Departamento de
Ingeniería Química

Valorization of Sludge Digestate and Biomass Wastes for the Electro-Generation of Hydrogen Peroxide

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ON SUSTAINABLE SOLID WASTE MANAGEMENT
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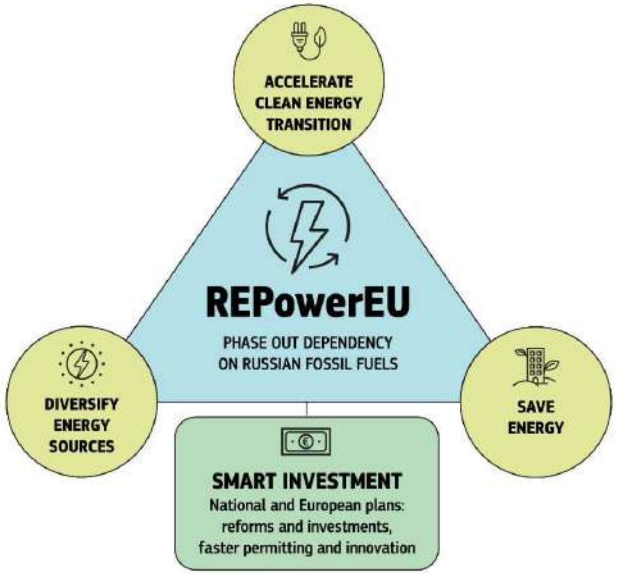
Paphos, 26th June 2024

Introduction

REPowerEU plan 2022



Reduce fossil fuel dependency — Ecological transition

Biomethane — 35 billion cubic meters by 2030

Digestate generation — 180 million metric tons annually

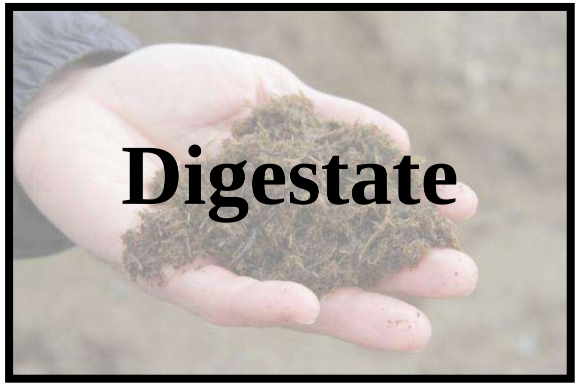
Introduction

Fertilizer for soil

Energy source

Environmental applications

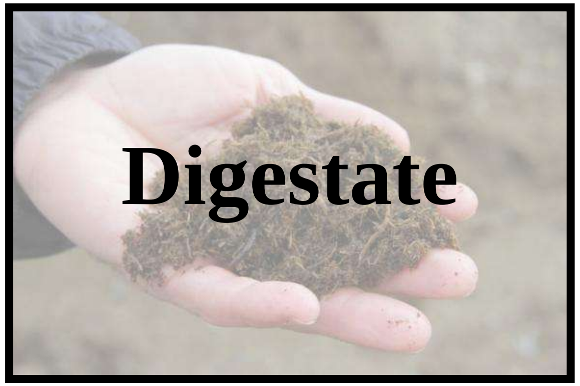
Electrochemistry

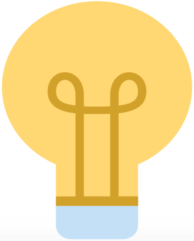


Introduction

Electrochemistry

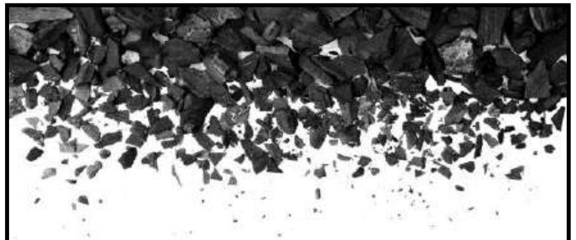
- Fuel cells
- MFCs
- Supercapacitors
- Electrochemical sensors





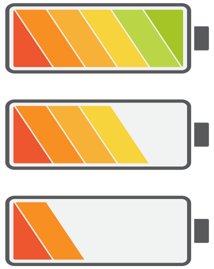
Limited research

Introduction



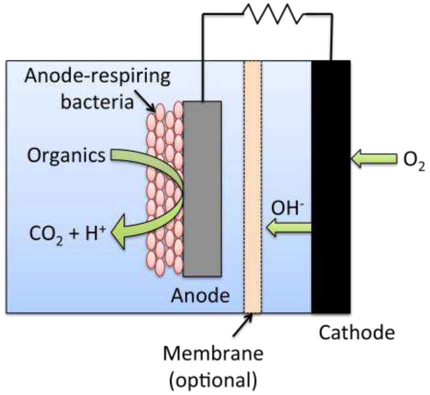
Agricultural residues

Energy storage

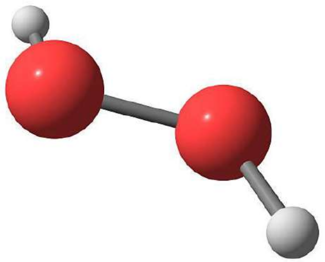


Hydrogen electrogeneration

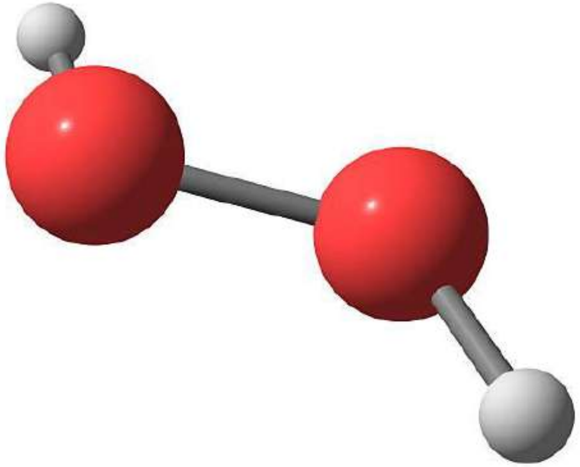
MFCs



H_2O_2

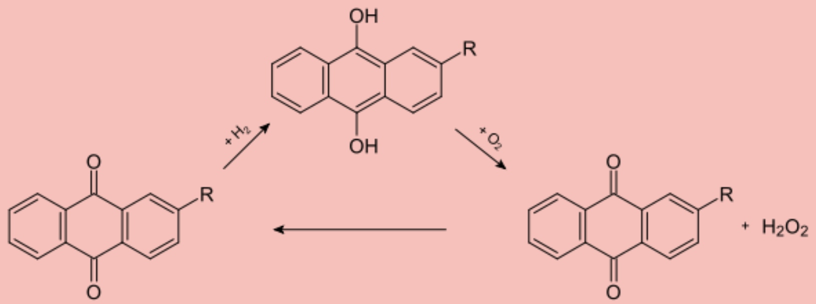


Introduction



1990	2020	2027
1.5	4.5	5.7

Millons tons/year



Anthraquinone process

$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$

Electrochemical generation

Introduction

Contents lists available at ScienceDirect
Electrochimica Acta
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Valorization of polluted biomass waste for manufacturing sustainable cathode materials for the production of hydrogen peroxide

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Contents lists available at ScienceDirect
Journal of Environmental Chemical Engineering
journal homepage: www.elsevier.com/locate/jece

Innovative carbon materials from lignocellulosic wastes for electrochemical hydrogen peroxide production: Bridging biomass conversion and material properties

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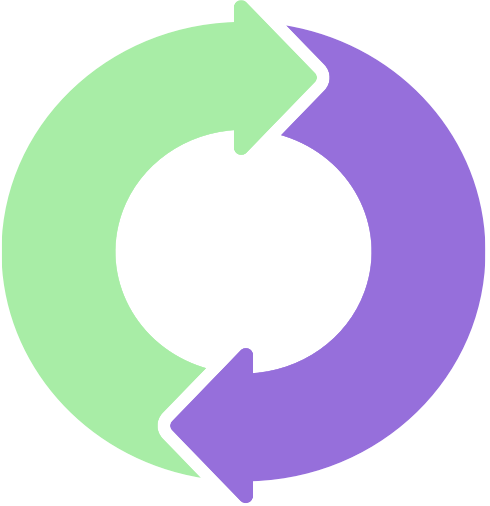
Spergularia rubra

Phragmites australis

Cladium mariscus

Typha domingensis

Objective



Study the capacity of digestate as a catalyst for the electrogeneration of H_2O_2

Digestate

+

Digestate + *Phragmites australis*

Methodology

Hydrothermal carbonization (HTC)

200 ºC / 2 h

- **D200**
- **PhA200**
- **H1:1**

Pyrolysis and chemical activation

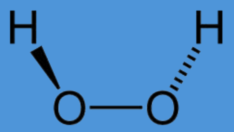
1000 ºC / 600 ºC KOH

- **D200-KOH**
- **H1:1-KOH**
- **H1:1-1000**

Electrode deposition

Immersion method

- Ultrasonic bath



Electrochemical generation of H_2O_2

- 2 h accumulation tests
- -0.9 V vs Ag/AgCl
- Aeration + stirring
- Undivided cell

Methodology

Physicochemical characterization

- EDS
- FTIR
- Raman
- N_2 adsorption isotherms
- HRSEM

Electrochemical characterization

- Linear sweep voltammetry (LSV)
- Chronoamperometry (CA)

Results

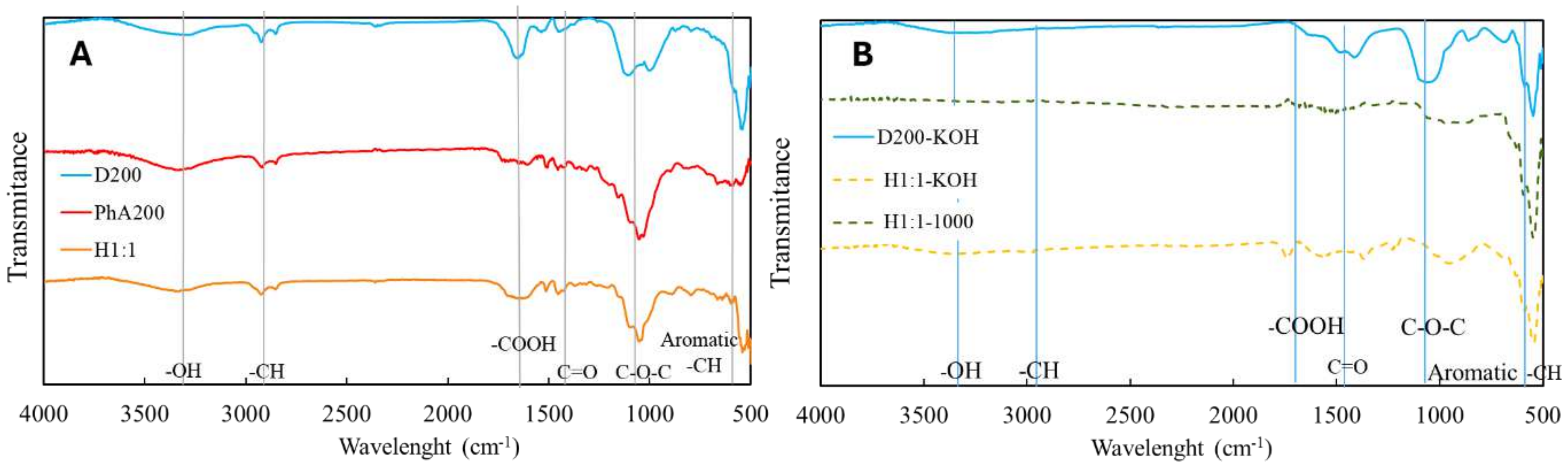
EDS

Parameters	PhA200	D200	H1:1	D200-KOH	H1:1-KOH	H1:1- 1000
C (% at)	70.73	52.97	67.10	38.63	53.89	76.72
O (% at)	29.22	33.62	24.93	36.23	26.60	12.78
Na (% at)	-		-	-	0.12	0.11
Mg (% at)	-	-	0.38	1.81	0.97	0.57
Al (% at)	0.02	0.89	0.56	2.06	1.98	0.66
Si (%at)	0.03	1.56	2.36	4.1	6.3	3.5
P (% at)	-	4.00	1.62	2.6	0.4	1.19
S (% at)	-	0.42	0.30	0.64	1.06	0.36
K (% at)	-	0.1	0.08	2.93	2.28	0.45
Ca (% at)	-	2.9	1.18	5.37	2.22	1.65
Ti (% at)	-	0.09	-	0.36	0.29	0.1
Fe (% at)	-	3.45	1.49	5.27	3.89	1.91

- ✓ Differences in C content
- ✓ Presence of Fe in simples with digestate

Results

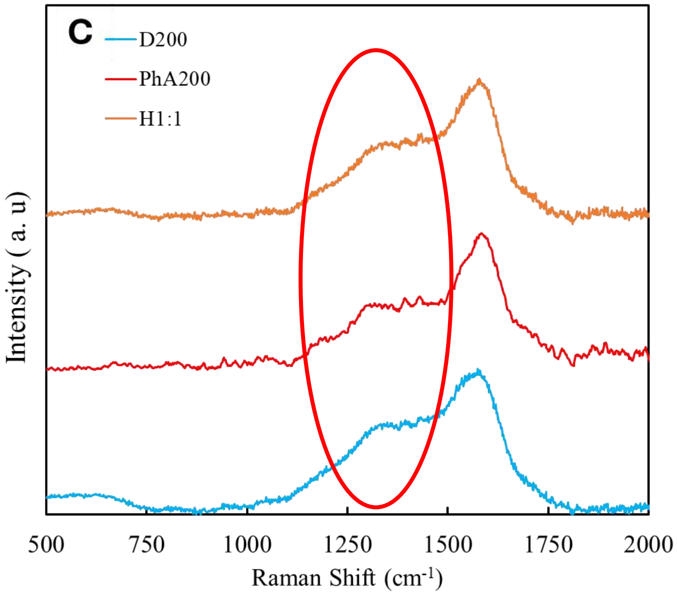
FTIR

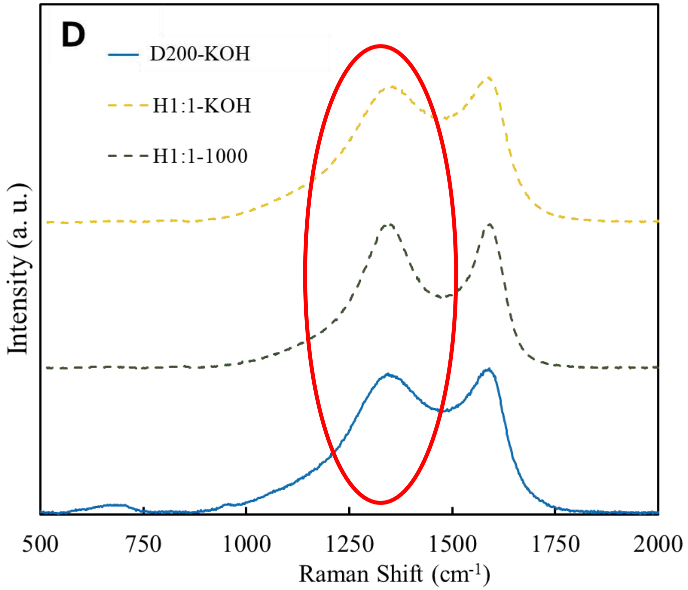


✓ Reduction of functional groups as the treatment temperature increases

Results

Raman



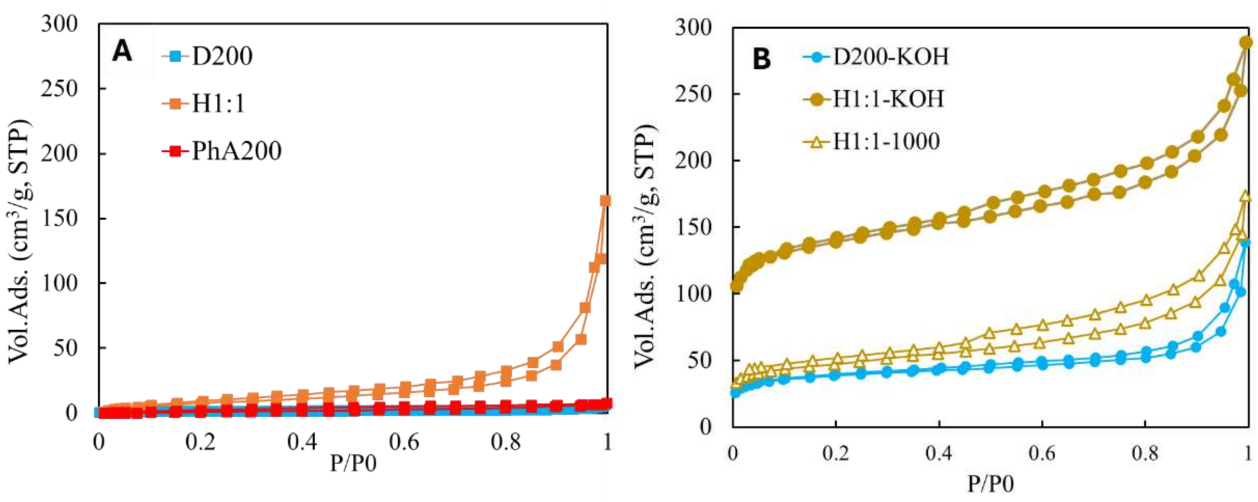


	D200	D200-KOH	PhA200	H1:1	H1:1-KOH	H1:1-1000
AD_1/AG	0.81	1.52	0.63	0.75	1.53	1.44

- ✓ Absent of possible defects and lack of sp^2 graphitic network ($AD_1/AG < 1$)
- ✓ D-band increase due to the growth of sp^2 domains in activated simples enhancing the defects ($AD_1/AG \approx 1.5$)

Results

N_2 adsorption isotherms

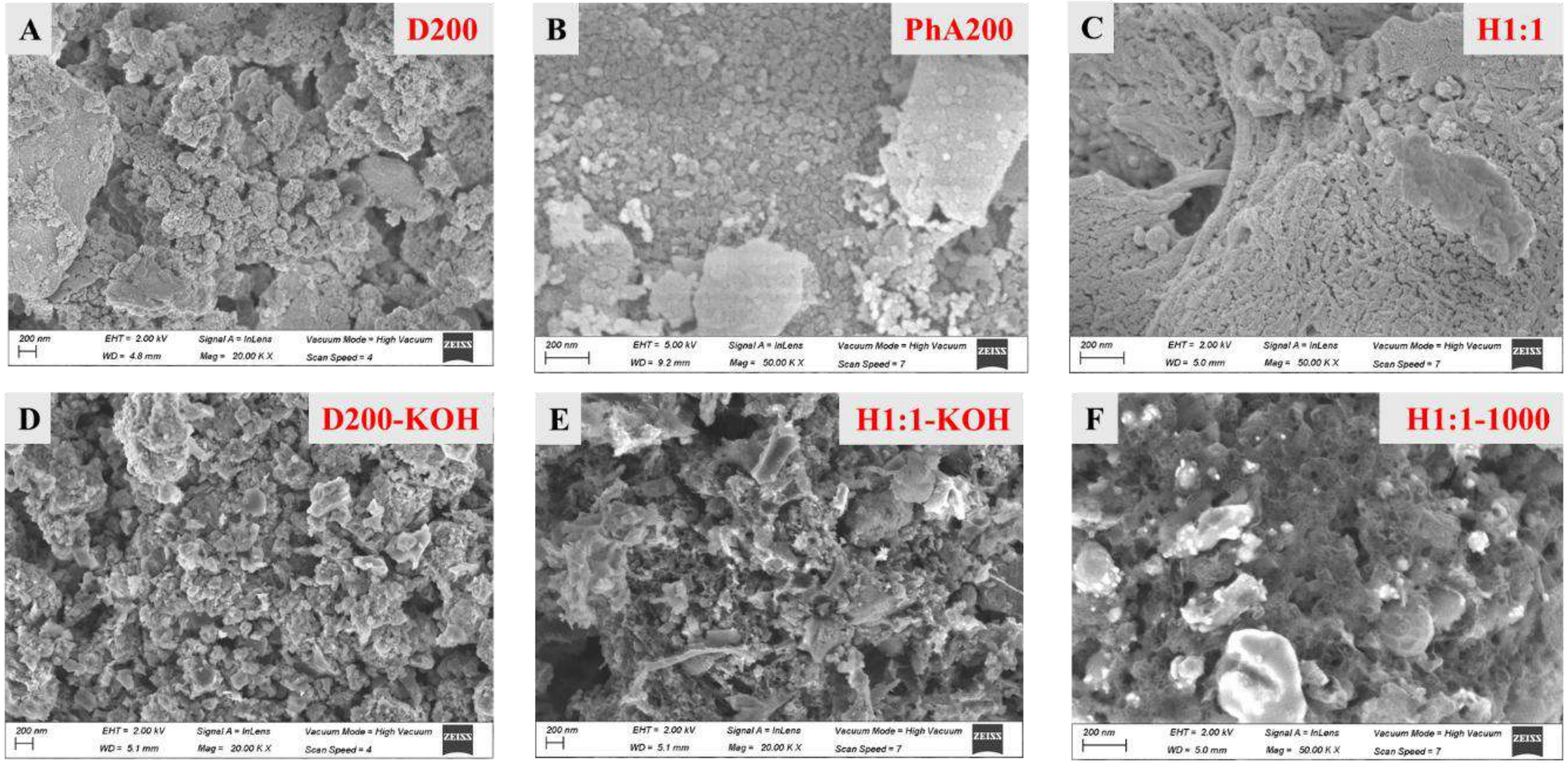


	D200	D200-KOH	PhA200	H1:1	H1:1-KOH	H1:1-1000
Specific Surface area (m^2/g)	5	142	14	31	525	174

- ✓ Lower surface area when chemically activating the digestate compared to *Phragmites australis*
- ✓ Higher termal stability for digestate (inorganic compounds in its structure)

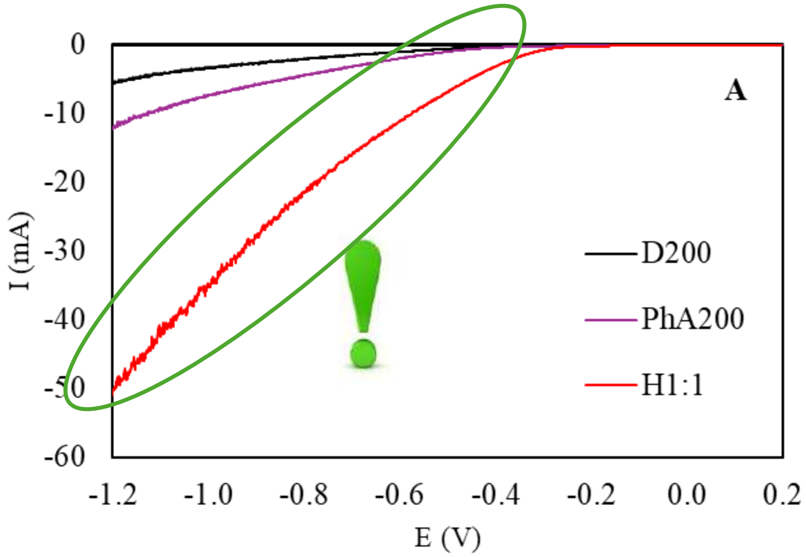
Results

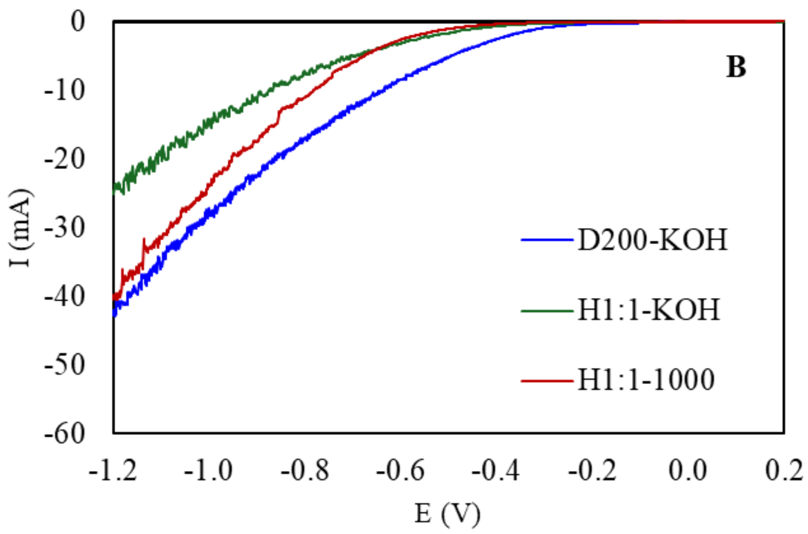
HRSEM



Results

LSV



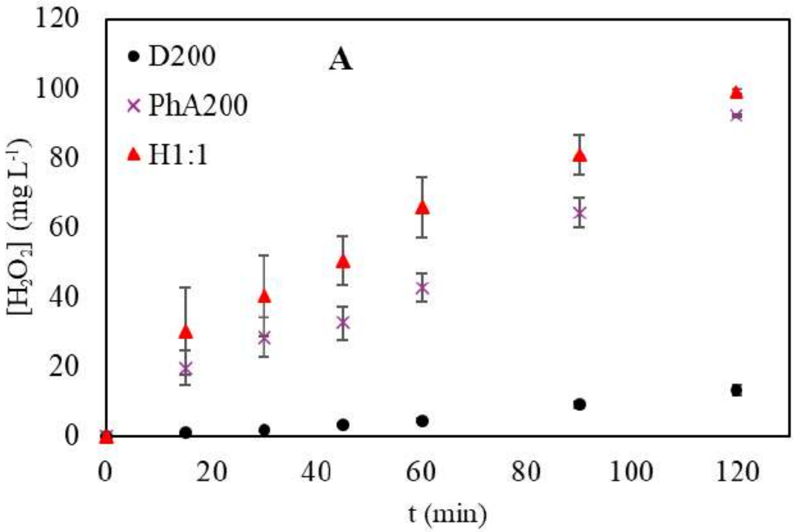


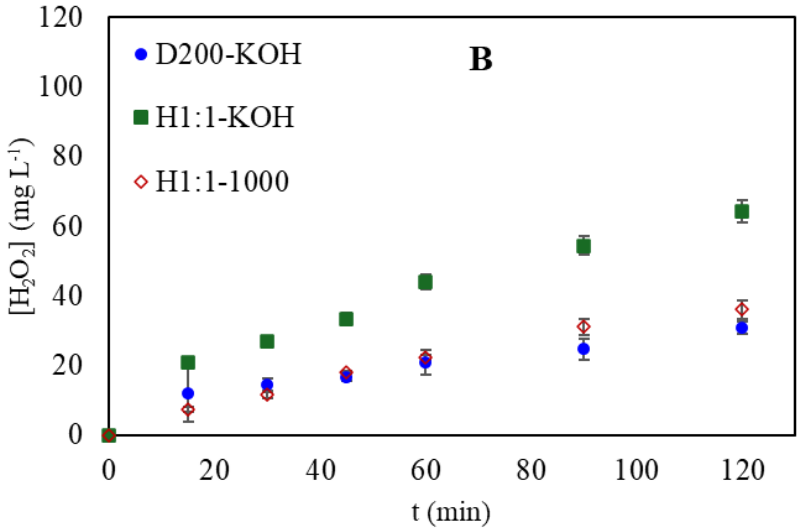
- ✓ Synergy between digestate and *Phragmites australis* in H1:1
- ✓ Lower intensities for the activates samples

Results

CA

- 9 cm^2 cathodes
- -0.9 V vs Ag/AgCl
- Undivided cell
- Constant aeration and stirring
- 0.05 M Na_2SO_4 electrolyte





✓ Poor results from D200. Good results when combined with *Phragmites australis* (H1:1)

✓ Better results for the hydrochars than for the activated samples ⇨ Presence of Fe in the digestate

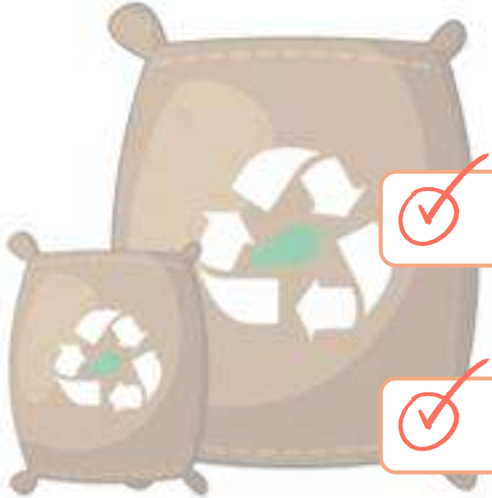
Results

CA

- 9 cm^2 cathodes
- -0.9 V vs Ag/AgCl
- Undivided cell
- Constant aeration and stirring
- 0.05 M Na_2SO_4 electrolyte

	FE (%)	EC (kWh $kgH_2O_2^{-1}$)
PhA200	100	4.2
H1:1	72	5.6
D200-KOH	56	7.0
H1:1-KOH	59	6.6
H1:1-1000	30	11.5

Conclusions



- Feasibility of using digestate for synthesizing carbonaceous catalysts
- Better performance of the digestate-*Phragmites australis* mixture Hydrochar (H1:1)
- Worst behaviour from activated materials
- Possibility of studying new digestate-*Phragmites australis* ratios

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THANK YOU

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