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Universidad Rey Juan Carlos

Workshop 2020

Innovative technologies for sustainable management of urban and industrial waste streams

Integrated waste treatment through the symbiosis of bio and catalytic processes

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BIO3

Drawbacks associated with the use of fossil feedstock

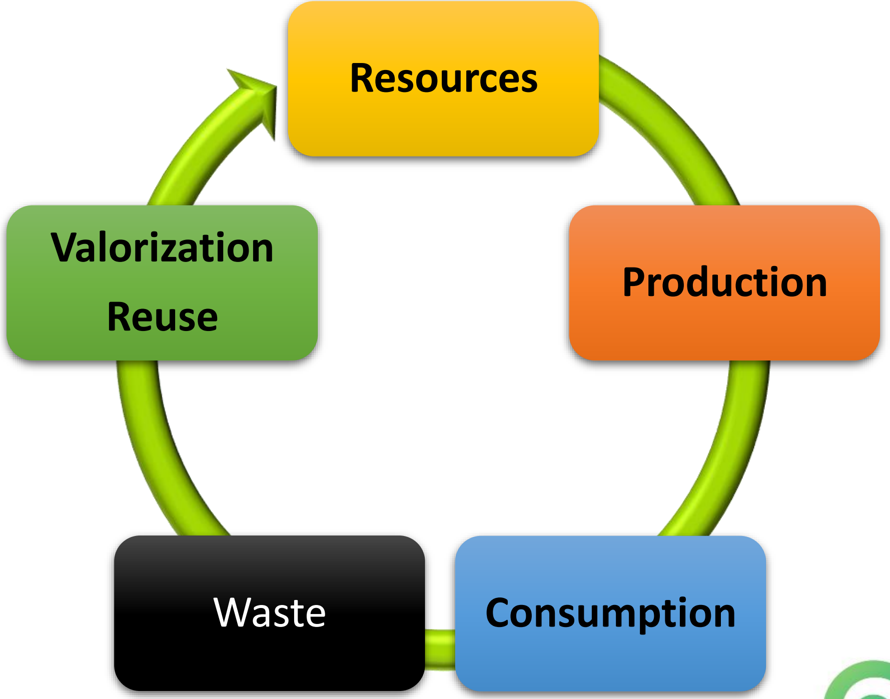
- ✓ Rapid **depletion** of fossil carbon
- ✓ Increase the $\mathbf{CO_2}$ atmospheric level

One of the alternatives resources available in abundance and also on a renewable basis is:

BIOMASS

From waste disposition to waste valorization

Biowaste

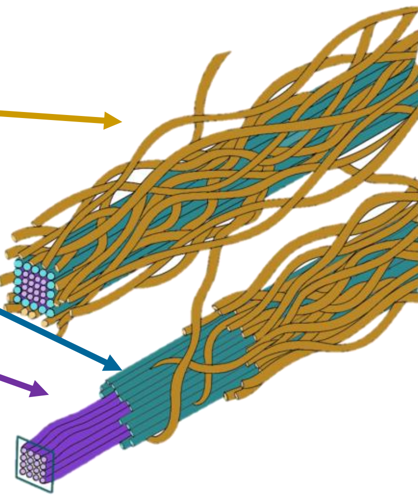


Circular economy

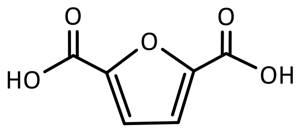
Lignin (18-25%)

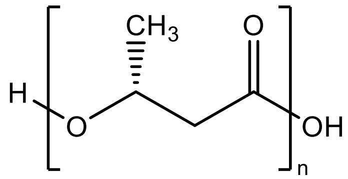
Hemicellulose (24-40%)

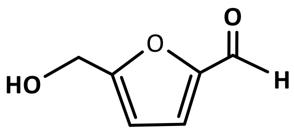
Cellulose (40-55%)

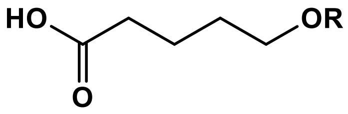


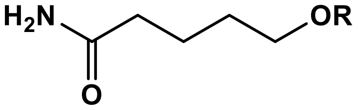
High-added value products

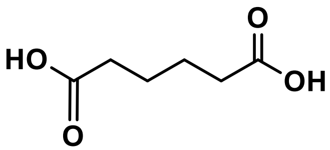


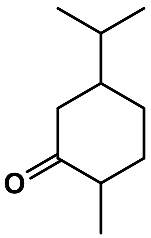






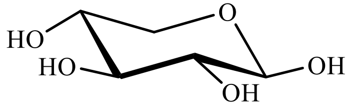


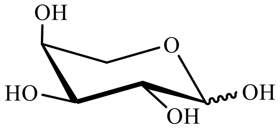


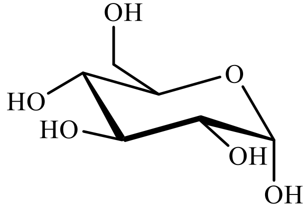


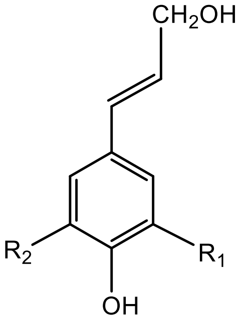
It's green!!

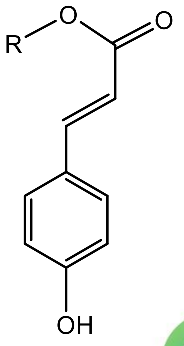
Low-cost platform chemicals











*Chemical **or** biological trasformations*

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Waste valorization

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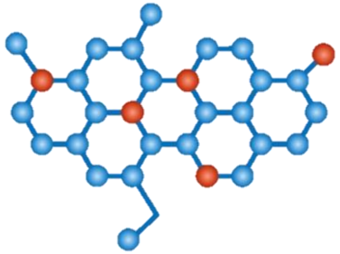
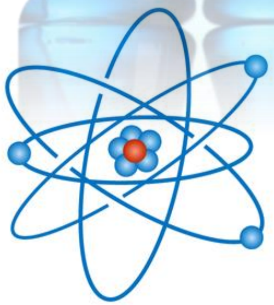
Bio-treatment

Chemical treatment





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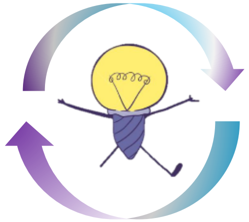
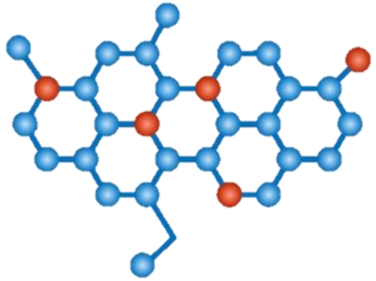
Waste valorization

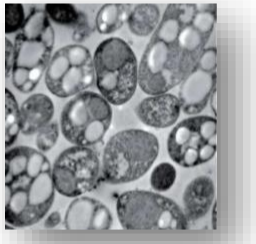




Purple non-Sulphur bacteria

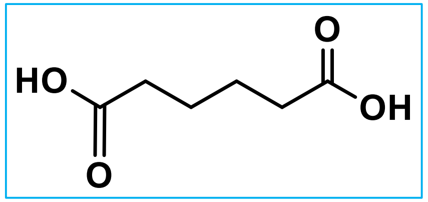
Heterogeneous catalyst

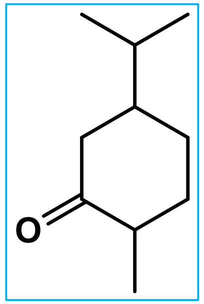
Proteins

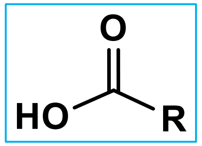


Bioplastics

A pretreatment is needed!







Non-versatile mixture of compounds!

Waste valorization: chemical treatment

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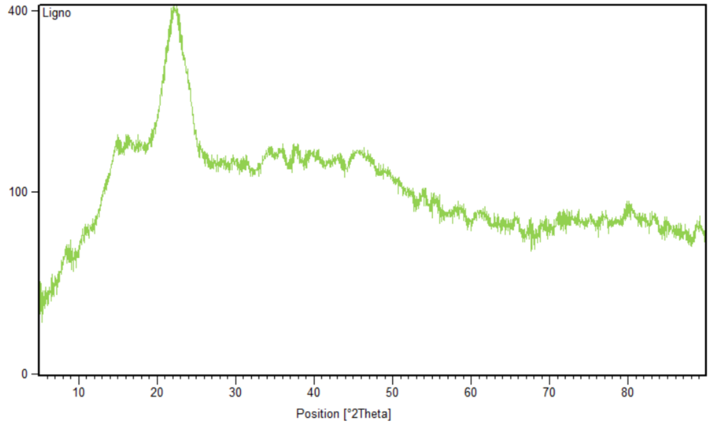
1st steps **1.** Optimize the highest PHB/PHV production ✓ (Luis Diaz Allegue presentation)

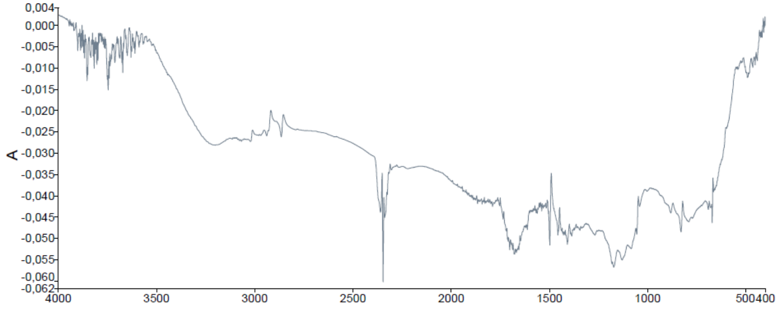
2. Lignocellulosic waste characterization ✓

XRD



$$CrI = \frac{I002 - Iamorphous}{I002}\ x\ 100 = 68\%$$

FTIR



TGA

- Cellulose = 41.2%
- Hemicellulose = 26.5 %
- Lignin = 24.8%
- Ash = 0.5%

Table 1. Macroscopic characteristics

Parameter	Value
TS (g/Kg)	980 ±8
VS (% TS)	94 ± 1
COD (g Kg^{-1} TS)	1120 ± 40

Table 2. Elemental analysis

Element	Value (%)
Carbon	47.2 ± 0.1
Nitrogen	0.8 ± 0.2
Hydrogen	5.9 ± 0.4
Oxygen	45.9

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Waste valorization

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3. Lignocellulosic waste treatment

Synthesis of catalysts

Cheap catalysts built on earth abundant metal oxides

Characterization

- Textural properties
- Structural properties
- Molecular properties

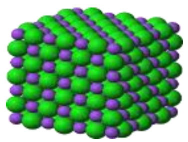
Catalytic lignocellulose pretreatment

- No additives
- Mild conditions
- Eco-friendly solvents

Liquid effluent

Solid effluent

Synthesis of solid supports



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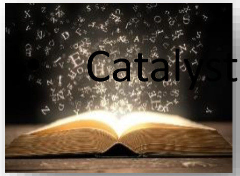
Synthesis and characterization of catalysts



Catalysts based on mixtures of V^{n+} and Fe^{n+}

High number of works related to metal-catalyzed reactions

$MgCaO_n$ (Brönsted and Lewis basicity)

Basic catalysts

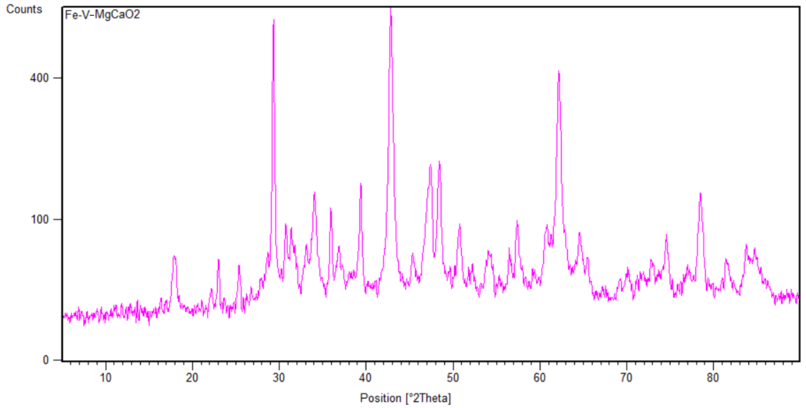
m- or t- ZrO_2 (Brönsted or Lewis acidity)

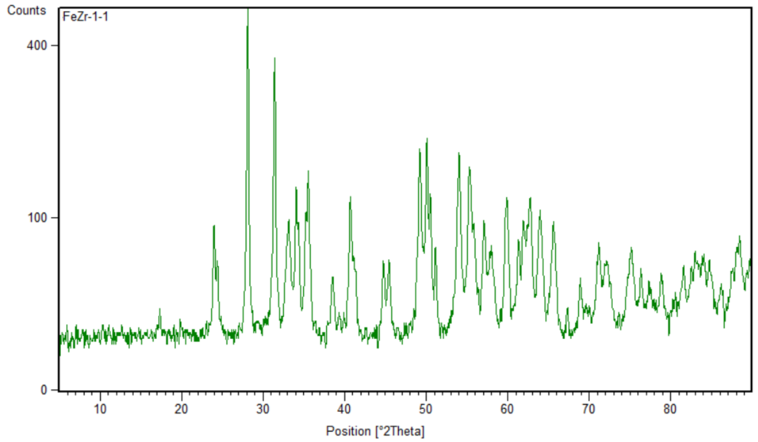
Acid catalysts

Bimetallic catalysts

Table 3. Catalysts synthesized

Solid	Composition (ICP)	BET (m^2/g)	Synthesis
$ZrFeO_x$ (100% *m*-ZrO_2)	1Zr:0.25Fe	82-110	Coprecipitation Calcination (air)
	1Zr:0.5Fe		
	1Zr:1Fe		
$FeVO_x$	2Fe:1V	21-45	Coprecipitation Calcination (air)
	1Fe:1V		
	0.5Fe:1V		
Fe(V)/$MgCaO_2$	20%Fe(or V)	15-35	Wet-impregnation Calcination (air)





Catalytic lignocellulose treatment (preliminary results)

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Reaction conditions: 0.1 g crushed waste, 20-40 % w/w catalysts, 5 mL H_2O, 2h, 120-140 ^oC

Table 4. Catalytic tests in the lignocellulose pretreatment using metal oxides as catalysts

Entry	Solid	Conversion (%)	Selectivity NVFA (%)	Selectivity VFA (%)	Selectivity Sugars (%)	Others	Catalyst recovery (%)
ZrFe	1Zr:0.25Fe	51	49	6	14	25	92-98
	1Zr:0.5Fe	58	41	5	20	24	
	1Zr:1Fe	61	38	4	19	30	
FeV	2Fe:1V	52	37	3	17	39	91-96
	1Fe:1V	60	37	3	24	30	
	0.5Fe:1V	65	38	4	32	21	
$MgCaO_2$	$MgCaO_2$	65	29	24	15	28	72
$Fe(V)/MgCaO_2$	$Fe/MgCaO_2$	72	26	22	19	28	92-98
	$Fe\text{-}V/MgCaO_2$	68	31	22	10	25	

Leaching!!

20% w/w catalyst, 120 ^oC. NREL techniques were used for the analysis of the reaction mixture

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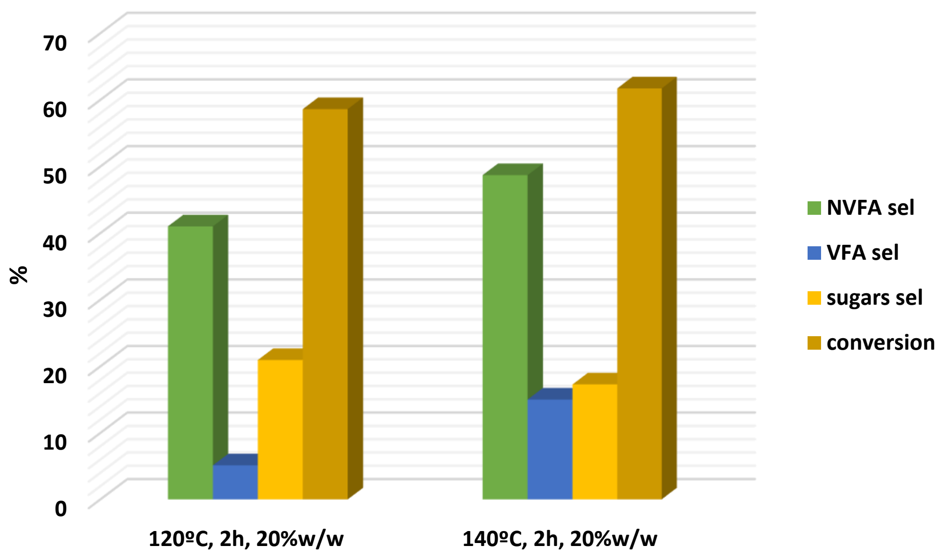
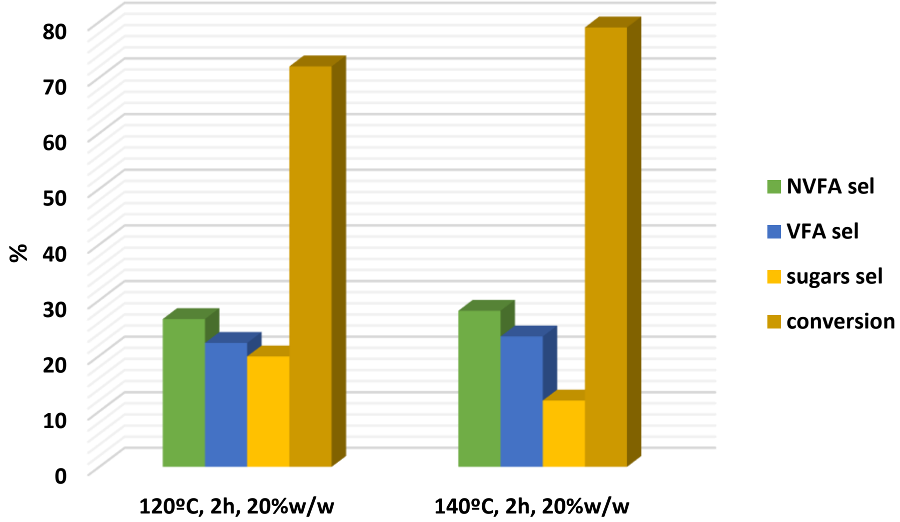
Catalytic lignocellulose treatment (preliminary results)

Optimizing conditions: Temperature

1Zr:0.25Fe

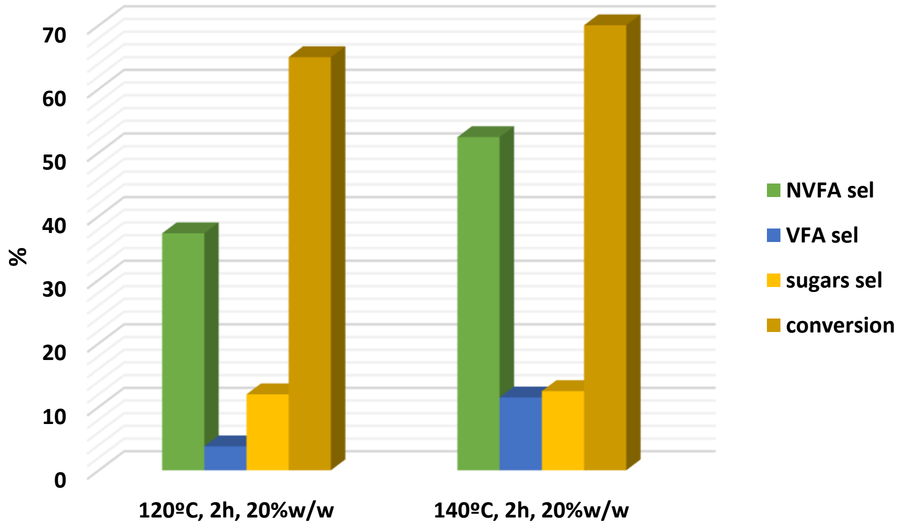


Fe/MgCaO$_2$



%oligomers increase

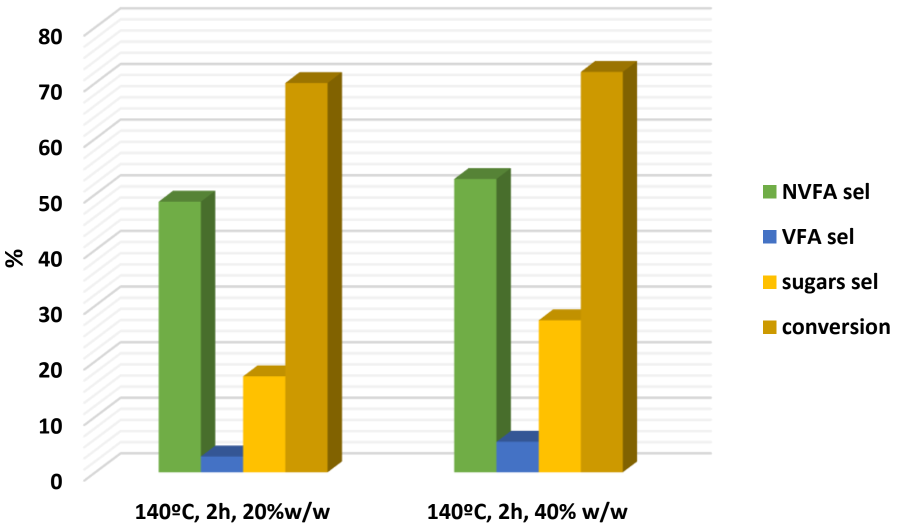
0.5Fe:1V



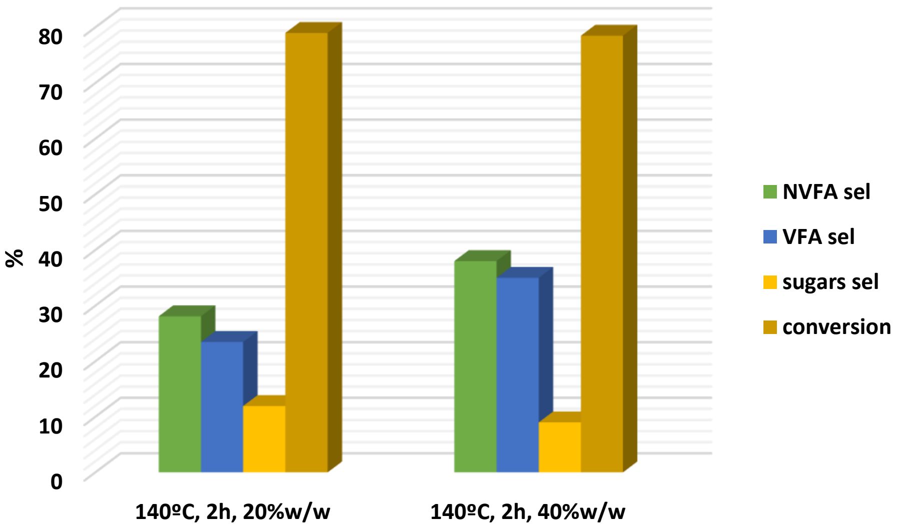
Catalytic lignocellulose treatment (preliminary results)

Optimizing conditions: Catalysts loading

1Zr:0.25Fe



Fe/$MgCaO_2$



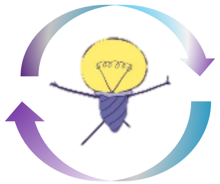
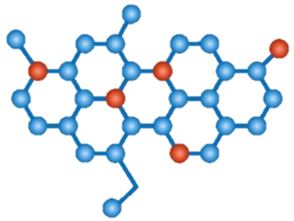
0.5Fe:1V

Conclusions

- Catalysts active on lignocellulose treatment were successfully synthesized and characterized
- Lignocellulose treatment was carried out with promising results
- High concentrations of NVFA and moderate of VFA were obtained

Future perspectives

- Finish the characterization of catalyst (basic/acid properties) and reaction condition optimization
- Scale up the best condition
- Biological valorization of the liquid effluent obtained (to PHA)
- Valorization of the solid effluent

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Grazie

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Thanks

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