

Interreg
Caraïbes



Fonds européen de développement régional

SARG'COOP
Programme caribéen de coopération de
lutte contre les algues sargasses

Recycling of sargassum for activated carbon production

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ACTIVATED CARBON ?

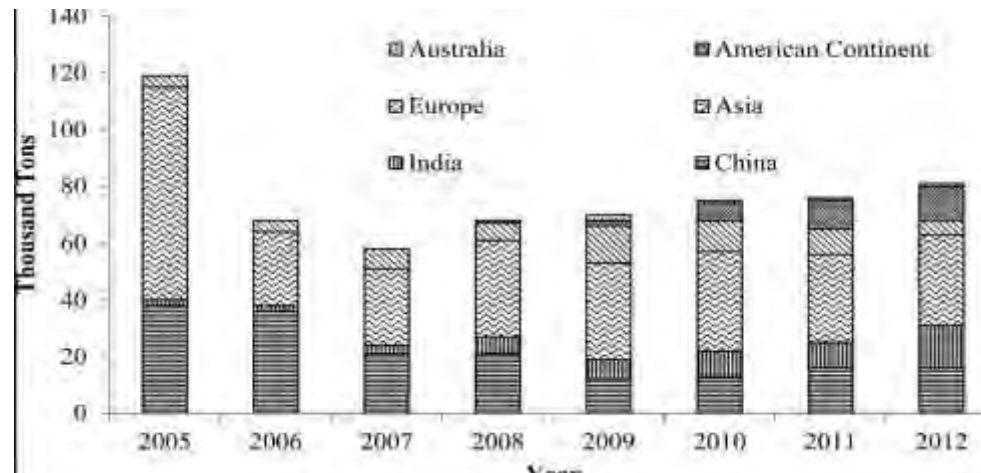
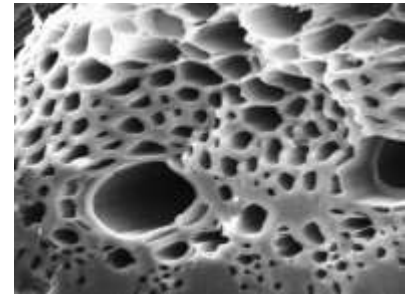
Carbon material

Previously produced from mineral carbon
Nowadays mainly produced from biomass
(mostly from coconut)
Porous material



Many applications

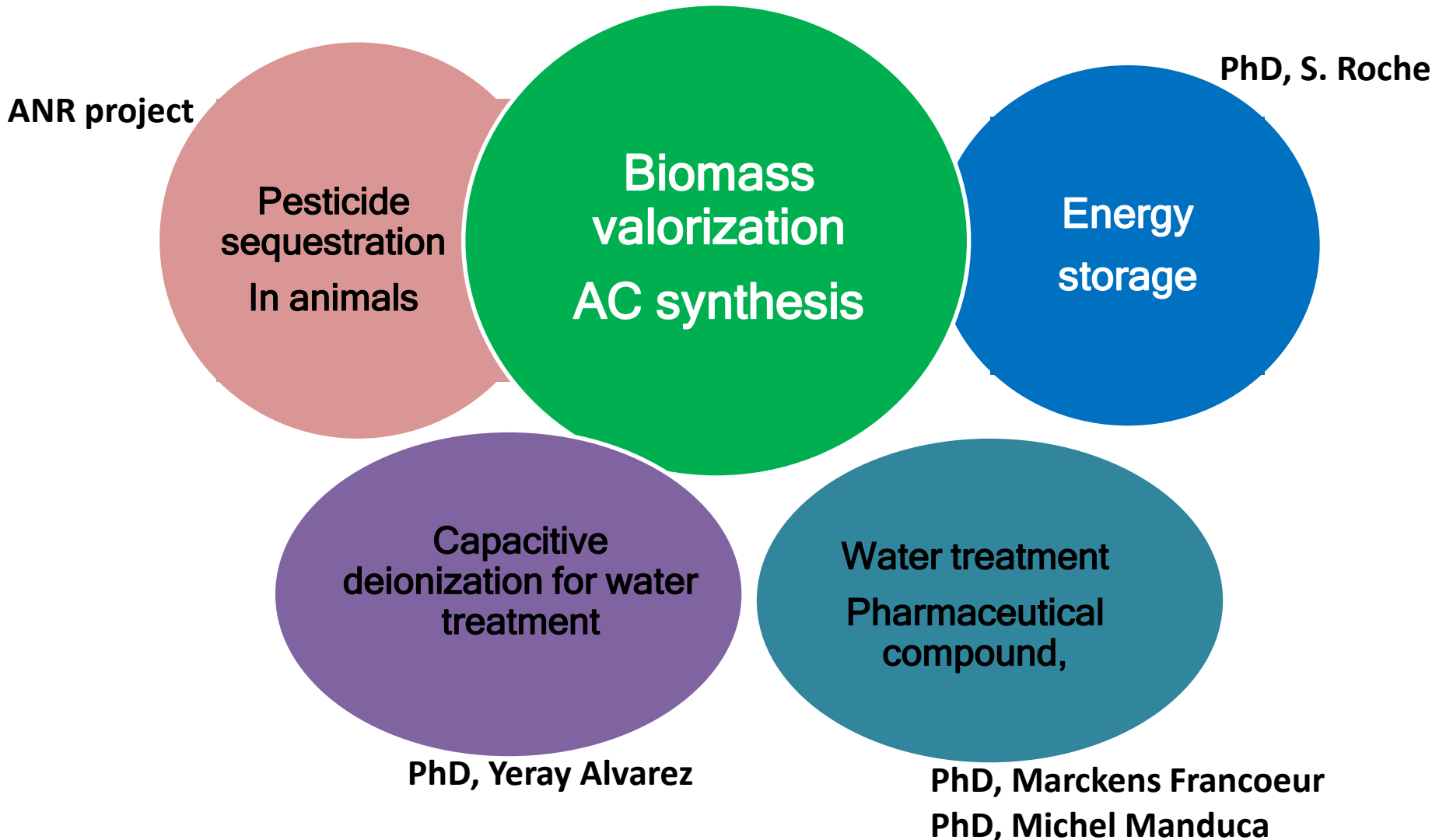
Water, air treatment, Food processing
Pharmaceutical applications, energy storage



Annual needs
1.9 Mio Tons

COVACHIMM2E

BIOMASS VALORIZATION FOR REMEDIATION AND ENERGY STORAGE



WHY PRODUCING CARBON MATERIAL FROM ALGA FOR CARBON MATERIAL PRODUCTION

Due to their chemical composition, seaweeds are fantastic precursors for nanotextured carbons preparation. Depending of pyrolysis conditions, oxygen enriched carbons, with tuned micro/mesoporosity can be obtained.



Natural
Carbon
source

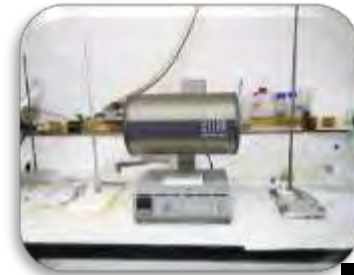
High chemical
variety

Highly available
and cheap

HOW TO PREPARE ACTIVATED CARBON ?

Fabrication

- ✓ pyrolysis
- ✓ Physical activation
- ✓ Chemical activation
- ✓ Hydrothermal carbonization



BIOCHAR

Precursor



Pyrolysis

500 - 700°C

Activation (H_2O , CO_2)

Physical activation

Chemical Impregnation (ac. Phos) + pyrolysis

Chemical activation

hydrothermal carbonization+ imprégnation + pyrolysis

HTC

**ACTIVATED
CARBON**

**ACTIVATED
CARBON**

a

CARBON ELECTRODES FOR SUPERCAPACITORS



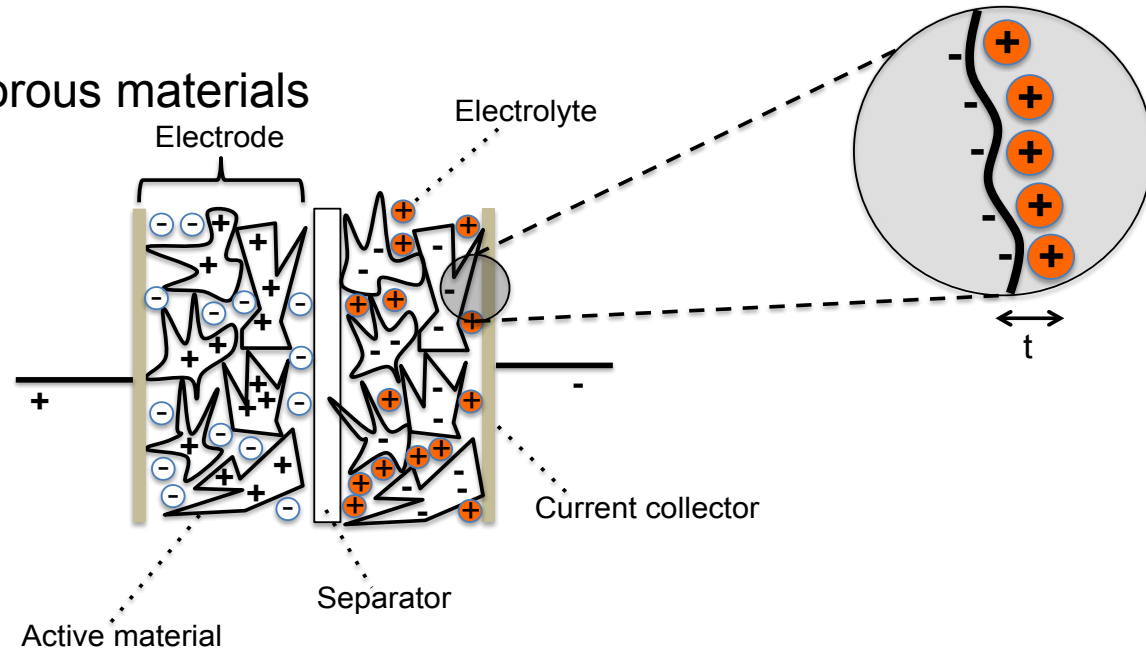
Batteries : called also electrochemical capacitors

Able to store and release energy in a short time (few seconds)

Used for electric vehicles, tramways, wind turbines, computers, for ex..

Supercapacitors are composed of:

- Electrode made of Highly porous materials
- such as carbon materials
- A separator
- An electrolyte



By applying a potential: positive charges remain on one plate, and negative charge on the other plate = charged state

During discharge: negative and positive charges are released

Preparation of precursors

- Collect of pelagic sargassum
- Drying
- Crushed and sieved

Preparation of sample CS600, CS700, CS800, CS900

- **Pyrolysis** ;
- $600^{\circ} \leq T^{\circ} \leq 900^{\circ}$

Preparation of sample CSN

- **HTC**
- $180^{\circ} < T < 250^{\circ}\text{C}$
- activation

Characterisation

- Chemical composition
- Textural parameters
- Electrochemical measurement

Carbon sample characterization

- **Textural characteristics**

- Nitrogen adsorption
- BET surface area
- Porous Volume

- **Surface chemistry**

- Xray photo-électron spectroscopy
- Elemental Analysis
- Surface fonctionnal groups

- **Electrochemical properties**

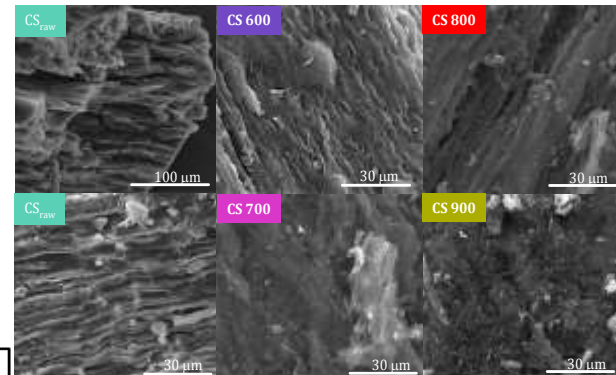
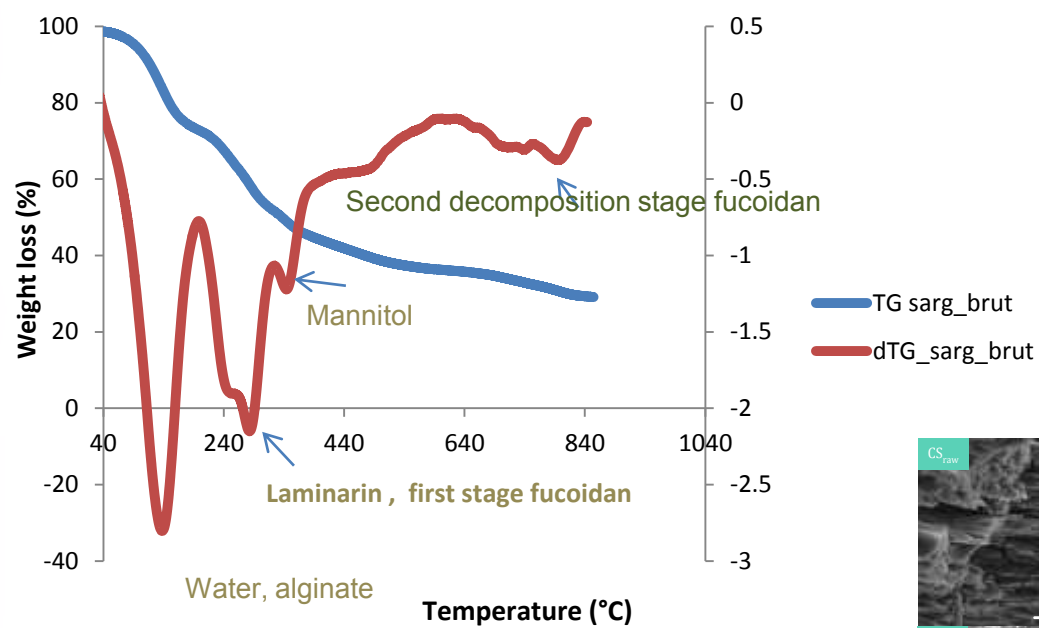
- Cyclic voltametry
- Galvanometry measurement



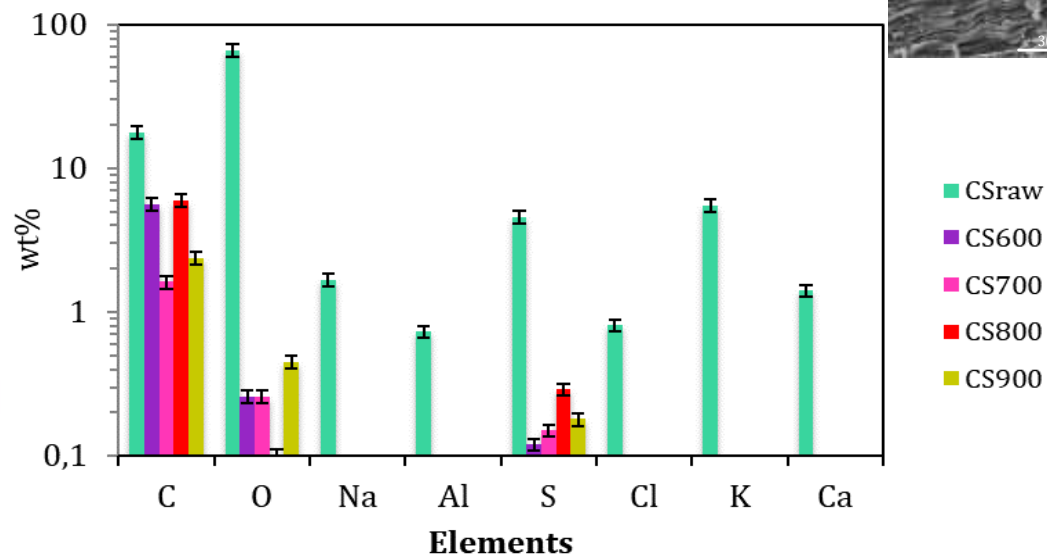
- Adsorption studies**

- kinetic
- Isotherm

Thermogravimetric analysis of Sargassum



EDX Analysis

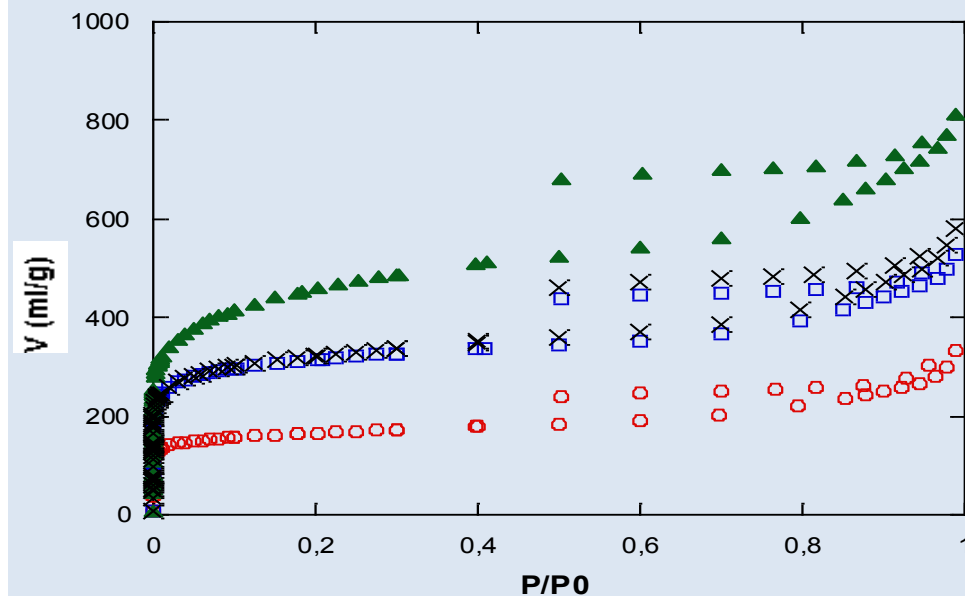


surface elemental composition obtained by XPS analysis

Atom	CS600	CS700	CS800	CS900
O 1s (%)	7.98	10	4.54	2.76
C 1s (%)	91.57	87.16	93.68	96.33
C2p (%)	nd	nd	nd	0.32
S 2p	nd	0.75	1.78	0.59
Si 2p	0.5	1.19	nd	nd
N 1s	nd	0.71	nd	nd
O/C	0.09	0.12	0.05	0.03

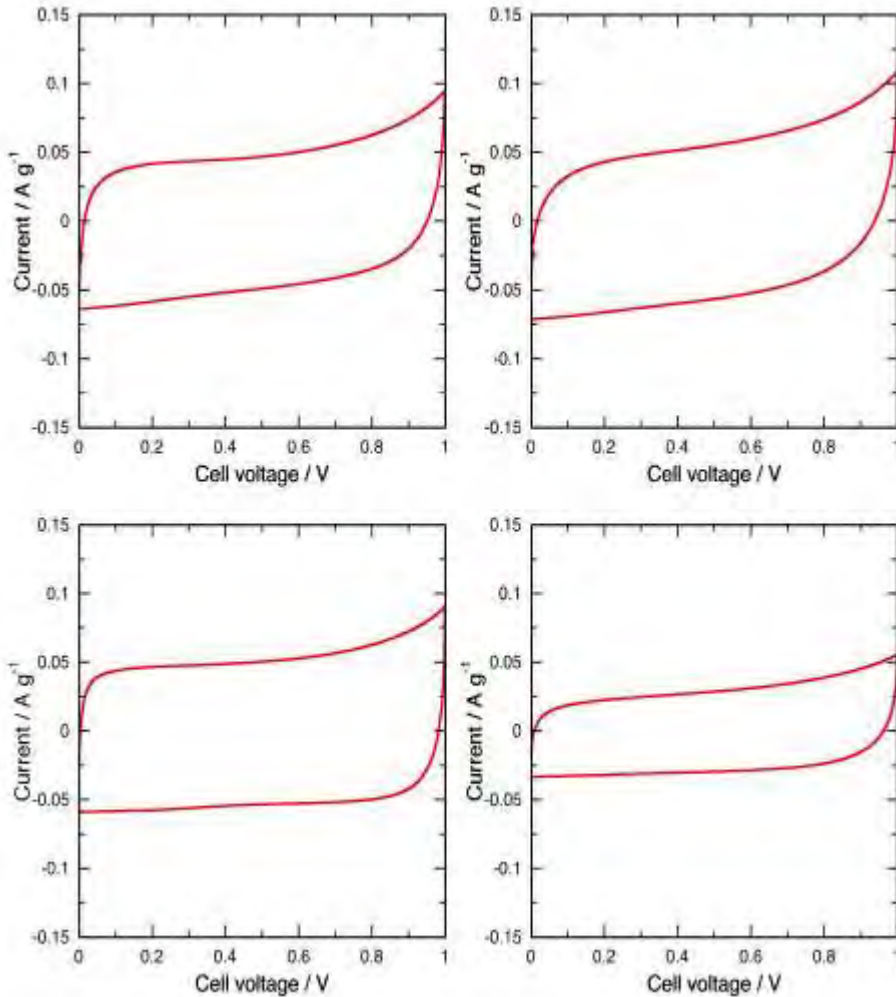
- The carbon samples contain different heteroatoms, O, Si,
- CS900 samples contain higher amount of oxygen
- CS700 samples contain higher amount of oxygen
- CS600 et CS700 contain Si
- CS700 and CS800 samples contain sulfur

Textural analysis

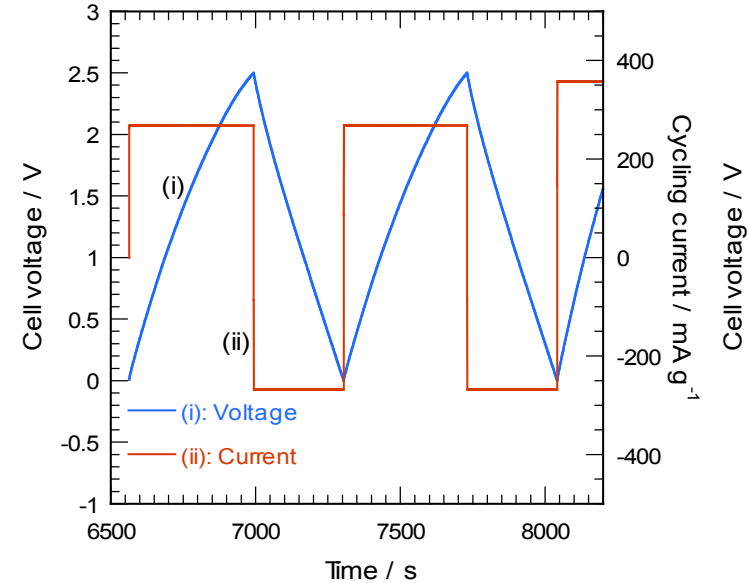


Carbon	Specific surface area (m ² /g) (with BET)	Mesopore Volume (cm ³ /g)	V _{micropore} (cm ³ /g)	% of micropore	Mean pore diameter (nm)
CS600	621	0.32	0.19	37.2	2.49
CS700	1179	0.51	0.39	43.3	2.32
CS800	1664	0.91	0.58	26.2	2.54
CS900	1199	0.60	0.39	39.4	2.44
CSN	1553	-	-	-	3.94*

Electrochemical study cyclic



- Rectangular shape: capacitive behaviour
- No faradic reactions
- CS 700, CS 800, have the better shapes



Charge/discharge galvanostatic cycling at 2.5 V of the seaweed carbon supercapacitor

Cyclic voltammograms of symmetric two-electrode capacitors (Roche et al, submitted)

Electrochemical results

Samples	Capacitance (F/g)	Electrolyte
CS600	84,4	1mol.L ⁻¹ H ₂ SO ₄
CS700	83,7	1mol.L ⁻¹ H ₂ SO ₄
CS800	95,1	1mol.L ⁻¹ H ₂ SO ₄
CS900	47,8	1mol.L ⁻¹ H ₂ SO ₄
CSN	141,78	6M KOH

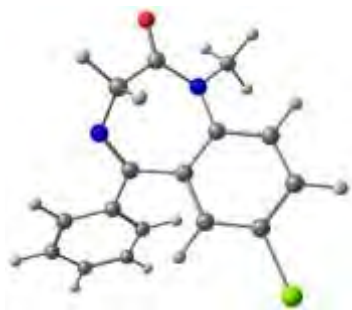
- For CSN a higher capa and CT samples optimal temperature is 800°C
- Higher capacitance, lower resistance

Material	Capacitance (F g⁻¹)	BET surface area (m² g⁻¹)	Electrolyte
Cassava peel	153	1352	H ₂ SO ₄
Coffee shells	150	842	KOH
Cherry stones	232	1292	H ₂ SO ₄
Bamboo	68	1251	H ₂ SO ₄ , KOH
Fir wood	197	2821	H ₂ SO ₄
Banana fiber	74	1079	Na ₂ SO ₄
Rubber Wood Saw Dust	138	912	H ₂ SO ₄
Argan (Argania spinosa)	259-355	2100	H ₂ SO ₄

Compared physical properties and electrochemical properties of different carbonized biomass precursors (Gaspard & Taberna, in Biomass for sustainable applications, RSC book series)

- **Our values are similar to those obtained in the literature for lignocelulosic precursors**

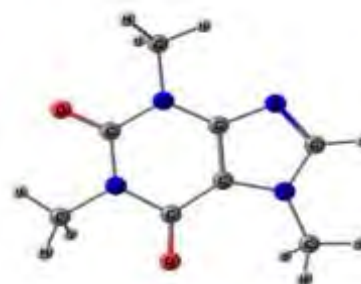
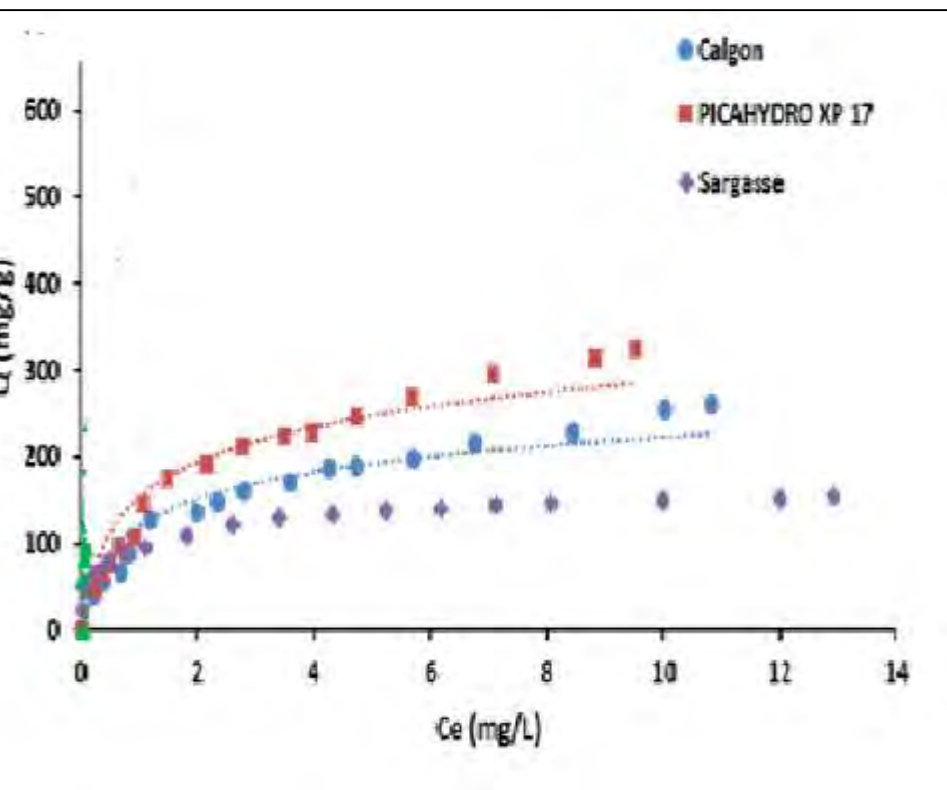
Treatment of water contaminated with micropollutant pharmaceutical Compounds, diazepam, caffeine



Diazepam

PhD M. Manduca

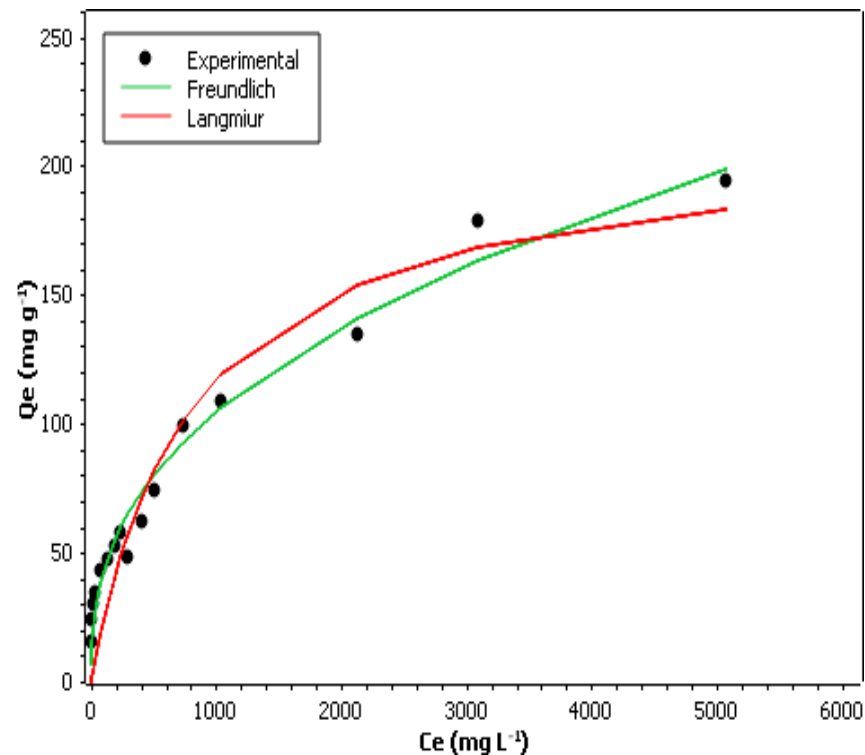
$$Q_{\max}(\text{mg g}^{-1}) = 190 \text{ mg/g}$$



Caffeine

PhD M. Francoeur

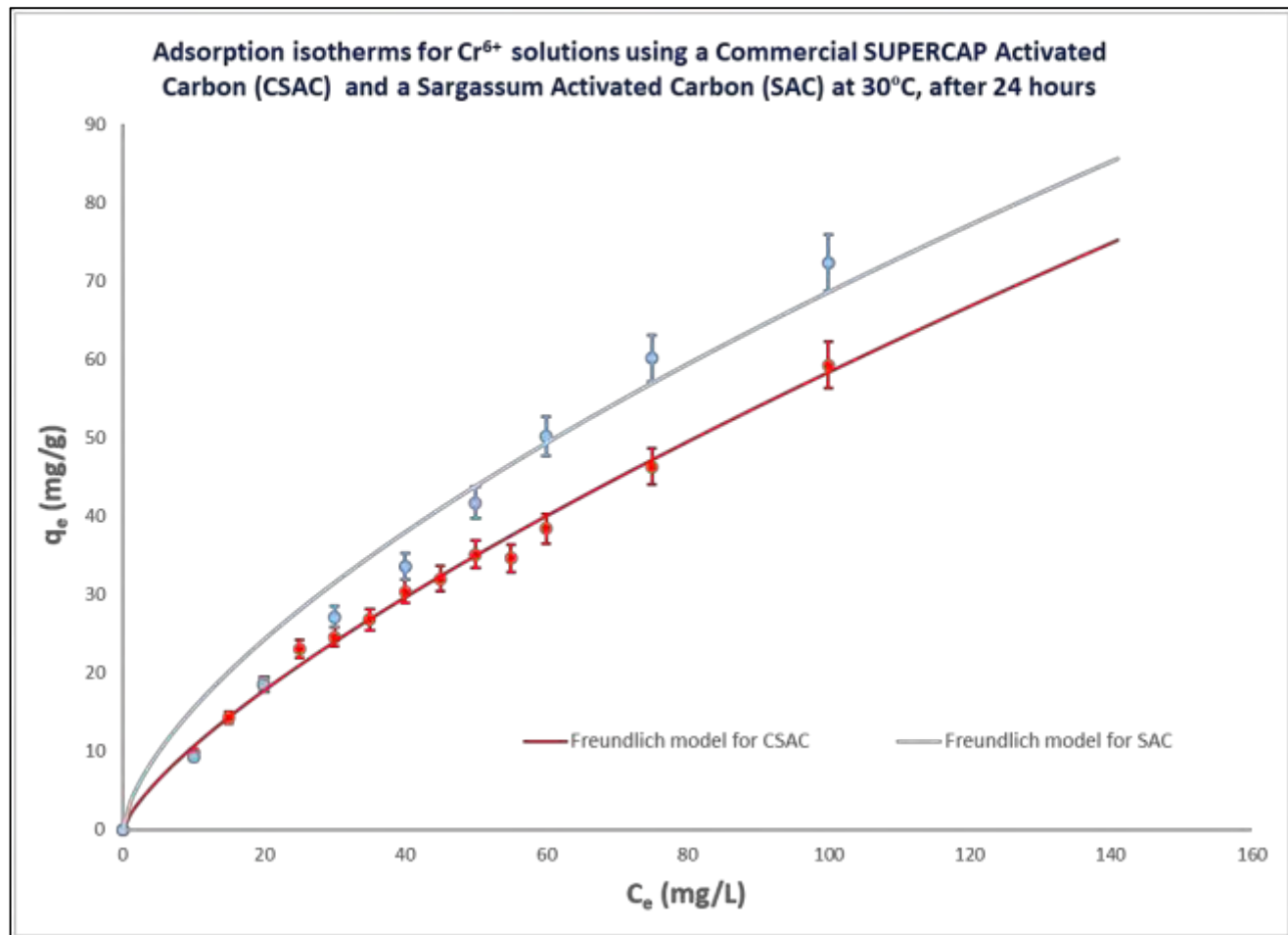
$$Q_{\max}(\text{mg g}^{-1}) = 212 \text{ mg/g}$$



Chromium adsorption

$$Q_{\max}(\text{mg g}^{-1}) = 57 \text{ mg/g}$$

PhD Y. Alvarez



CONCLUSION

AC can be prepared from sargassum by different procedure

Sargassum AC has good electrochemical properties

Sargassum AC has good adsorptive properties for organic compounds and chromium



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**THANK YOU FOR YOUR
ATTENTION**