ADSORPTION OF HEXAVALENT CHROMIUM FROM WATER USING ACIDIC ACTIVATED CARBONS FROM SARGASSUM SEAWEED

Álvarez Galván Y.[1,2], Yacou C.[1], Louis-Thèrése J.[1], Liranzo-Gómez R.[3], Brehm N.[2], Jauregui-Haza U.[3], Gaspard S.[1]

[1]Laboratory COVACHIM-M2E, EA3592, Université des Antilles, BP250, 97157, Pointe-à-Pitre, Guadeloupe, France
[2]NBC SARL, Rue Saint Cyr, 5 Résidence Océane, 97300, Cayenne, France www.nbcsarl.com
[3]Instituto Tecnológico de Santo Domingo, Av. de los Próceres, Santo Domingo, Dominican Republic

yeray.alvarez@nbcsarl.com

Abstract

Since 2011, massive amounts of sargassum seaweed Sargassum spp (Sargassum fluitans and Sargassum natans) invade regularly, the coasts of more than 18 countries and islands in the Caribbean causing environmental damages, health hazard during their decomposition, and high negative impacts on economic activities such as fishery and tourism. The development of valuable materials from this huge amount of biomass, preferably at low cost is a challenge to beat this environmental problem. This work reports on the successful exploitation of Sargassum spp by the production of carbon materials. The activated carbon produced from Sargassum was chemically activated using phosphoric acid (H_3PO_4) at different ratios Sargassum:acid in a pilot muffle furnace, and biochar was prepared by pyrolysis. They were utilized as adsorbents for the removal of Cr(VI) from aqueous solution.

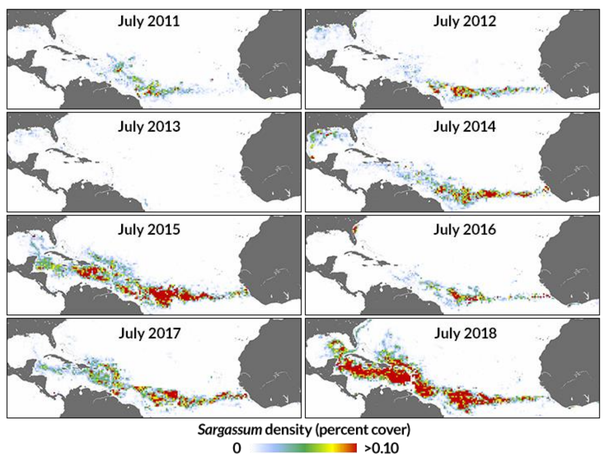
Adsorption experiments were carried out varying the initial chromium ion concentration. Adsorption results obtained for Sargassum activated carbon (SAC) were compared with those of the commercial SUPERCAP activated carbon (CSAC). The kinetic studies showed comparable results for SAC and CSAC indicating that the production of activated carbon from Sargassum seaweed could be used in the development of a new adsorbent for water treatment. Moreover, the valorization of Sargassum seaweed is considered for the development of capacitive deionization units, that could be a reasonable short and long-term solution for this environmental issue. Further studies must be performed to evaluate the physical and chemical characteristics of these porous carbon materials and their promising use in the development of supercapacitors and capacitive deionization units.

Introduction

Since 2011, satellites have detected a wide band of Sargassum algae, a type of brown seaweed, extending each July from the west coast of Africa to the Gulf of Mexico (color depicts mean density). They have been dubbed the great Atlantic Sargassum belt. Only in 2013, this situation changed because of the high ocean-surface temperatures). A record Sargassum band was discovered in 2018.

The massive arrival of algae on the shores of the Caribbean countries and islands has become an enormous environmental, economic and health issue. Therefore, the valorization of these Sargassum seaweed is a necessary challenge.

In this preliminary study, the ability of these algae to produce activated carbon has been evaluated. Their adsorption capabilities for hexavalent chromium were assessed.



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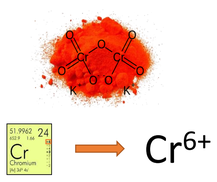
Goal

The main goal of this work is to evaluate the use of sargassum seaweed as a promising precursor for the production of activated carbon being able to absorb hexavalent chromium.



Activated Carbon production

1. Air drying (10 days)
2. Drying in the oven at 105°C (12h → overnight)
3. Grinding
4. Sieving (0.5 to 1.5mm)
5. Activation: H_3PO_4 impregnation (12h)
6. AC production (mufle furnace at 600ºC, 1h, heating at 5ºC/min) – Ratios (0.5/1, 2/1, 3/1)
7. Cooling overnight (around 24 hours)
8. Washing with deionized water until getting pH = 7
9. Total drying of the produced activated carbon

Sargassum natans

Sargassum fluitans

With the aim of determining the adsorption capacities of the activated carbons produced from Sargassum seaweed, a comparison of different sargassum activated carbons was performed. Also, a 800ºC pyrolized Sargussum Activated Carbon (SAC) already produced in the COVACHIM-M2E lab and a Commercial SUPERCAP Activated Carbon (CSAC) were studied.

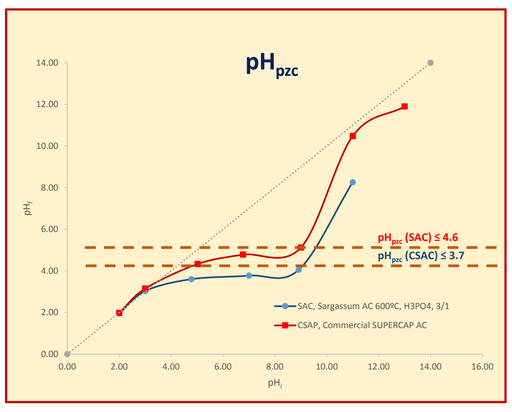
Results

Characterization of the Activated Carbons

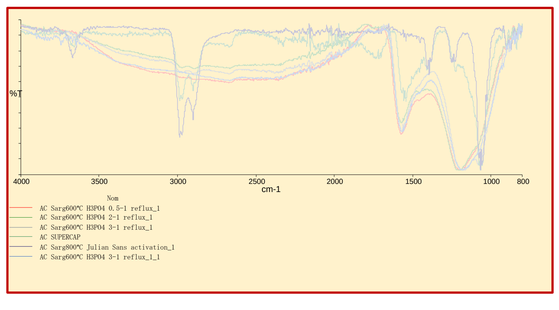
Boehm and pH_{pzc}

Boehm: Total Acidity and Total Basicity

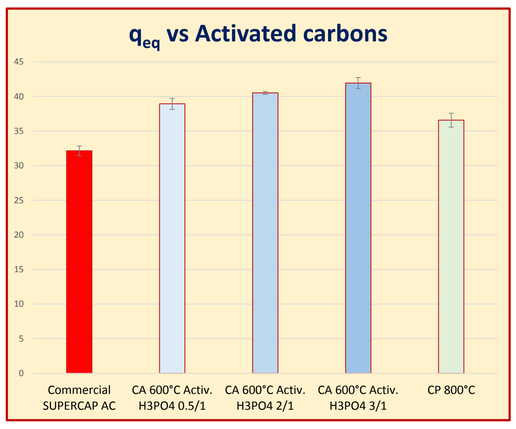
Sample name	Acid groups (mg_{eq} H^+/g)	Basic groups (mg_{eq} OH^-/g)
SAC 600ºC, 0.5/1, H3PO4	96.91	18.40
SAC 600ºC, 2/1, H3PO4	101.70	19.40
SAC 600ºC, 3/1, H3PO4	103.62	20.40
Commercial SUPERCAP AC	53.73	14.40
SPC 800ºC, only pyrolized	92.11	0.40



FTIR



Preliminary selection of the best AC for further studiesº



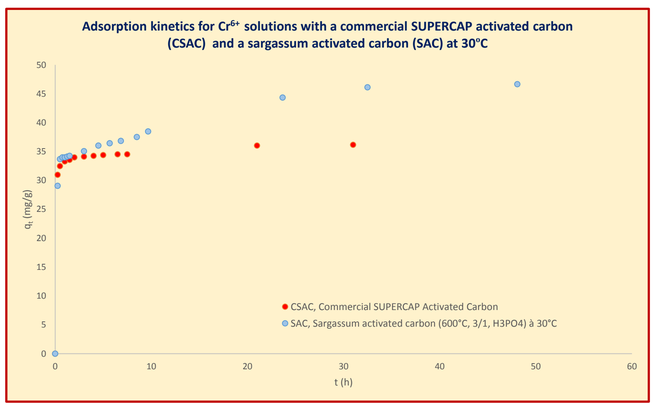
Initial concentration of K_2CrO_7: 60 mg/L

$$T_{adsorption} = 30ºC$$
$$pH_{initial} = 5.0$$
$$t_{adsorption} = 24\ hours$$

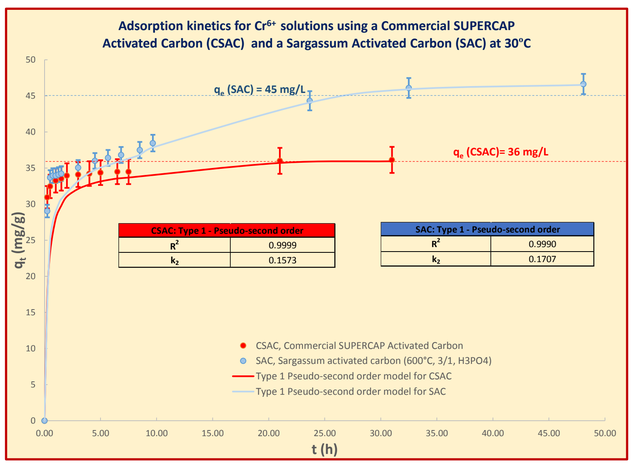
Best Activated Carbon

SAC 600ºC, H_3PO_4, R: 3/1

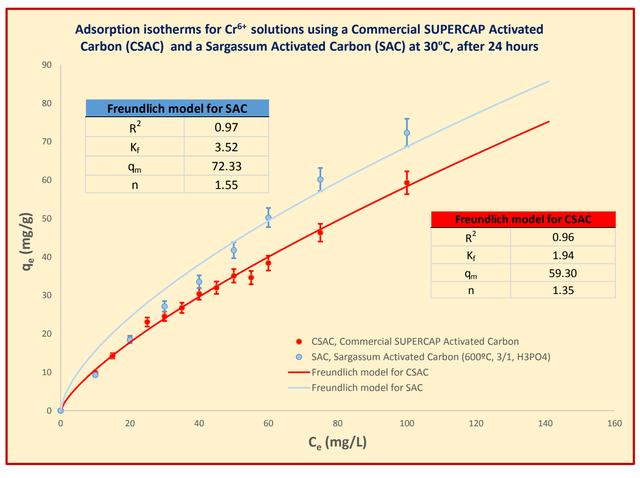
Comparison between CSAC and SAC



Adsorption kinetics Modeling



Adsorption Isotherms Modeling



Concluding Remarks

1. The activated carbon produced from Sargassum seaweed (SAC) has been compared with a commercial SUPERCAP activated carbon (CSAC). The SAC showed really good results, even higher than the results obtained for the CSAC.
2. The adsorption experiments showed that increasing the ratio H_3PO_4/precursor, a better Cr (VI) adsorption is obtained.
3. The chromium (VI) uptake by the SAC (Sargassum Activated Carbon) was best described by a pseudo second-order rate model.
4. The experimental adsorption data was evaluated with 4 adsorption models (isotherm adsorption modeling). The Freundlich adsorption model showed a good match with the data obtained for both, CSAC and SAC activated carbons.

References

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