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

Recycling of sargassum for activated carbon production

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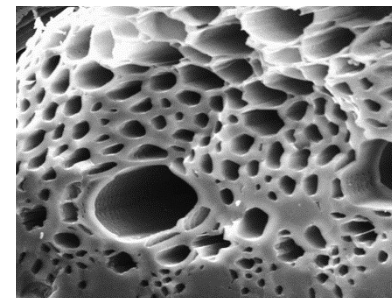
ACTIVATED CARBON ?

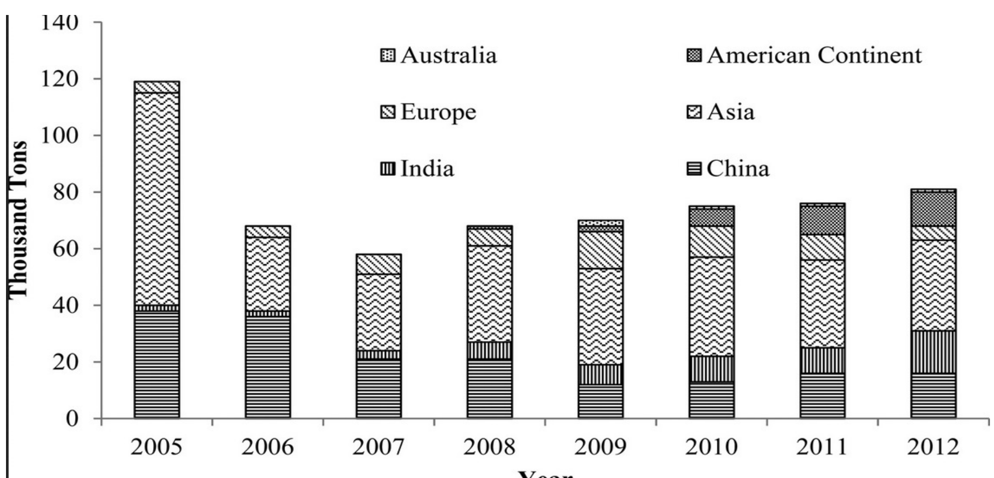
Carbon material

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

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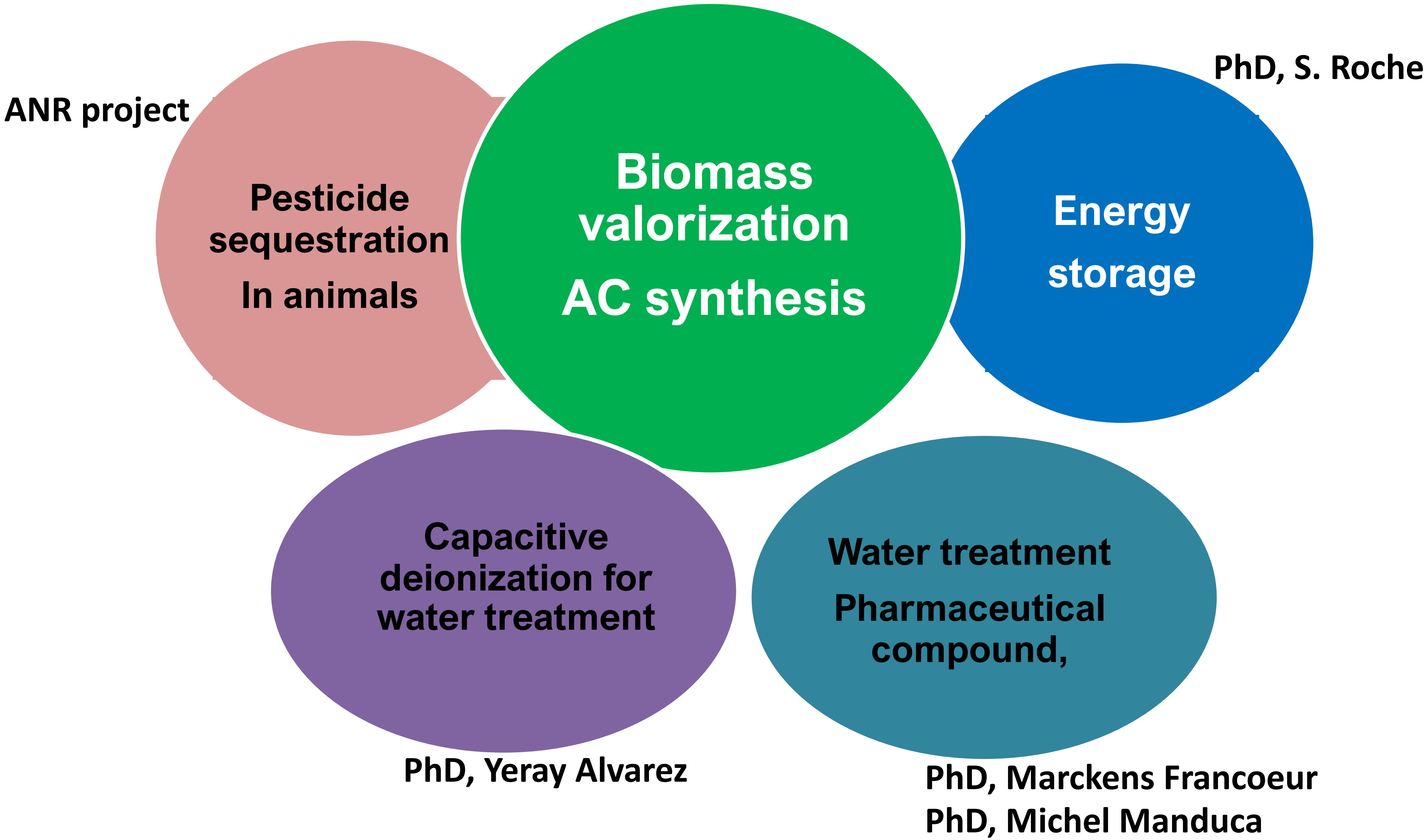
BIOMASS VALORIZATION FOR REMEDIATION AND ENERGY STORAGE



WHY PRODUCING CARBON MATERIAL FROM ALGA FOR CARBON MATERIAL PRODUCTION

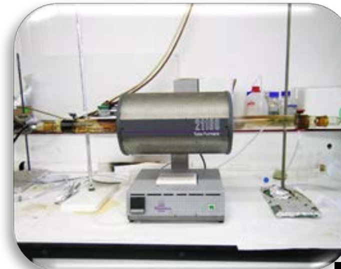
Due to their chemical composition, seaweeds are fantastic precursors for nanotextured carbons preparation. Depending of pyrolysis conditions, oxygen enriched carbons, with tuned micro/mesoporosity can be obtained.

- **Natural Carbon source**
- **High chemical variety**
- **Highly available and cheap**

HOW TO PREPARE ACTIVATED CARBON ?

Fabrication

- ✓ pyrolysis
- ✓ Physical activation
- ✓ Chemical activation
- ✓ Hydrothermal carbonizatin



BIOCHAR

Pyrolysis

Precursor

500 - 700°C

Activation (H_2O, CO_2)

ACTIVATED CARBON

Physical activation

Chemical Impregnation (ac. Phos) + pyrolysis

a

Chemical activation

ACTIVATED CARBON

hydrothermal carbonization+ imprégnation + pyrolysis

HTC

CARBON ELECTRODES FOR SUPERCAPACITORS

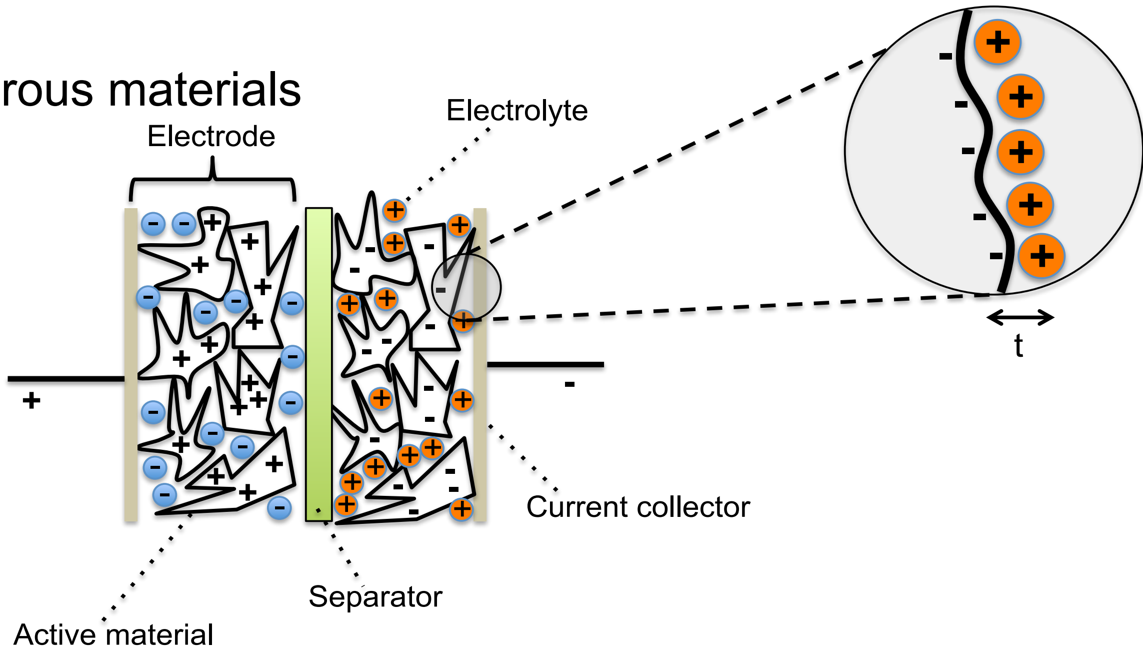
Batteries : called also electrochemical capacitors

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

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

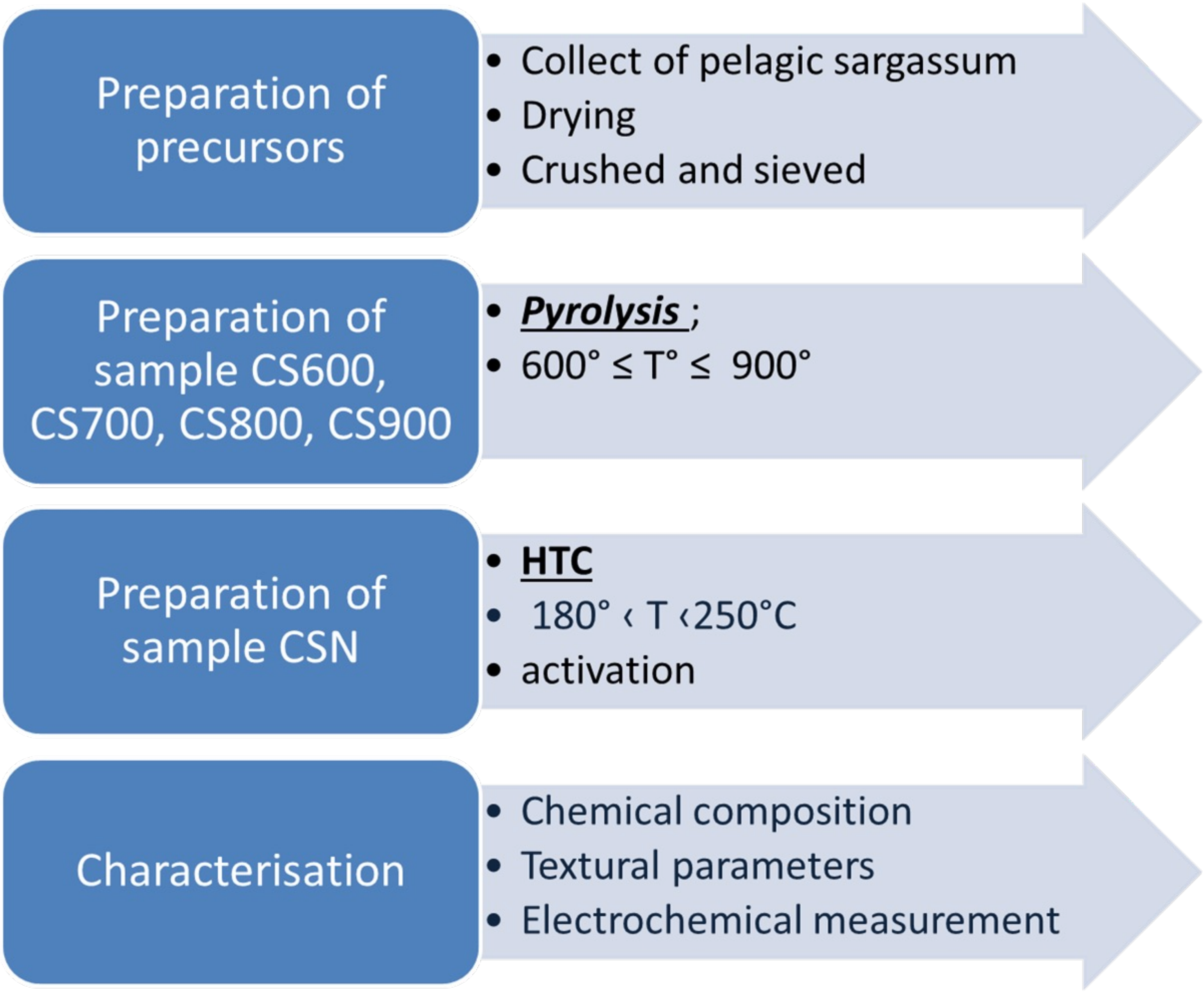
Supercapacitors are composed of:

- 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

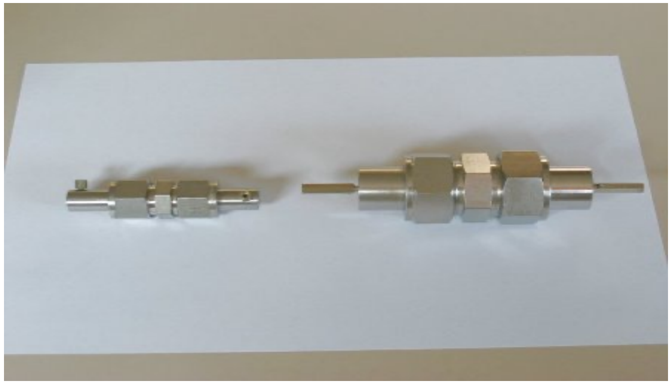

Preparation of precursors
• Collect of pelagic sargassum
• Drying
• Crushed and sieved
Preparation of sample CS600, CS700, CS800, CS900
• Pyrolysis ;
• 600° ≤ T° ≤ 900°
Preparation of sample CSN
• HTC
• 180° ‹ T ‹250°C
• activation
Characterisation
• Chemical composition
• Textural parameters
• Electrochemical measurement

Carbon sample characterization

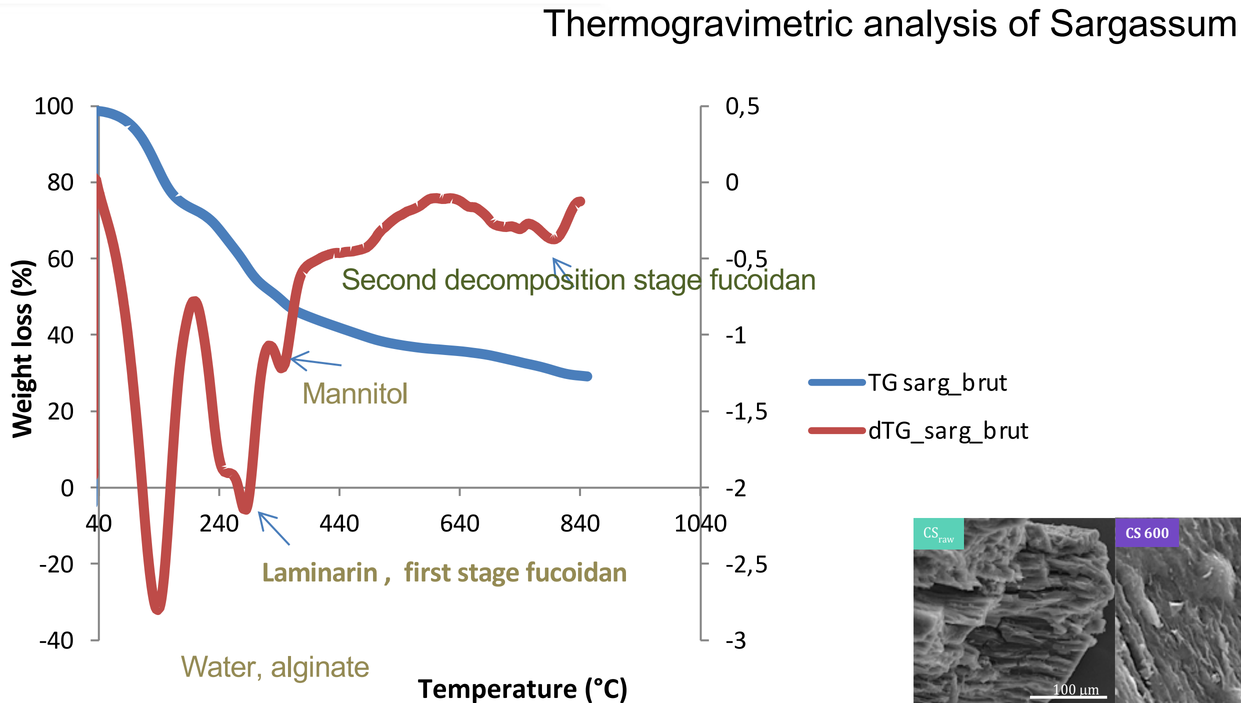
- **Textural characteristics**
  - Nitrogen adsorption
  - BET surface area
  - Porous Volume

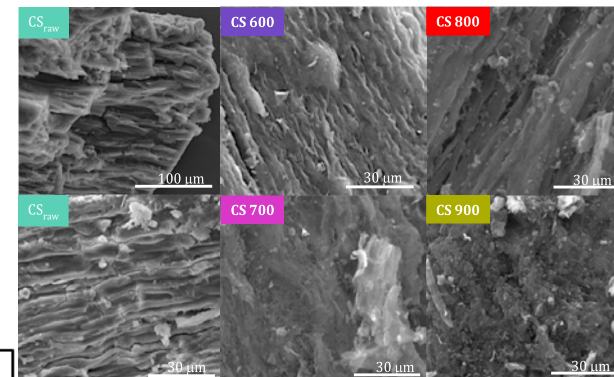
- **Surface chemistry**
  - Xray photo-électron spectroscopy
  - Elemental Analysis
  - Surface functionnal groups

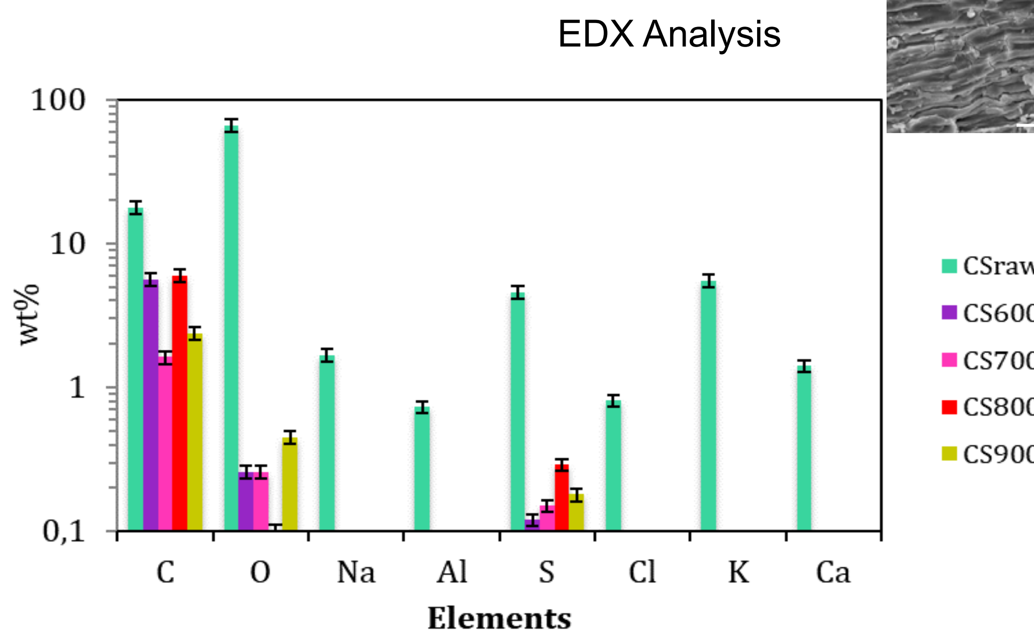
- **Electrochemical properties**
  - Cyclic voltametry
  - Galvanometry measurement



- **Adsorption studies**
  - kinetic
  - Isotherm


Thermogravimetric analysis of Sargassum
Weight loss (%)
100
80
60
40
20
0
-20
-40
0,5
0
-0,5
-1
-1,5
-2
-2,5
-3
40
240
440
640
840
1040
Temperature (°C)
Second decomposition stage fucoidan
Mannitol
Laminarin , first stage fucoidan
Water, alginate
TG sarg_brut
dTG_sarg_brut


CSraw
CS 600
CS 800
CSraw
CS 700
CS 900
100 µm
30 µm
30 µm
30 µm
30 µm
30 µm

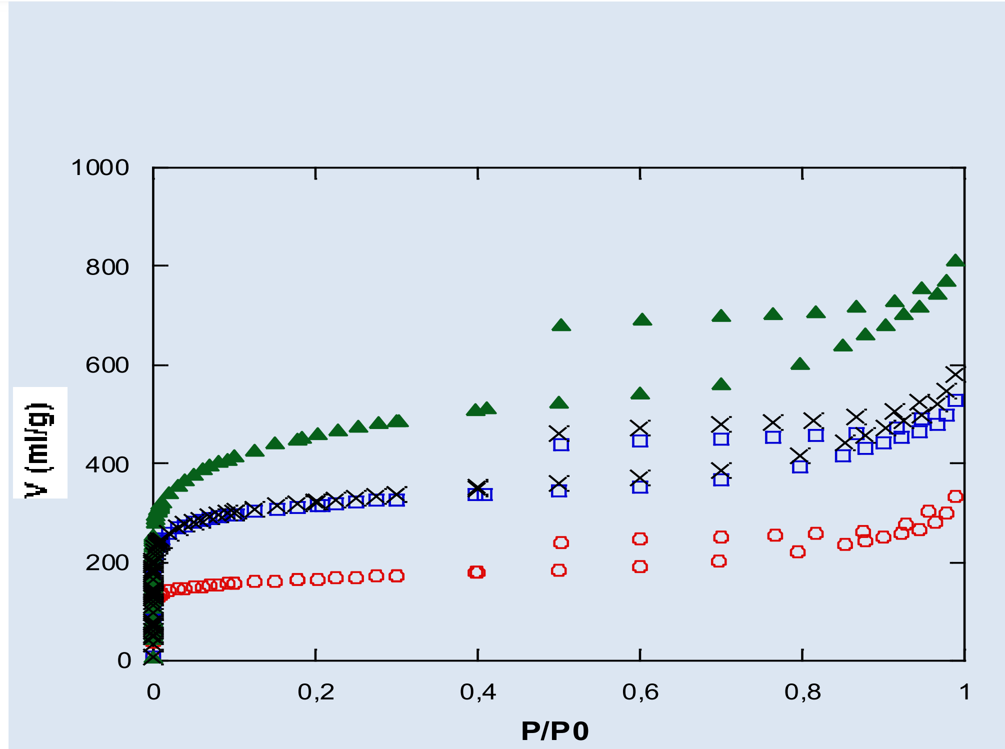

EDX Analysis
wt%
100
10
1
0,1
C
O
Na
Al
S
Cl
K
Ca
Elements
CSraw
CS600
CS700
CS800
CS900

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

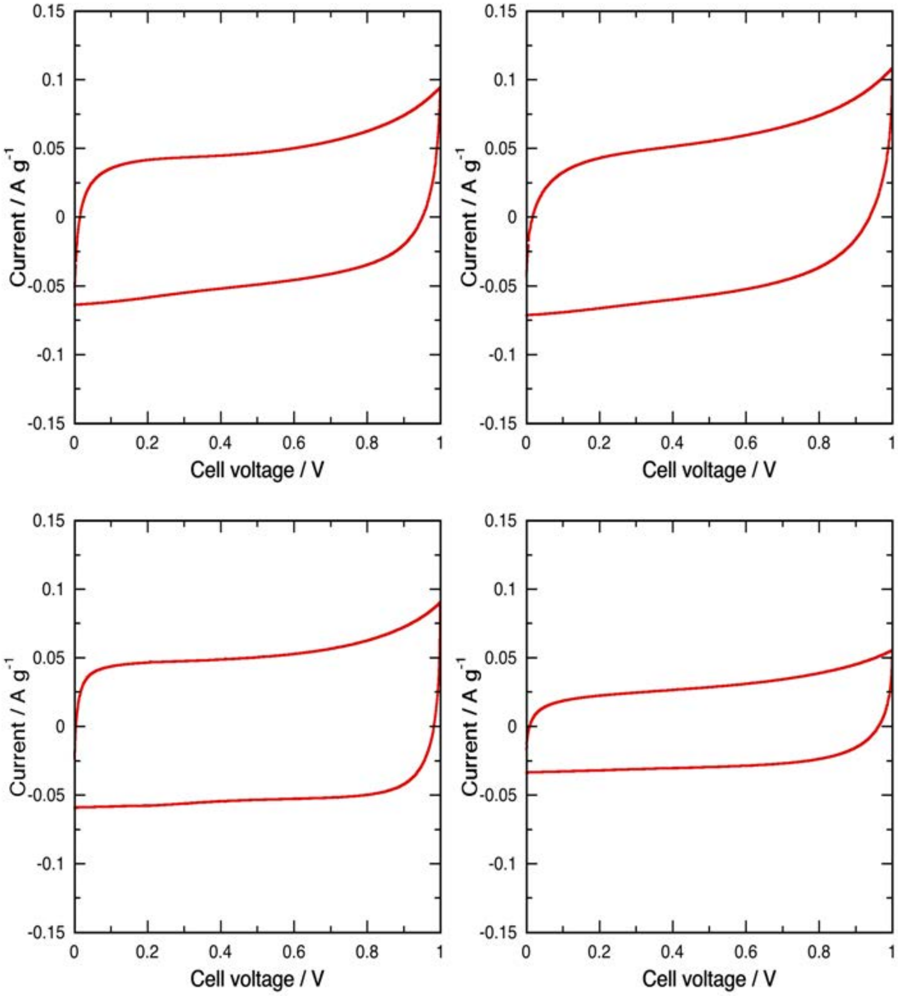
- The carbon samples contain different heteroatoms, O, Si,
- CS900 samples contain higher amount of oxygen
- CS700 samples contain higher amount of oxygen
- CS600 et CS700 contain Si
- CS700 and CS800 samples contain sulfur

Textural analysis

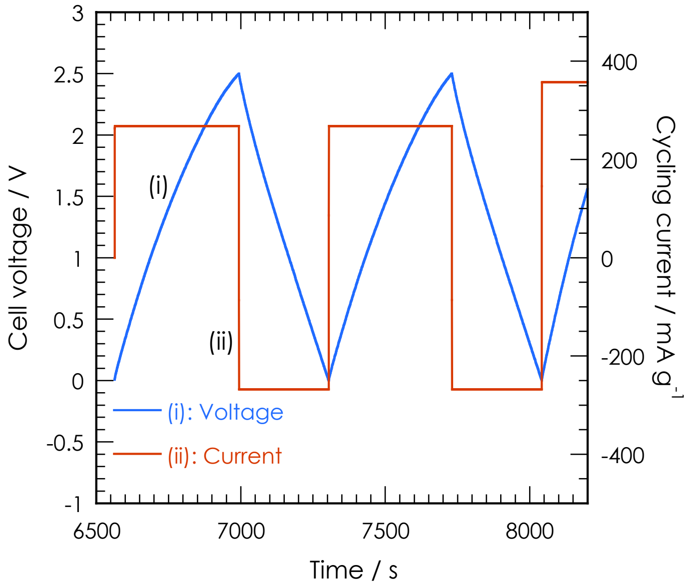


Carbon	Specific surface area (m^2/g) (with BET)	Mesopore Volume (cm^3/g)	$V_{micropore}$ (cm^3/g)	% of micropore	Mean pore diameter (nm)
CS600	621	0.32	0.19	37.2	2.49
CS700	1179	0.51	0.39	43.3	2.32
CS800	1664	0.91	0.58	26.2	2.54
CS900	1199	0.60	0.39	39.4	2.44
CSN	1553	-	-	-	3.94*

Electrochemical study cyclic



- Rectangular chape: capacitive behaviour
- No faradic reactions
- CS 700, CS 800, have the better chapes



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_2SO_4
CS700	83,7	1mol.L^{-1} H_2SO_4
CS800	95,1	1mol.L^{-1} H_2SO_4
CS900	47,8	1mol.L^{-1} H_2SO_4
CSN	141,78	6M KOH

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

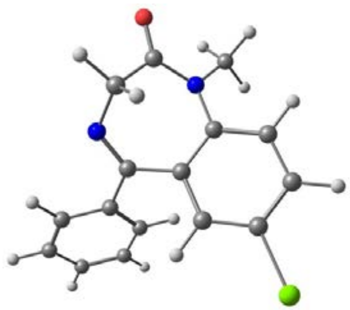
PhD S. Roche

Material	Capacitance (F g^{-1})	BET surface area (m^2 g^{-1})	Electrolyte
Cassava peel	153	1352	H_2SO_4
Coffee shells	150	842	KOH
Cherry stones	232	1292	H_2SO_4
Bamboo	68	1251	H_2SO_4, KOH
Fir wood	197	2821	H_2SO_4
Banana fiber	74	1079	Na_2SO_4
Rubber Wood Saw Dust	138	912	H_2SO_4
Argan (Argania spinosa)	259-355	2100	H_2SO_4

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

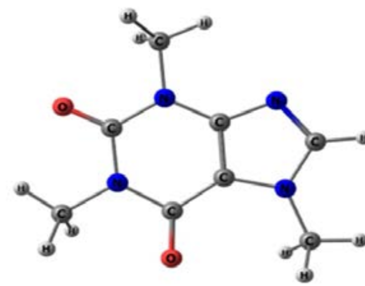
- **Our values are similar to those obtained in the literature for lignocelulosic precursors**

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



Diazepam

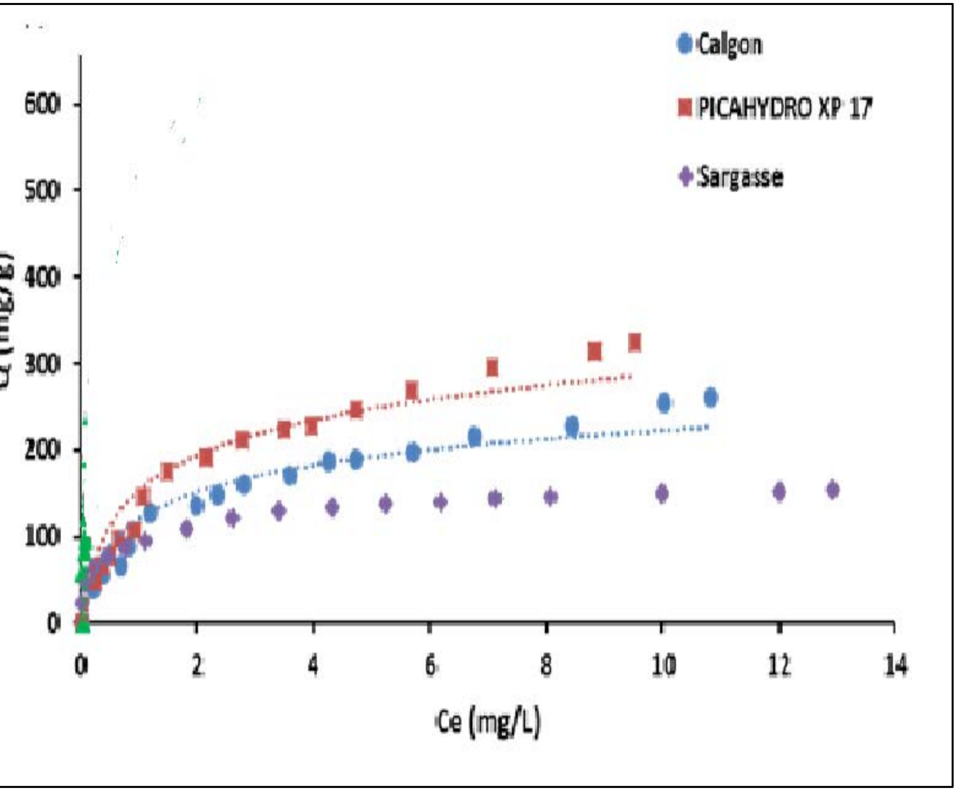
PhD M. Manduca



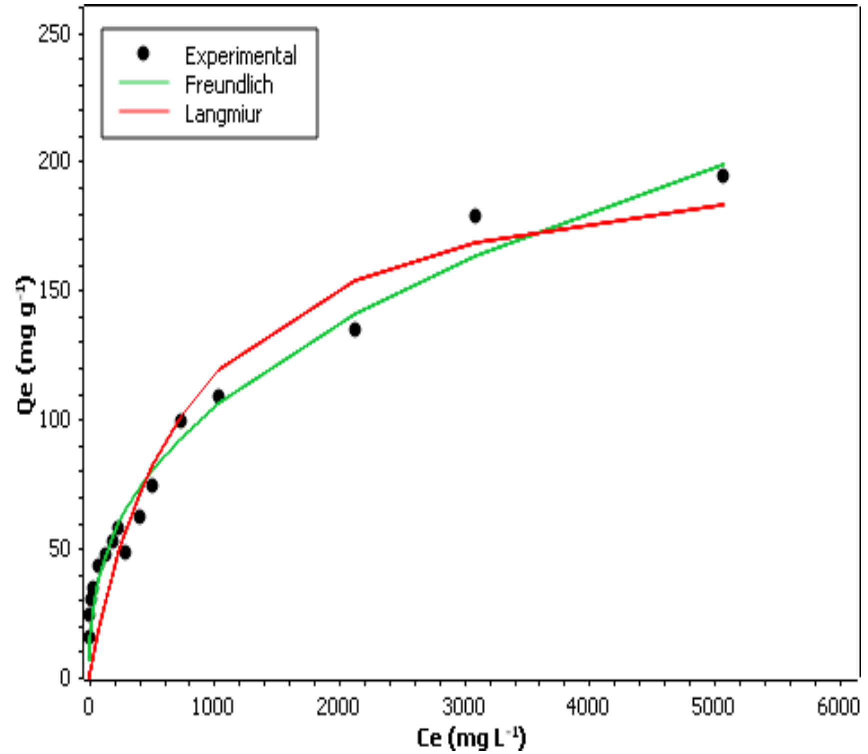
Caffeine

PhD M. Francoeur

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



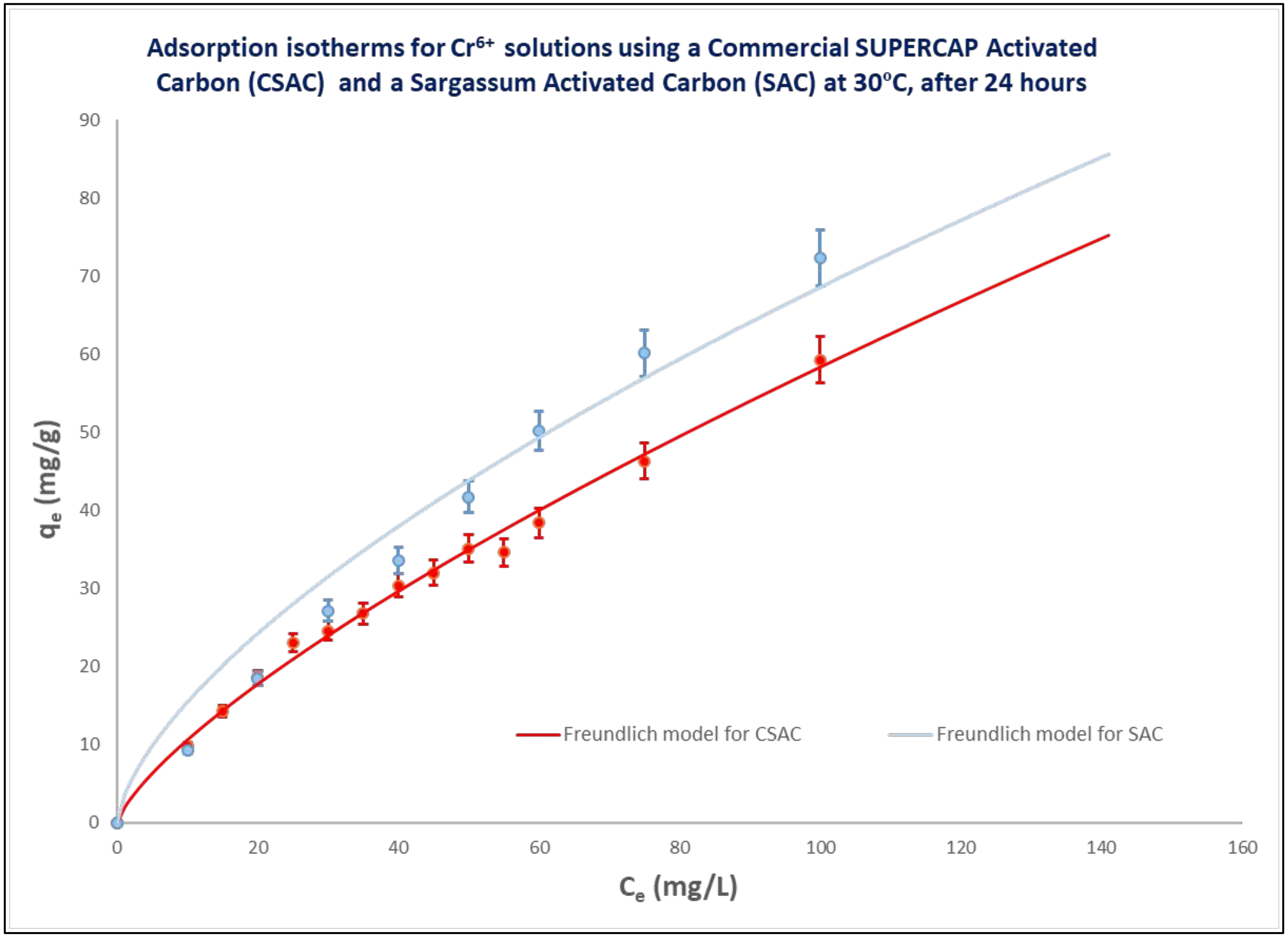
Q_{max}(mg g^{-1}) = 212 mg/g



Chromium adsorption

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

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

ACKNOLEDGMENTS

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THANK YOU FOR YOUR ATTENTION