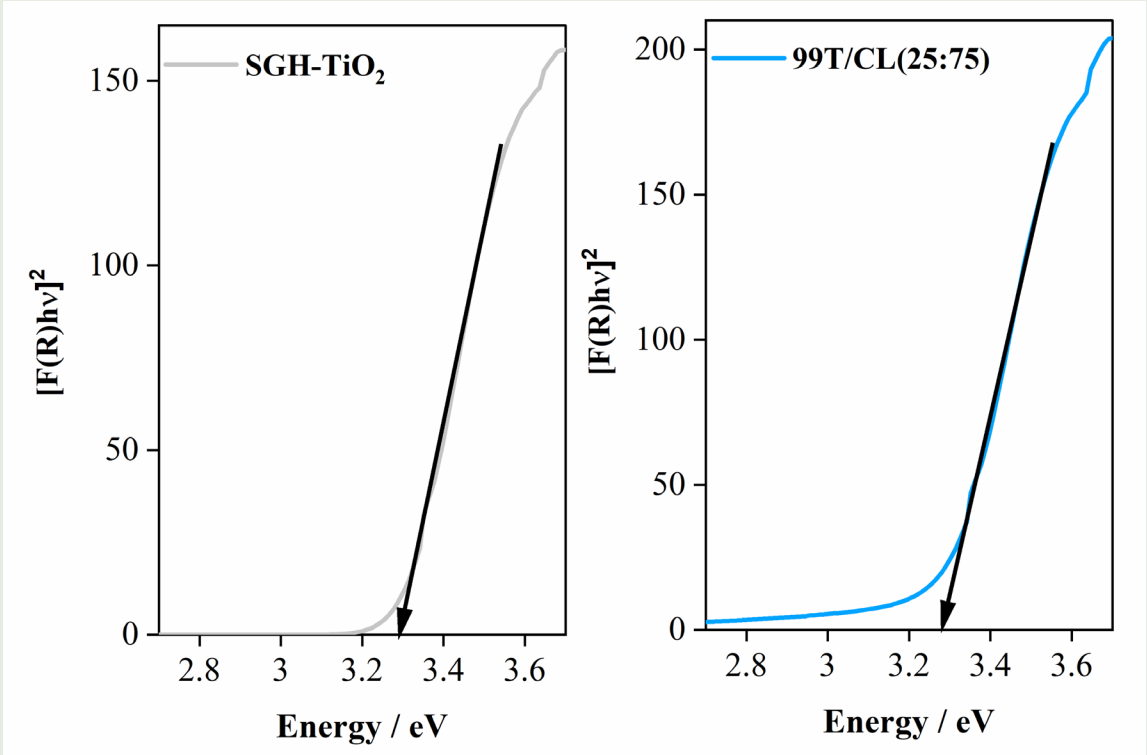
75T/CL nanocomposites and SGH-TiO_2 showed comparable specific surface area and crystallographic features

I am CELISE

UV-Visible DRS analysis

75T/CL nanocomposites showed absorption in the entire UV-Visible region (220-800 nm), which could be advantageous for visible light photocatalysis



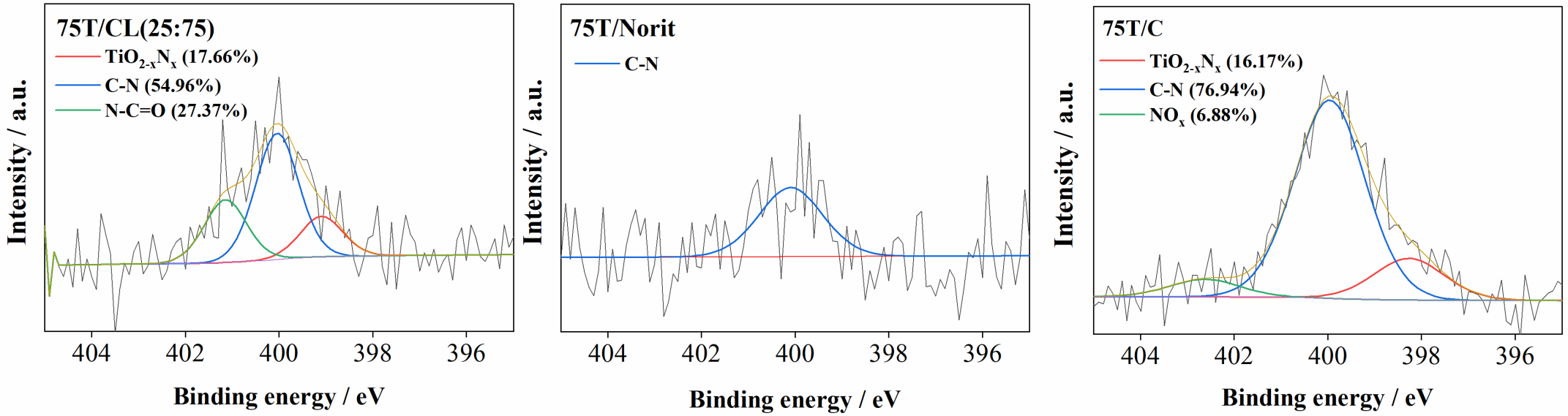


Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

XPS analysis

Doping of nitrogen into titania framework is related to the presence of chitosan. This could be advantageous from the viewpoint of photocatalytic activity of 75T/CL(25:75) nanocomposite under visible light

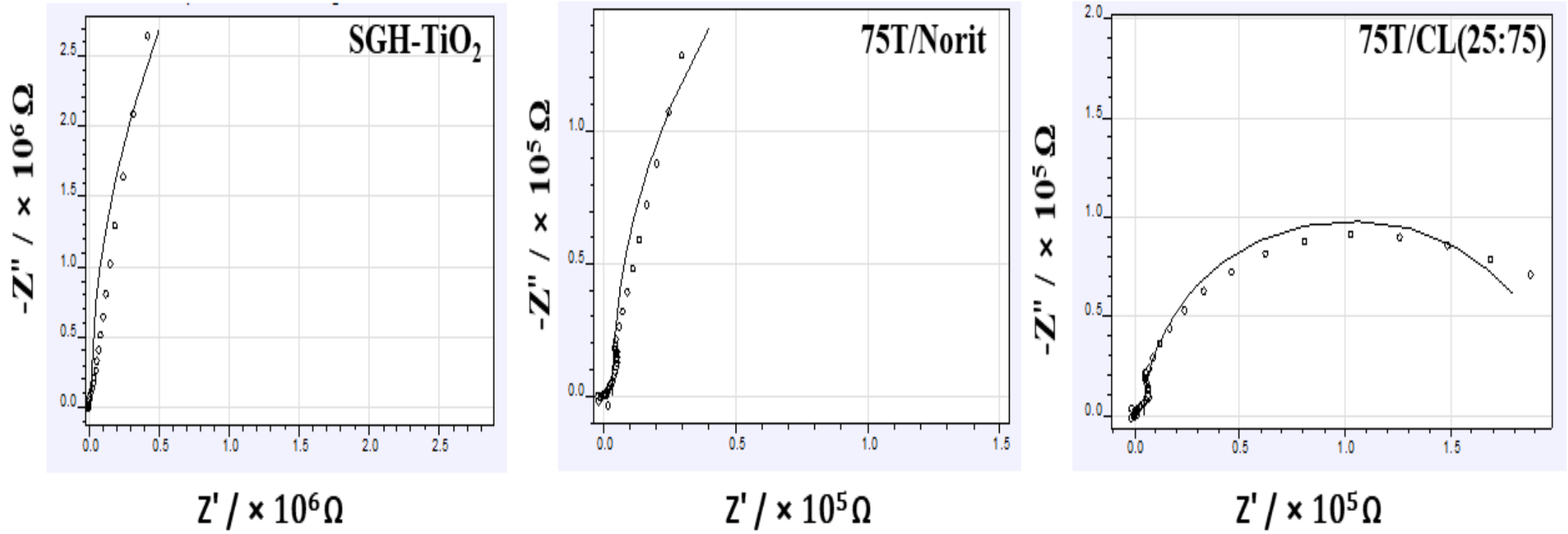


Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

Impedance spectroscopy studies

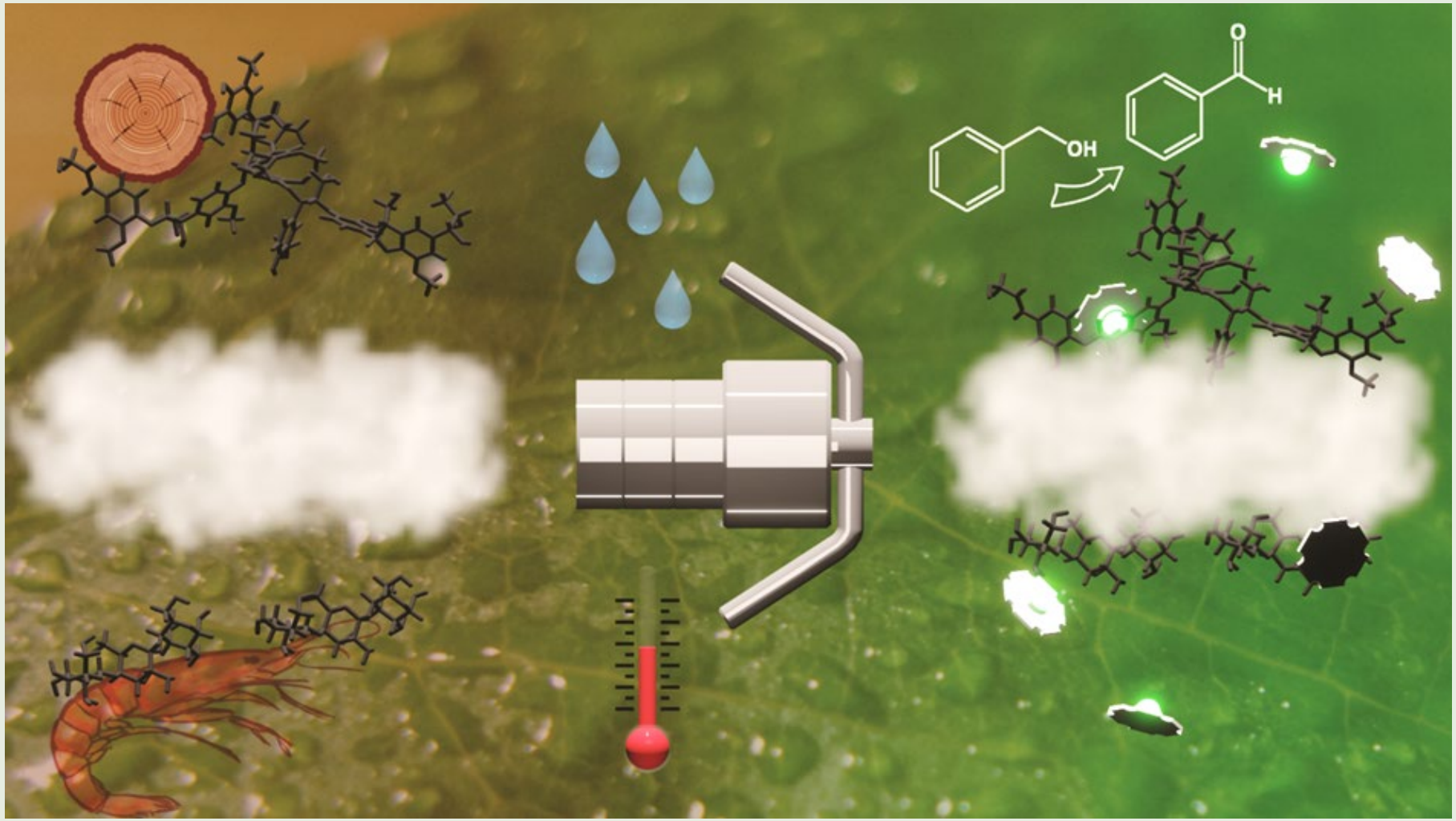
The Nyquist curves of SGH-TiO_2, 75T/Norit and 75T/CL(25:75) were fitted with the Randles equivalent circuit



Colmenares et al., RSC Adv., 11 (2021) 34996-35010

I am CELISE

Take-Home Message



What next?: Colombian coffee wastes for lignin extraction... and something else...

I am CELISE

ARISTOTLE UNIVERSITY OF THESSALONIKI

Prof. K. Triantafyllidis

https://ktrianta.webpages.auth.gr

Group...

Laboratory of Chemical & Environmental Technology

IChF
Institute of Physical Chemistry PAS

Acknowledgments

OPUS-20 project nr 2020/39/B/ST5/00076

NATIONAL SCIENCE CENTRE
POLAND

This work has also received funding from the **CELISE** – Sustainable production of Cellulose-based products and additives to be used in SMEs and rural areas project within the European Union's Horizon 2020 research and innovation program, Marie Sklodowska-Curie Actions – RISE, with the grant agreement No. 101007733

CELISE Med Term Meeting
24th-25th of July-2023, Warsaw, POLAND

Instituto de Investigación en Ingeniería

UNIVERSIDAD COOPERATIVA DE COLOMBIA