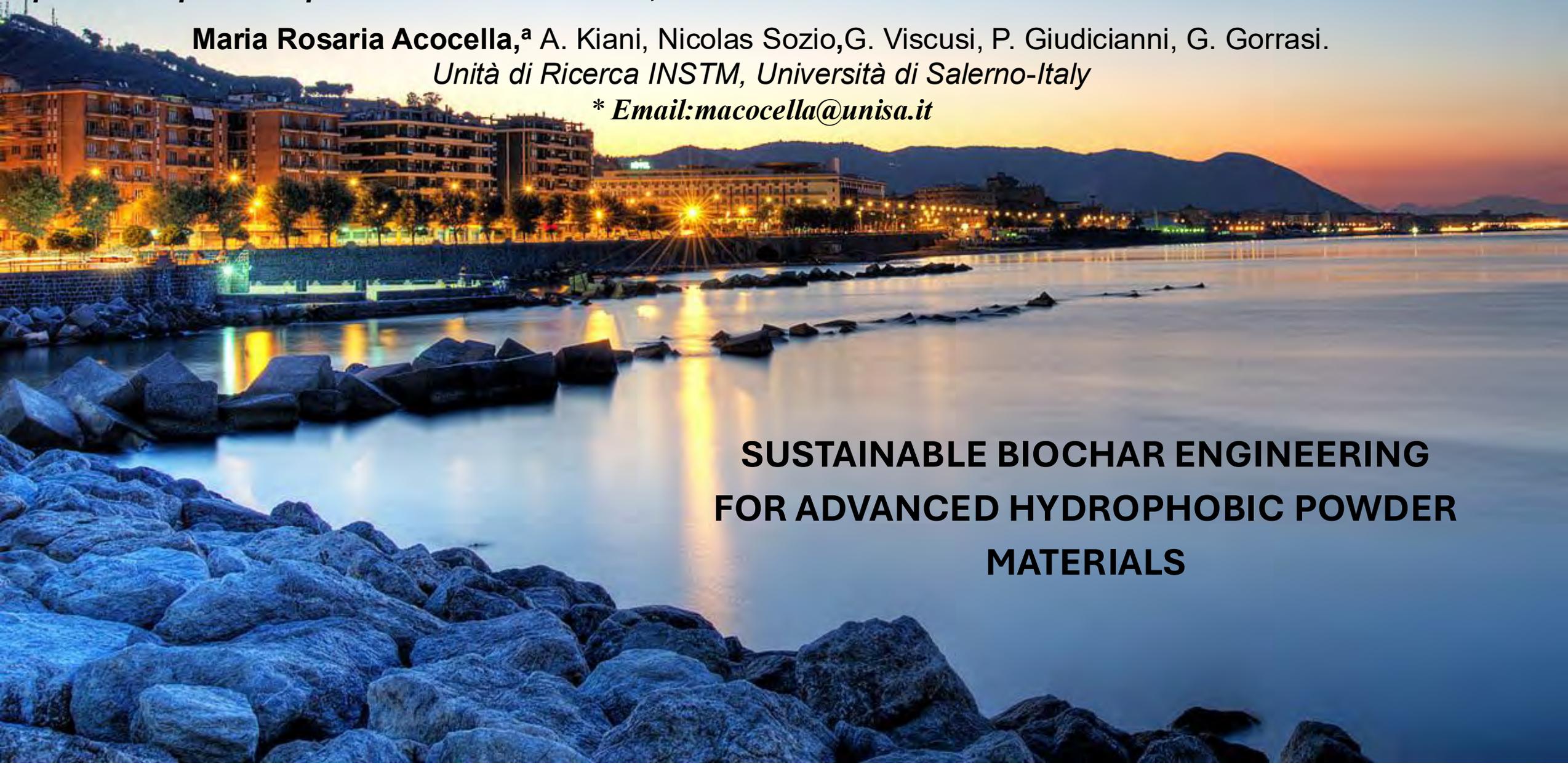


1°PCE: Powder Coating Evolution-1°PLA: Powder and Liquid Anticorrosion *Materie prime per processi di formulazione per sistemi di finitura con rivestimenti in polvere e tecnologie anticorrosive con prodotti liquidi e in polvere- Palazzo FAST, Milano-25 Febbraio 2026.*

Maria Rosaria Acocella,^a A. Kiani, Nicolas Sozio, G. Viscusi, P. Giudicianni, G. Gorrasi.
Unità di Ricerca INSTM, Università di Salerno-Italy
** Email: macocella@unisa.it*

**SUSTAINABLE BIOCHAR ENGINEERING
FOR ADVANCED HYDROPHOBIC POWDER
MATERIALS**



HYDROPHOBIC COATING

ANTI-WETTING



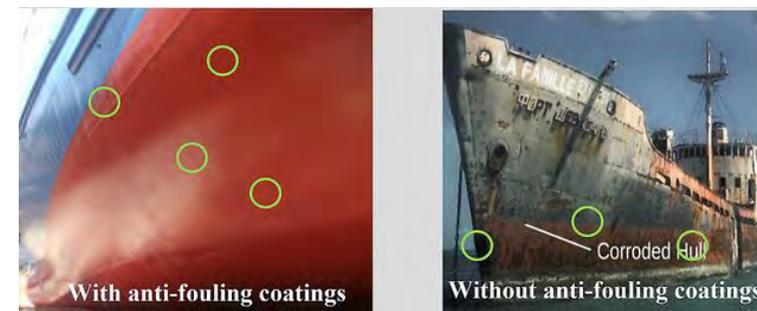
ANTI-ICING



ANTI-CORROSION



ANTI-FOULING

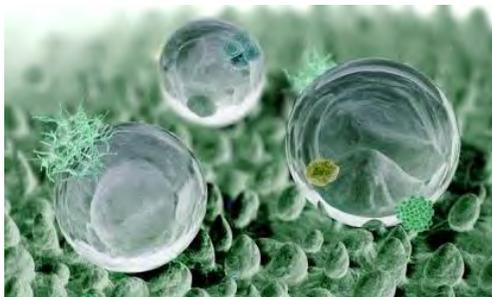


**HYDROPHOBIC AND
SUPERHYDROPHOBIC
COATING
MATERIALS CARBON-
BASED**

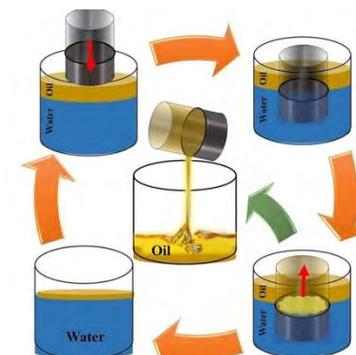
Langmuir **2010**, 26 (20), 16110–16114.

ACS Omega **2019**, 4 (1), 509–517.

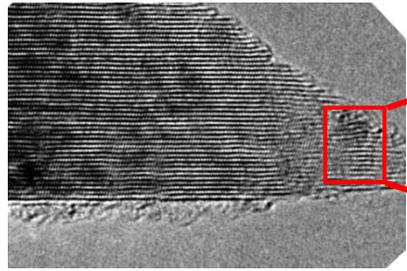
SELF-CLEANING



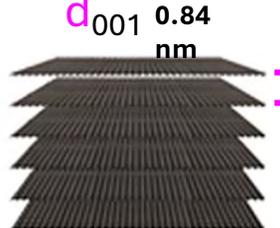
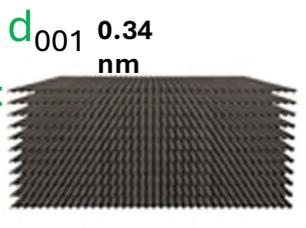
OIL-WATER SEPARATION



GRAPHITE-BASED MATERIALS: OXIDATION



GRAPHITE

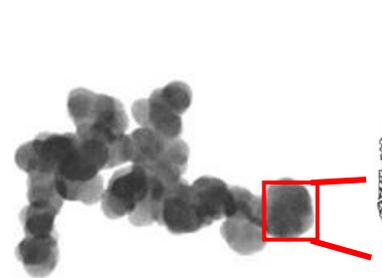


Ball milling

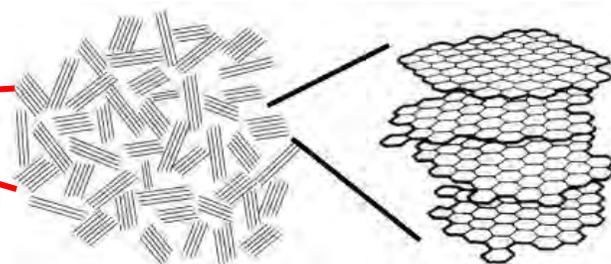
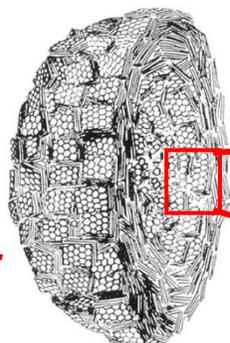


Graphene Oxide (eGO)

Hummers oxidation
 $\text{KMnO}_4, \text{NaNO}_3, \text{H}_2\text{SO}_4$



CARBON BLACK

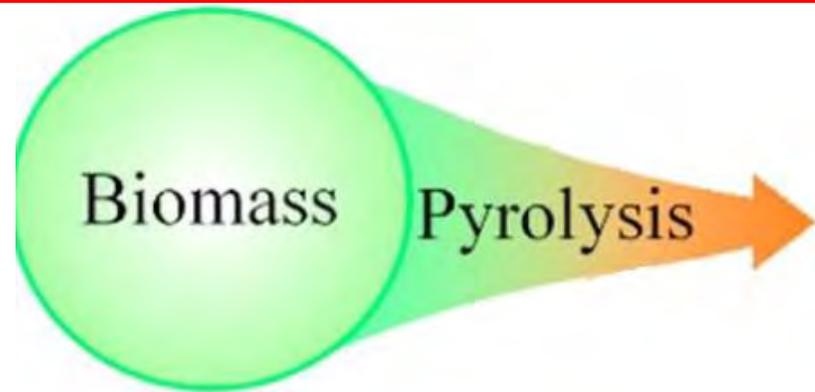
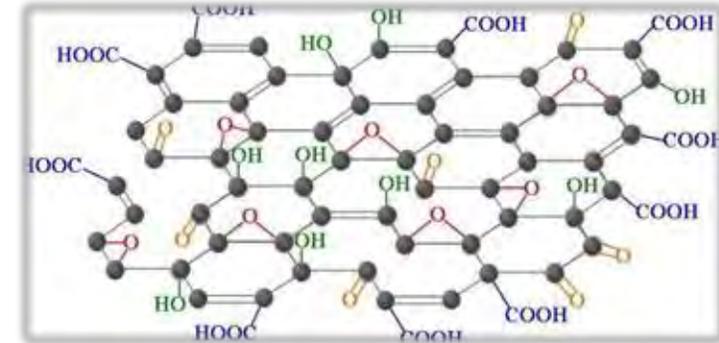


Hummers oxidation

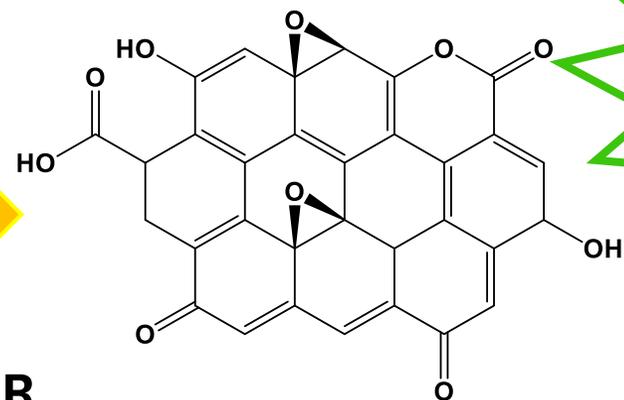
$\text{KMnO}_4, \text{NaNO}_3, \text{H}_2\text{SO}_4$

W.S. Hummers Jr., R.E. Offeman *JACS*, 1958, 80, 1339

NON-RENEWABLE SOURCES

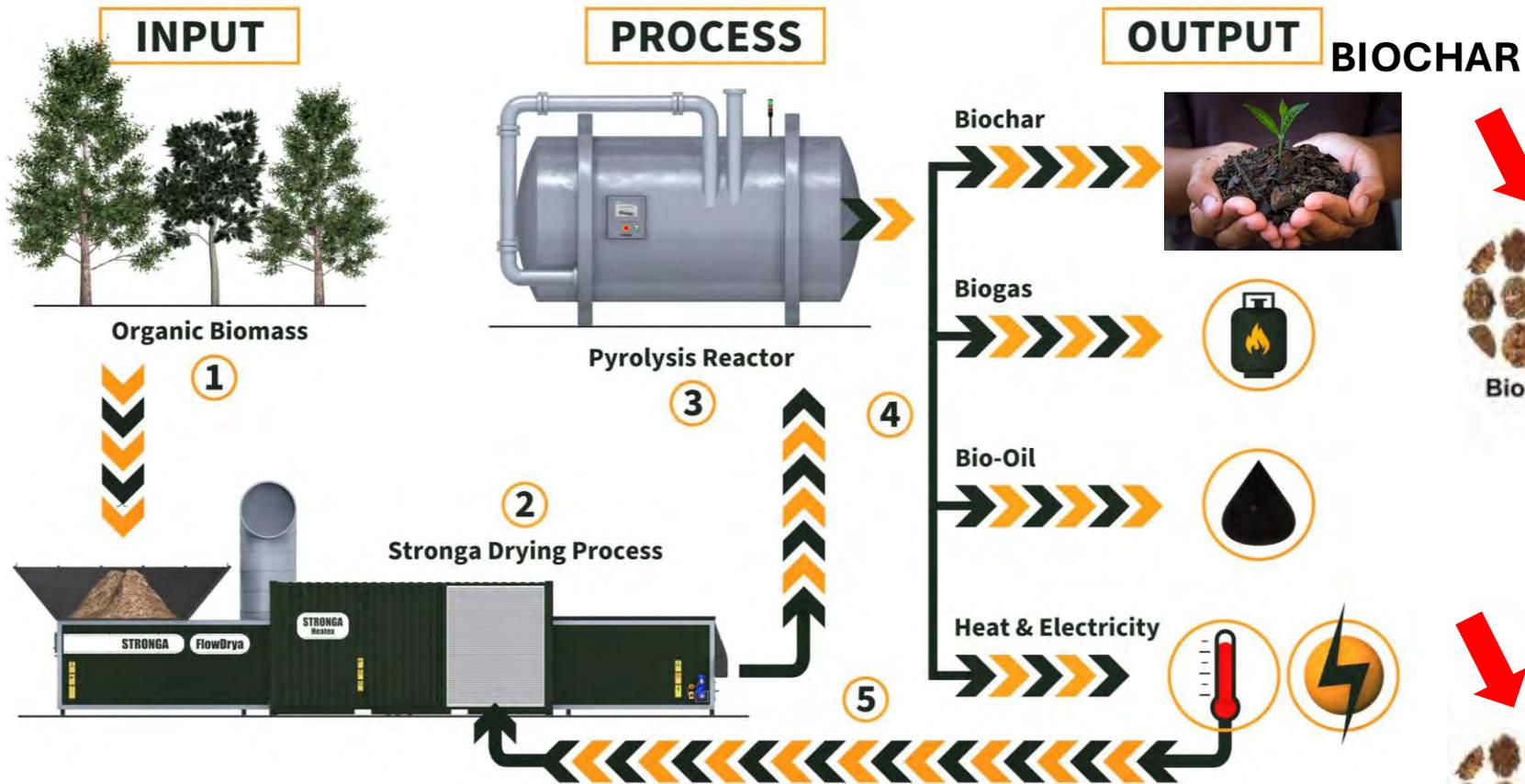


BIOCHAR

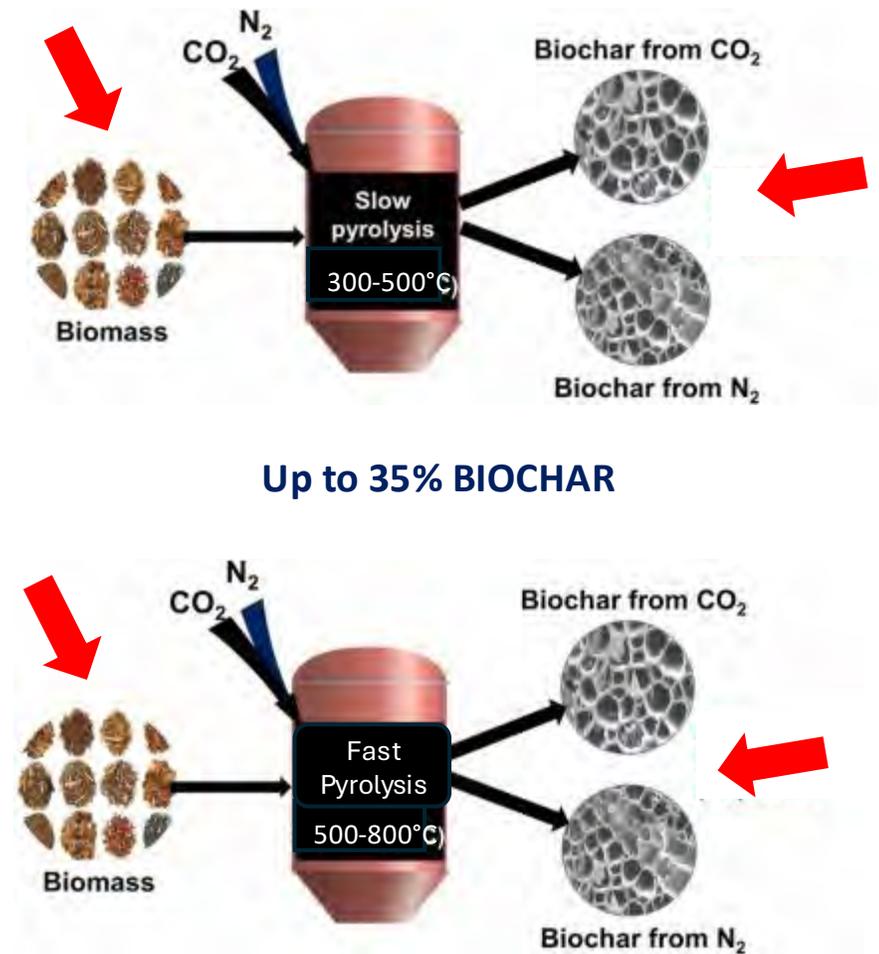


RENEWABLE SOURCES

BIOCHAR PRODUCTION

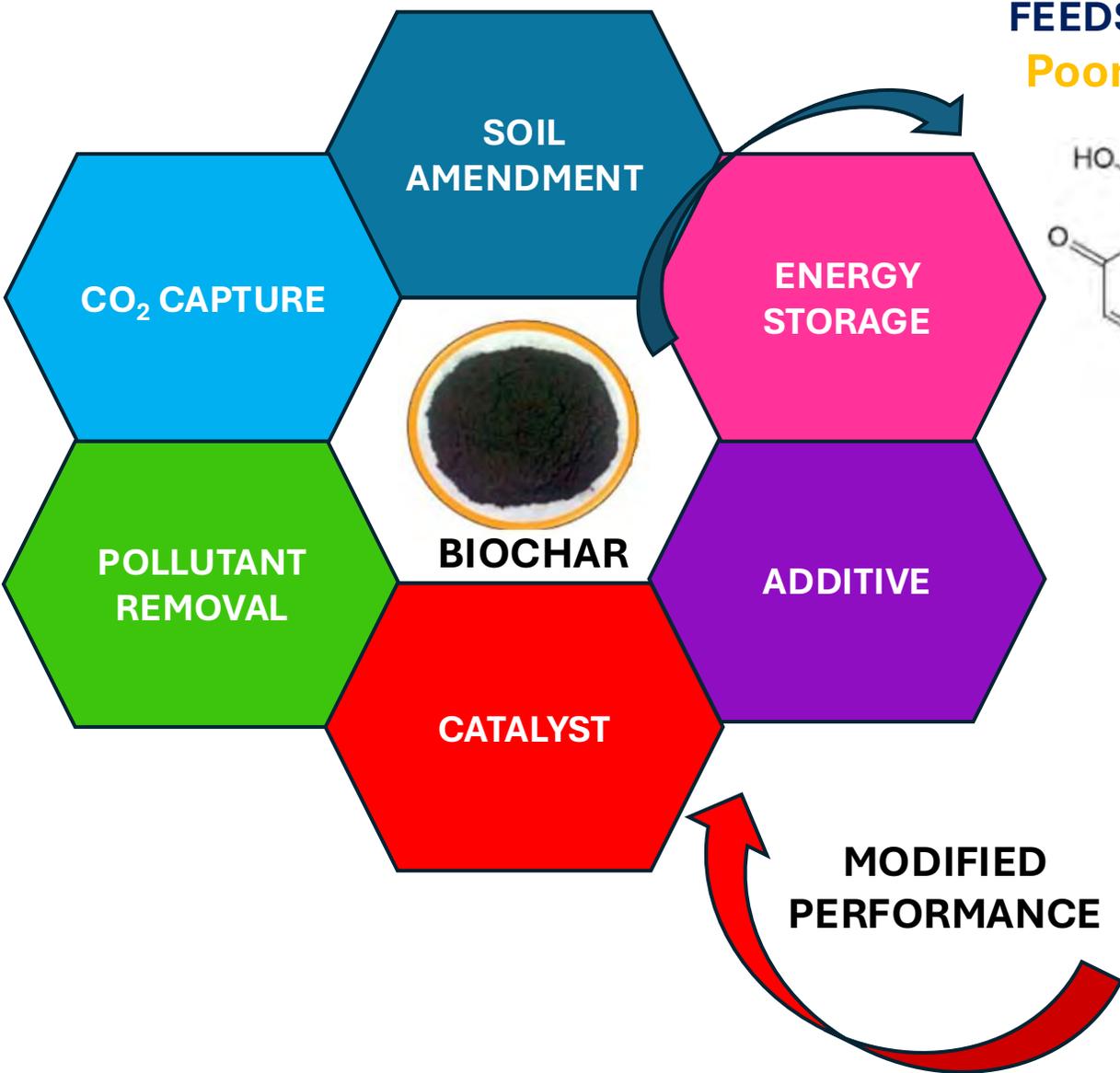


FEEDSTOCK AND PYROLYSIS CONDITIONS AFFECT THE BIOCHAR PROPERTIES



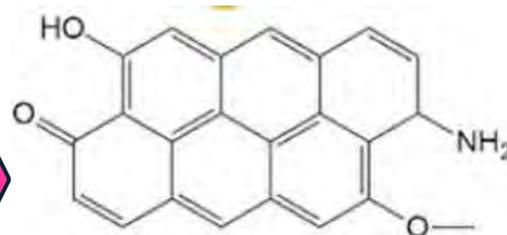
Up to 15% BIOCHAR

BIOCHAR APPLICATIONS

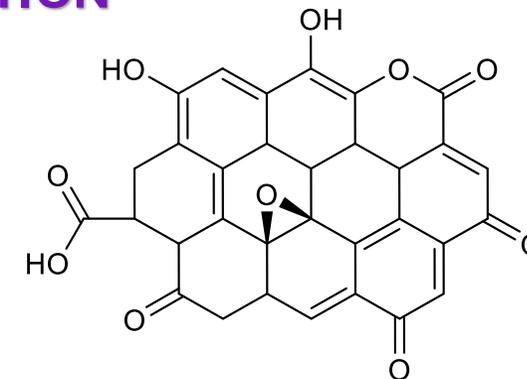


FEEDSTOCK, PYROLYSIS

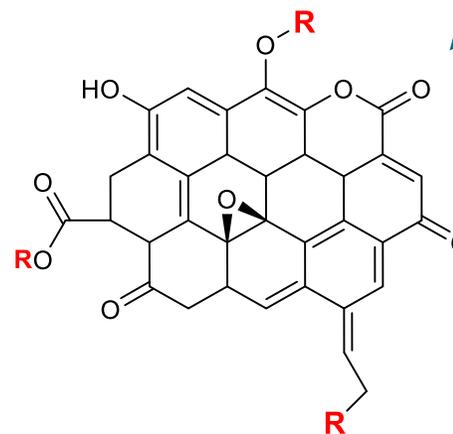
Poor functional groups



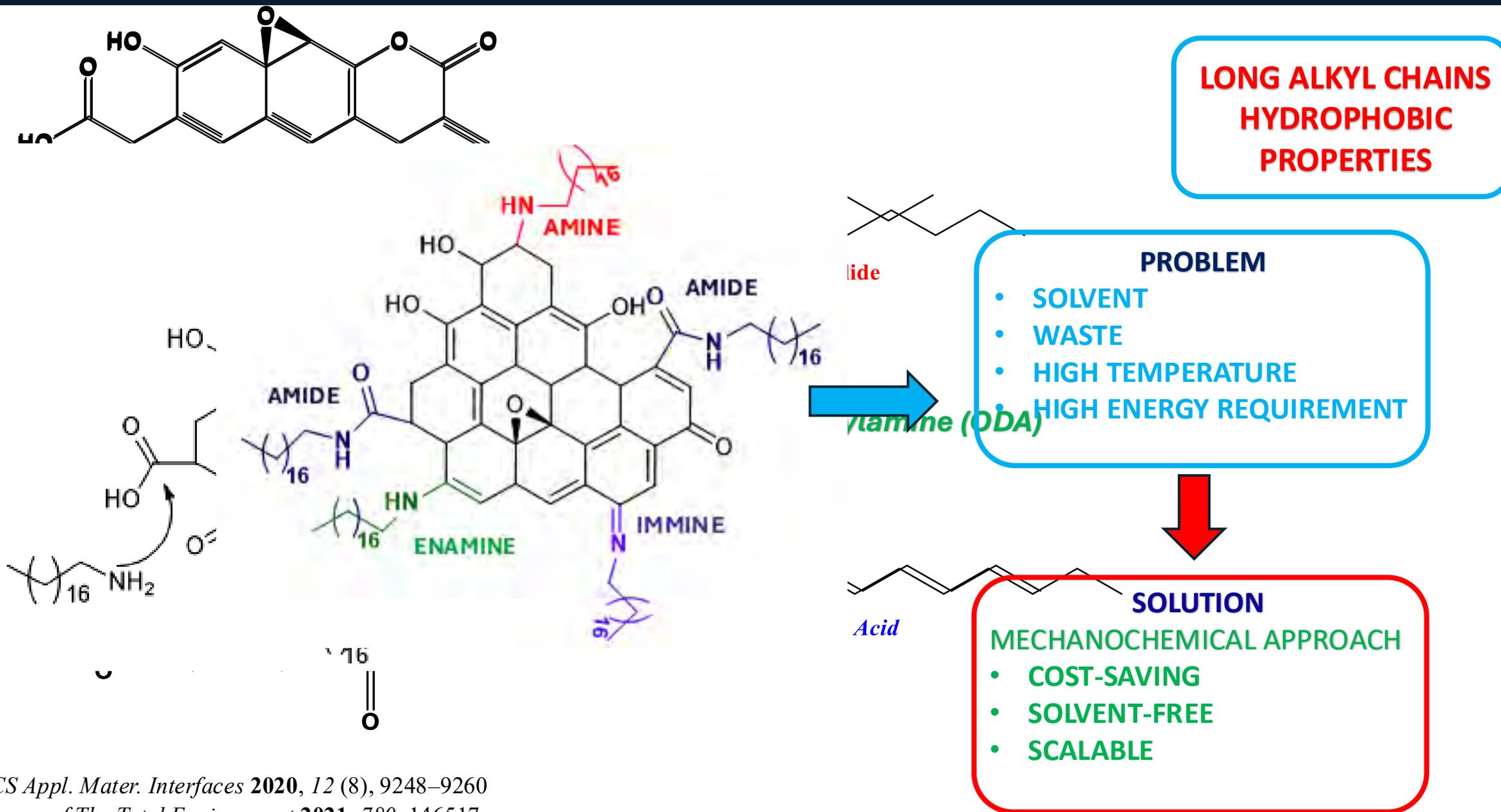
CHEMICAL MODIFICATION



FUNCTIONALIZATION



POSSIBLE FUNCTIONALIZATION PATHWAYS

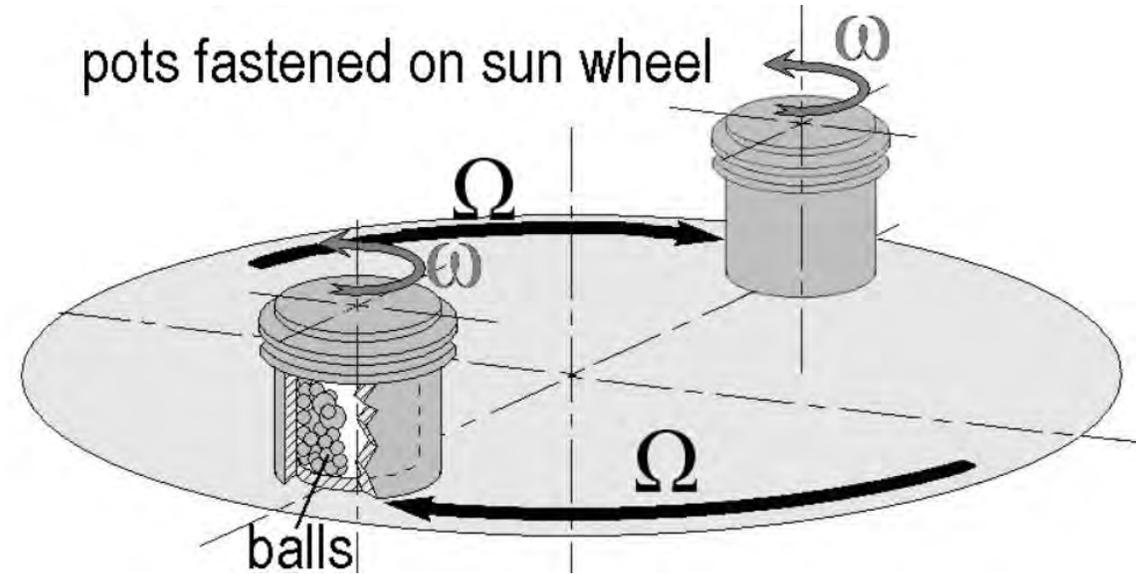


ACS Appl. Mater. Interfaces **2020**, 12 (8), 9248–9260

Science of The Total Environment **2021**, 780, 146517.

RSC Sustainability **2024**, 2 (9), 2581–2588

PLANETARY BALL MILLING



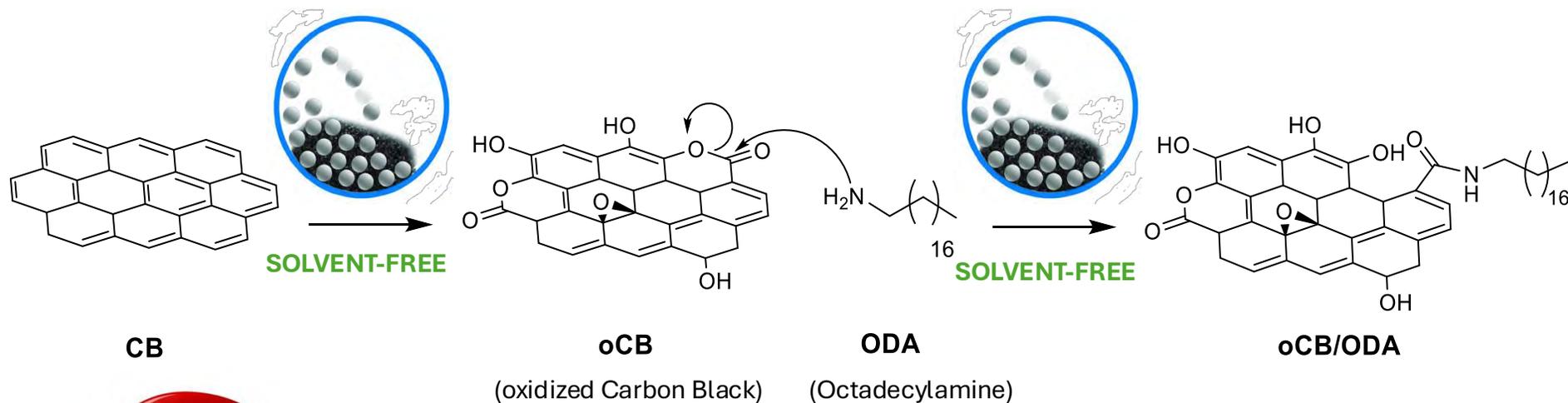
BM reduces particle size and can break or build chemical bonds by colliding milling balls

Effective Parameters

- **Ball to Powder ratio**
- **Milling time**
- **Milling speed**
- **Nature of the balls**

FUNCTIONALIZATION OF OXIDIZED CARBON BLACK (oCB)

MECHANOCHEMICAL APPROACH



HYDROPHYLIC

Water dispersion



HYDROPHOBIC

Water dispersion

**STRUCTURAL SIMILARITIES
BETWEEN oCB AND BIOCHAR**

**MECHANOCHEMISTRY
CAN WORK?**

AIMS OF THE WORK

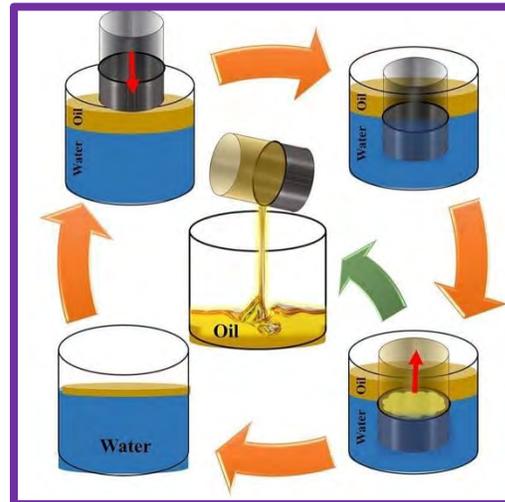
1) MECHANOCHEMICAL FUNCTIONALIZATION



2) IS IT HYDROPHOBIC? CAN WE REALIZE AN HYDROPHOBIC COATING?

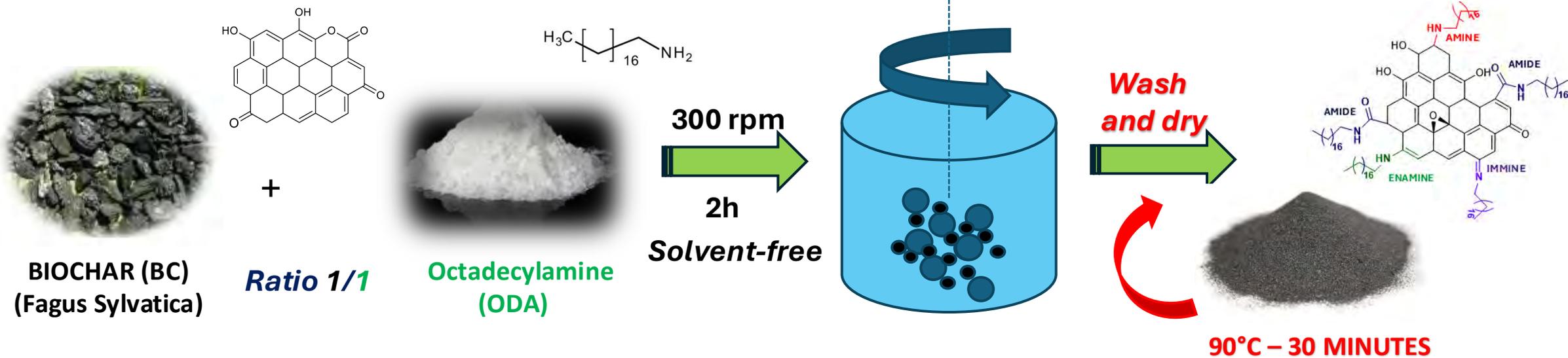


3) APPLICATION IN OIL-WATER SEPARATION

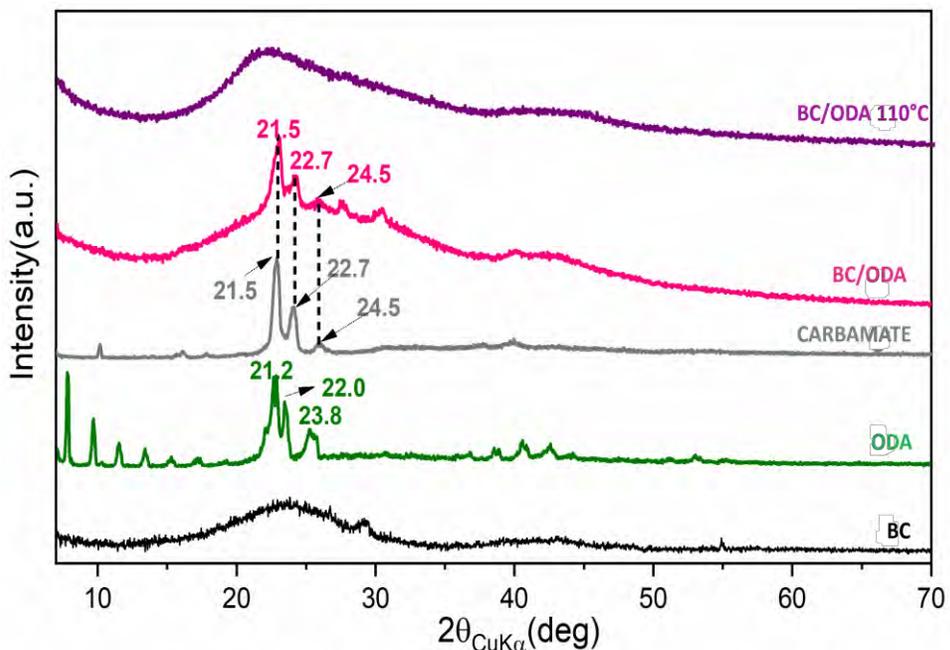


IF YES

MECHANOCHEMICAL FUNCTIONALIZATION



WAXD

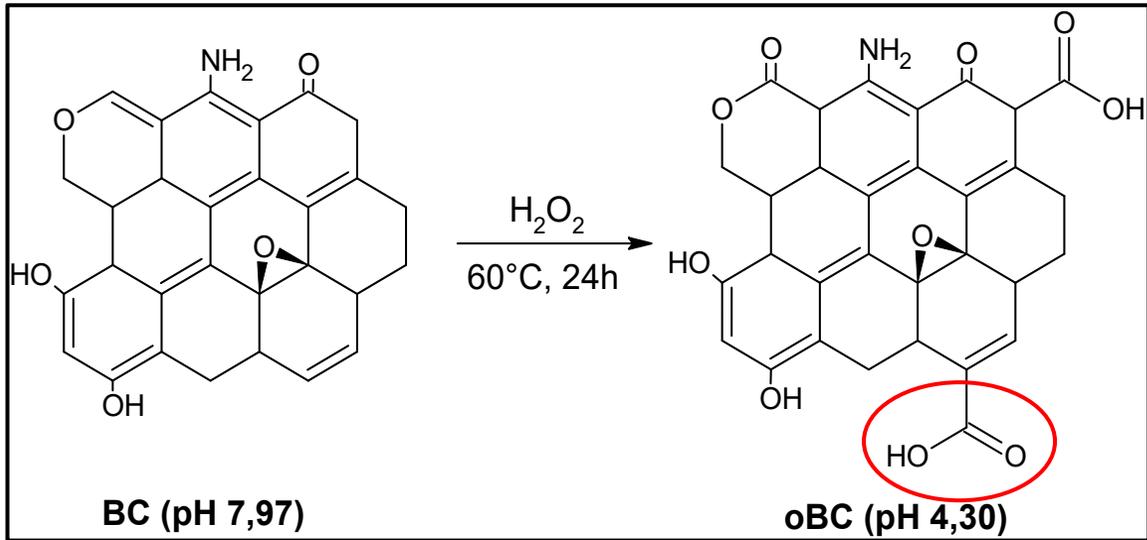


**MODERATE INCREASE
OF NITROGEN CONTENT**

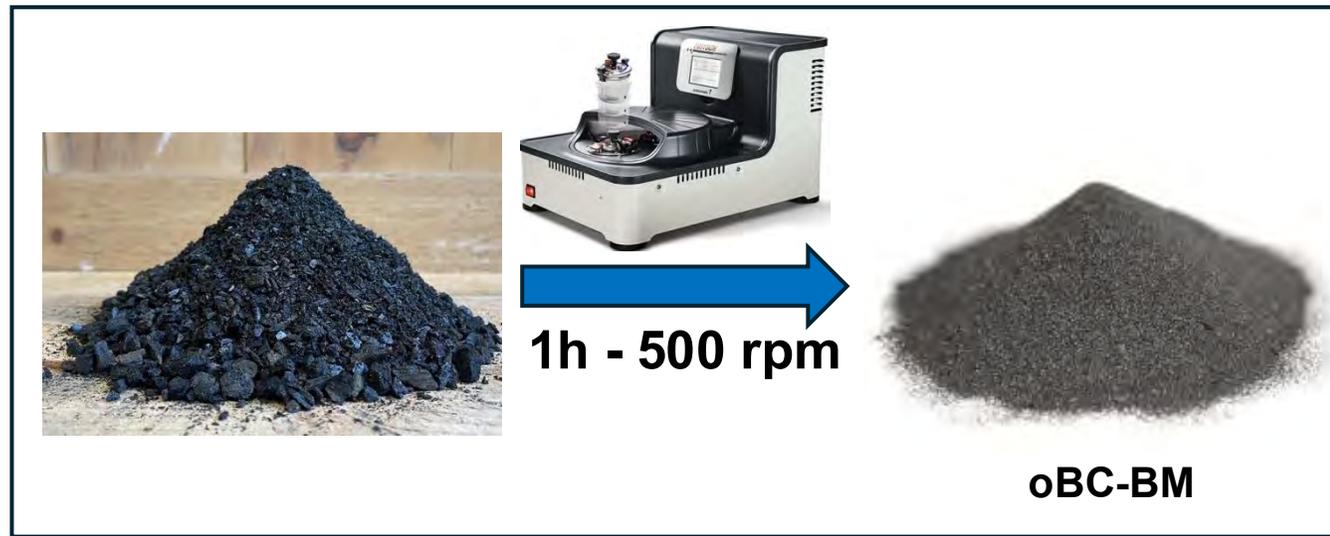
ELEMENTAL ANALYSIS (EA)					
	% C	% H	% O	% N	O/C
Biochar (BC)	78.9	2.7	18.0	0.4	0.23
BC/ODA	81.3	3.4	14.5	0.8	0.18

OXIDATION AND ACTIVATION STEP

GREEN OXIDATION



MILLING-ACTIVATION STEP



ELEMENTAL ANALYSIS(EA)

	% C	% H	% O	% N	O/C
BC	78.9	2.7	18.0	0.4	0.23
oBC	72.7	2.8	24.0	0.5	0.33

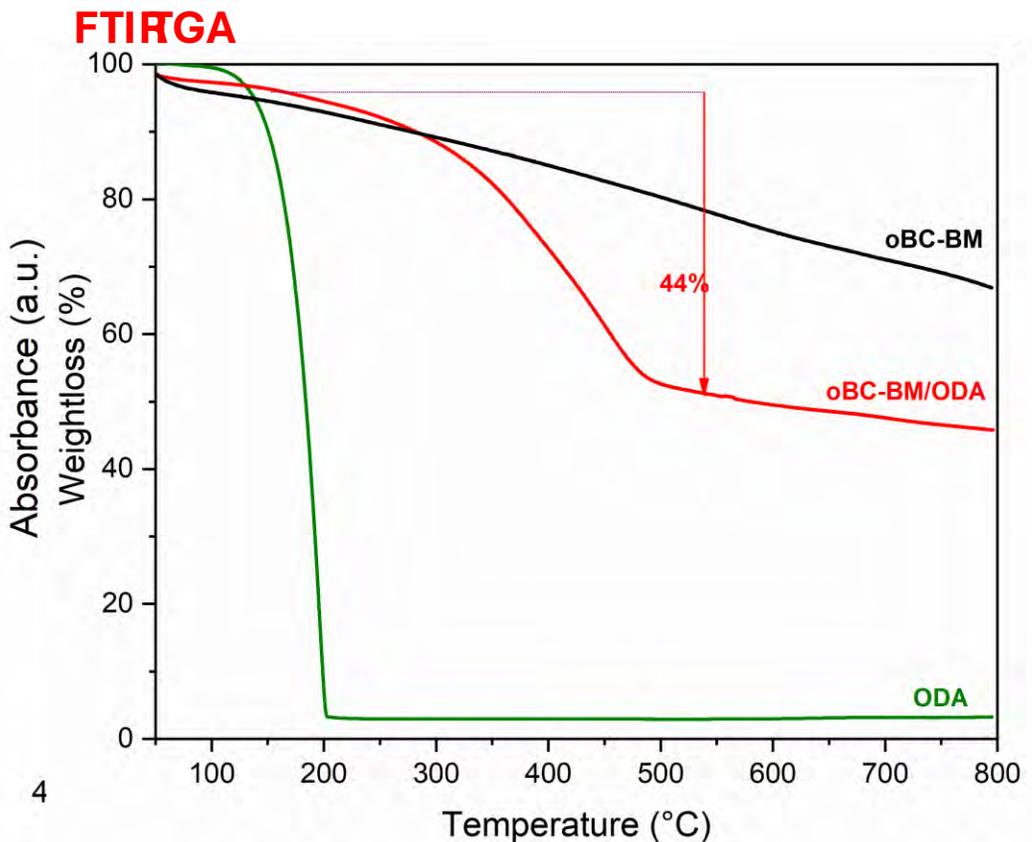
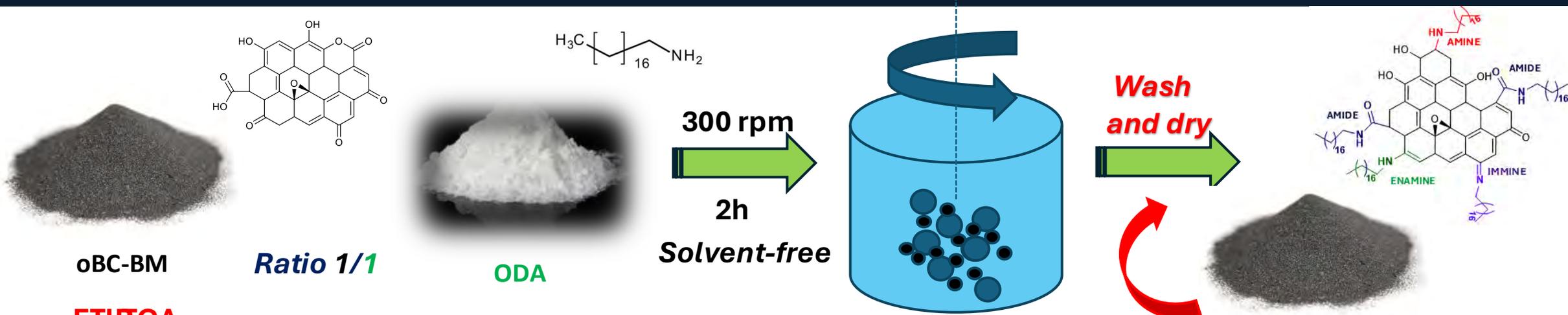
INCREASING OF OXYGEN
CONTENT

Surface area (m²/g)

	Surface area (m ² /g)	pH
BC	81	7.97
oBC	<1	4.30

HIGHER EXPOSURE OF
FUNCTIONAL GROUPS

MECHANOCHEMICAL FUNCTIONALIZATION



ELEMENTAL ANALYSIS (EA)

	% C	% H	% O	% N	O/C
oBC-BM	69.7	1.3	28.9	0.1	0.41
oBC-BM/ODA	80.5	7.2	10.0	2.4	0.13

**STRONG INCREASE OF
NITROGEN CONTENT**

DISPERSIBILITY TEST AND COATING

DISPERSIBILITY TEST

		Contact Angle (CA)	
		CA (t=0)	CA (t=60s)
HF		123±0	0
1 layer		126±4	117±2

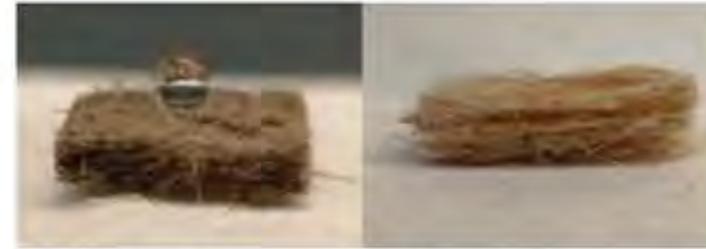
STABLE UP TO 6h

COATING



COATED HEMP

UNCOATED HEMP



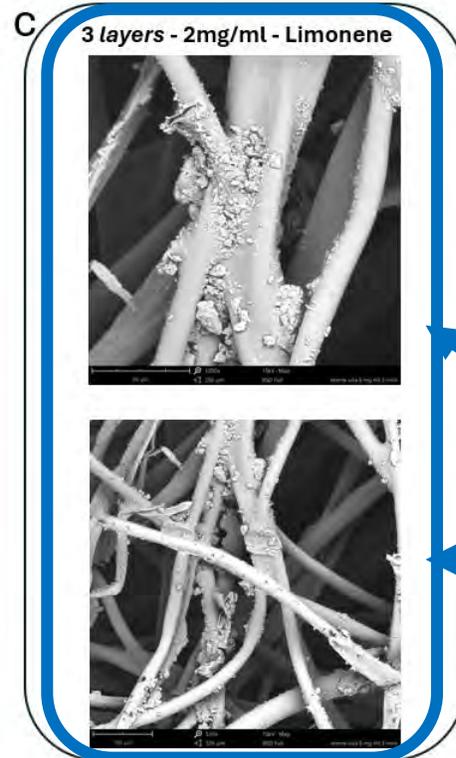
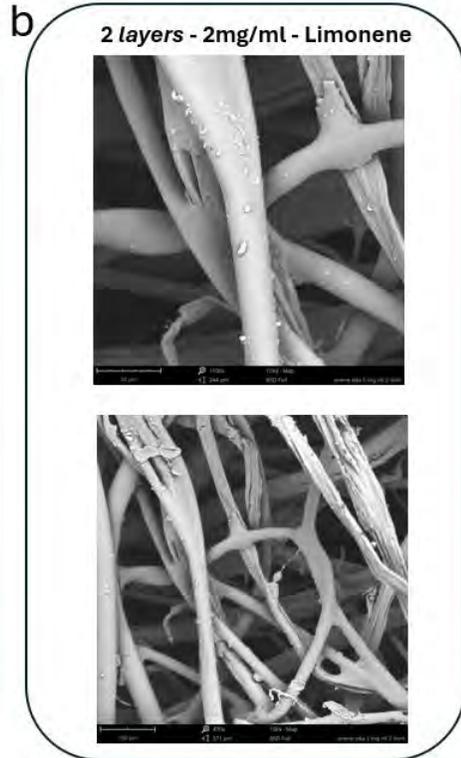
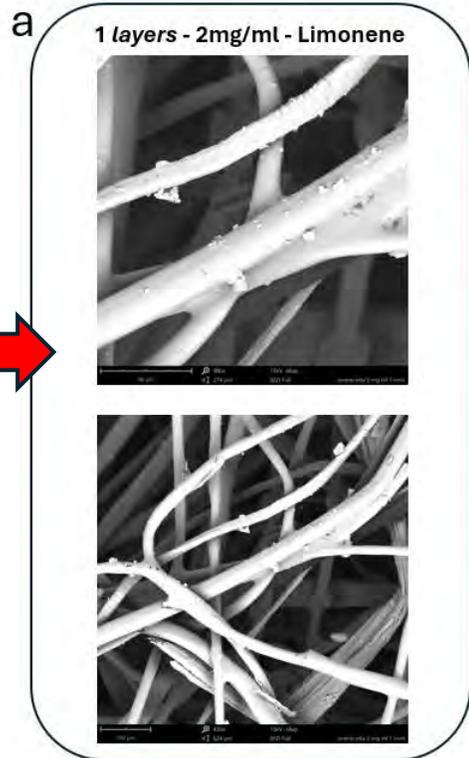
COATED HEMP

UNCOATED HEMP



**SUSTAINABLE
COATING
FOR
AGRICULTURAL
TEXTILE INDUSTRY**

MULTILAYER COATING

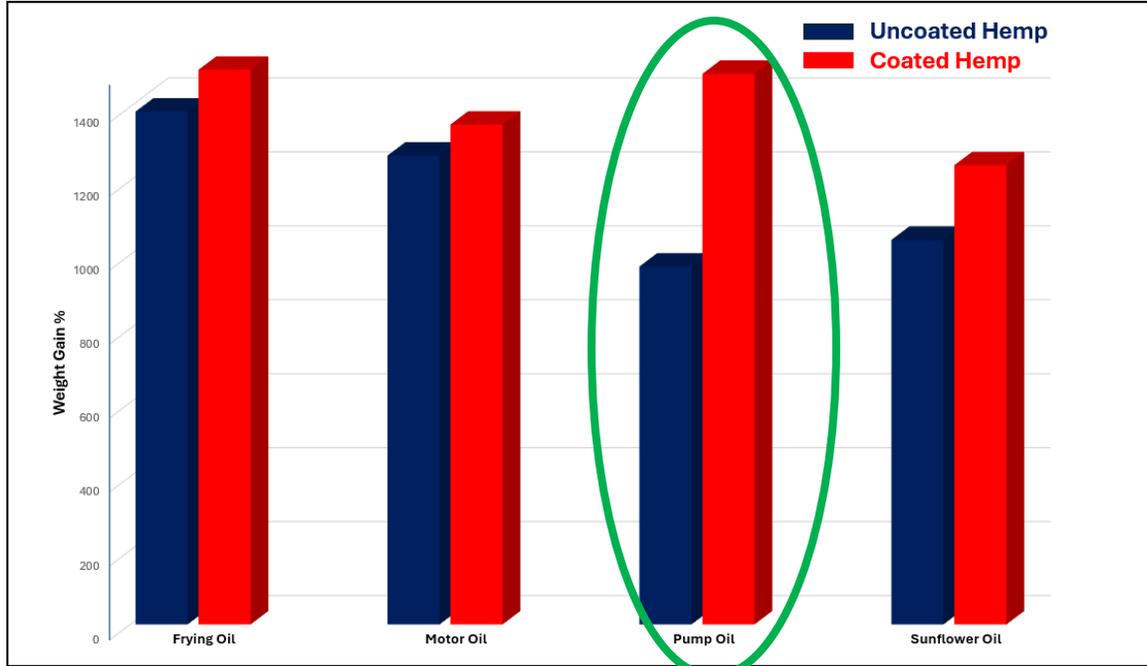


	CONTACT ANGLE (CA)	
	CA (t=0)	CA (t=60s)
CANAPA	123±0	0
1 layer	126±4	117±2
2 layers	108±4	104±1
3 layers	107±1	102±1

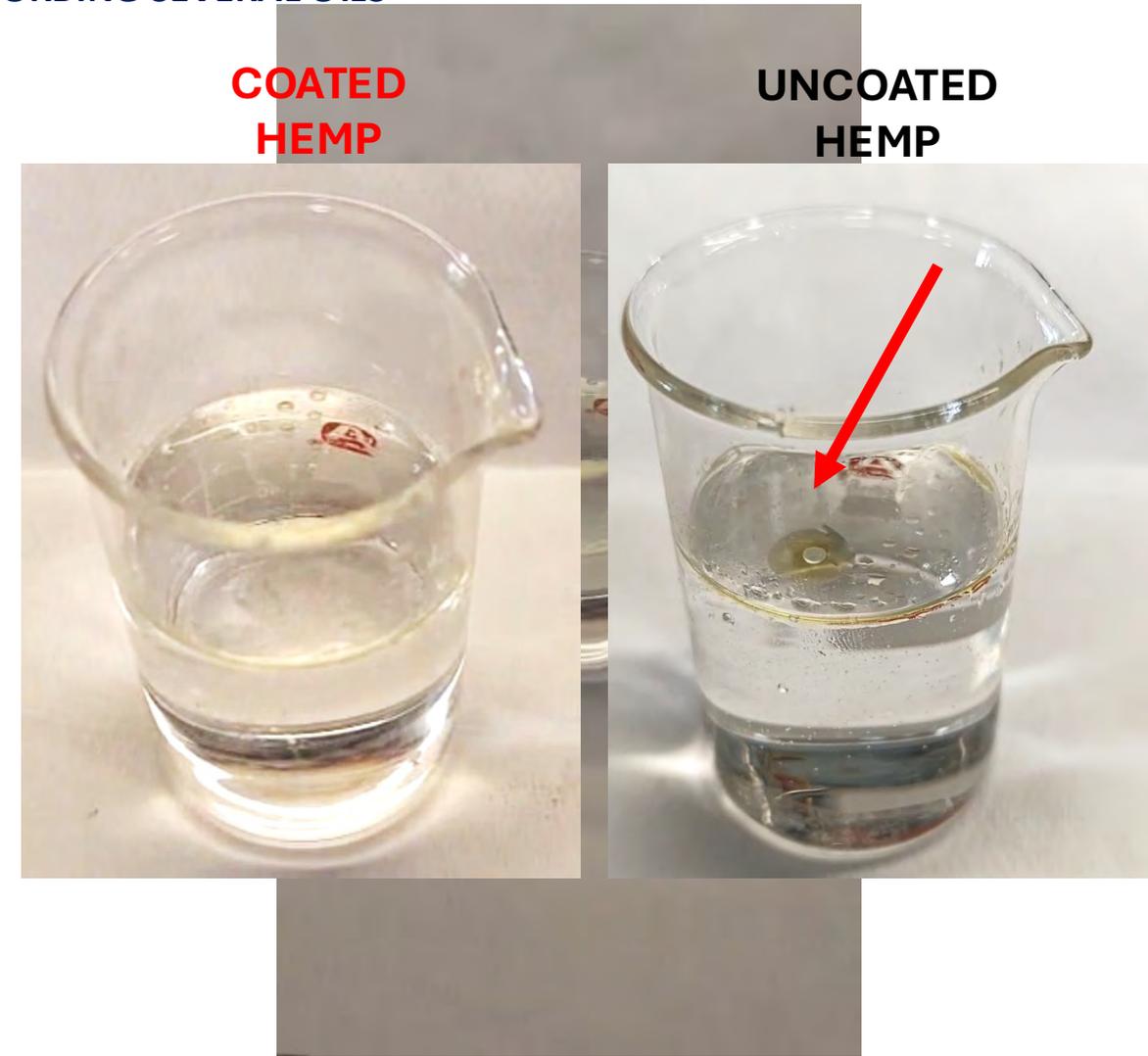
AGGREGATION OF FUNCTIONALIZED BIOCHAR

APPLICATION IN OIL-WATER SEPARATION

WEIGHT GAIN (%) OF PRISTINE AND COATED HEMP FIBERS AFTER ABSORBING SEVERAL OILS

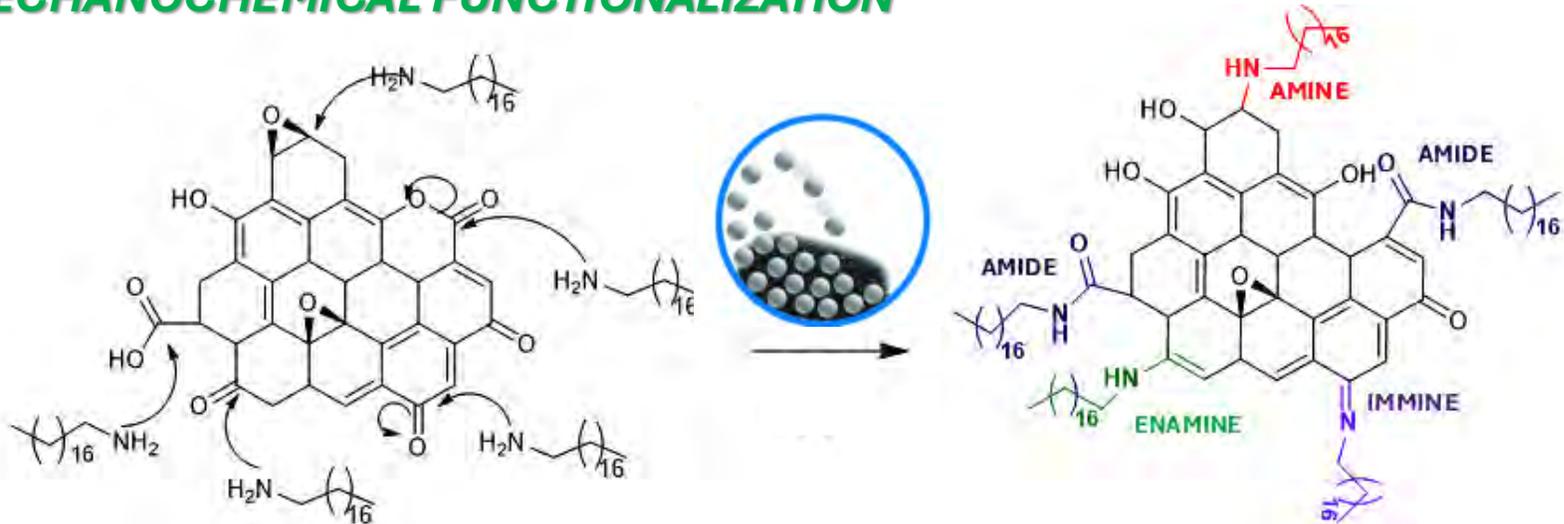


COATED HEMP
15 TIMES INCREASE THE
INITIAL WEIGHT AFTER
PUMP OIL SORPTION



TAKE HOME MESSAGES

1) MECHANOCHEMICAL FUNCTIONALIZATION

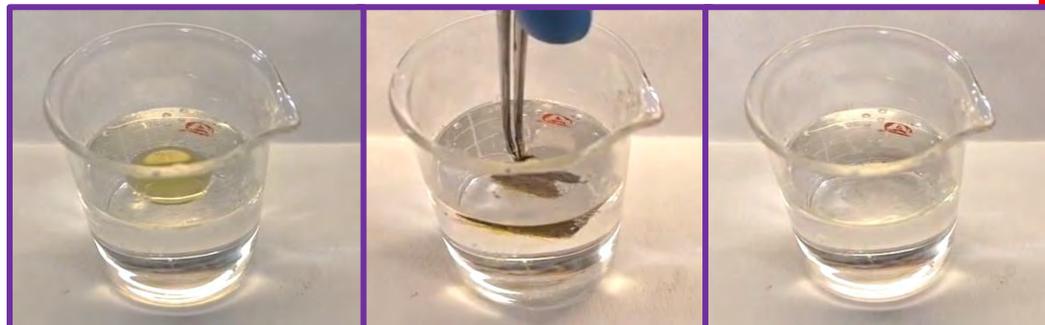


UP TO 44% DEGREE OF FUNCTIONALIZATION

**2) THE FUNCTIONALIZED BIOCHAR WITH ODA IS HYDROPHOBIC
WE CAN REALIZE HYDROPHOBIC COATING**



3) APPLICATION IN OIL-WATER SEPARATION



HYDROPHOBIC COATING

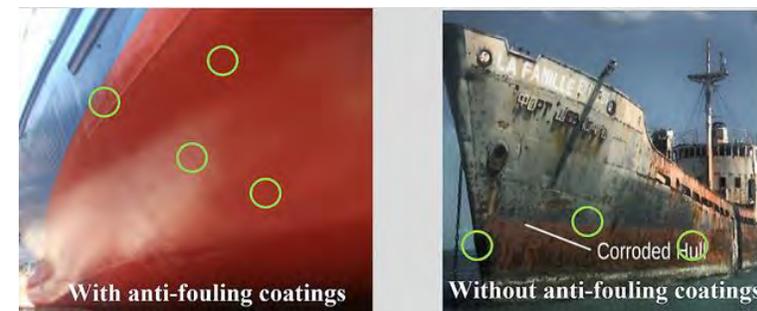
ANTI-WETTING



ANTI-ICING



ANTI-FOULING



ANTI-CORROSION

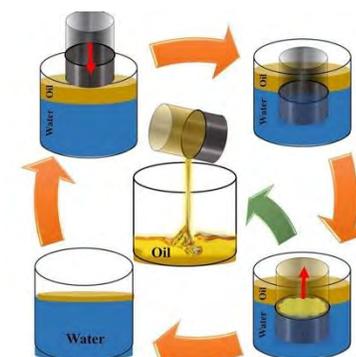


**HYDROPHOBIC AND
SUPERHYDROPHOBIC
COATING
MATERIALS CARBON-
BASED**

SELF-CLEANING



OIL-WATER SEPARATION



Acknowledgements

University of Salerno

Department of Chemistry and Biology

PhD, A. Kiani

Student Nicola Sozio

Department of Industrial Engineering

Prof. G. Gorrasi

Dr. G. Viscusi

Prin 2022 PNRR, “DEveloping MEchanochemical Technologies to Render Crop Protection Agrochemicals Greener (**DEMETRA**)” (contract number P202289FCM).



Thank You!

HYDROPHOBIC PROPERTIES

HEMP
BEHAVIOUR IN
WATER

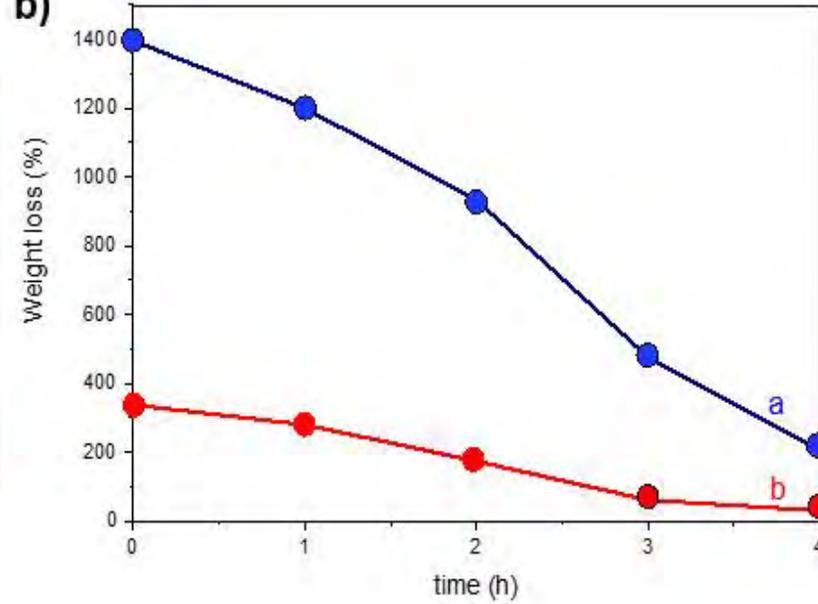
a)



UNCOATED
HEMP

COATED
HEMP

b)



SORPTION AND
DESORPTION OF
COATED AND
UNCOATED