Uptake of Radioactive Ions from Aqueous Solutions by Biopolymers

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Introduction

The aim of this research is the comparative use of biological adsorbents such as waste green tea (GT) and powdered yellow corn cob (YC) with the conventional biosorbents powdered chitosan (CH) and marine brown algae (LN) for the adsorption of uranium and thorium ions from solutions.

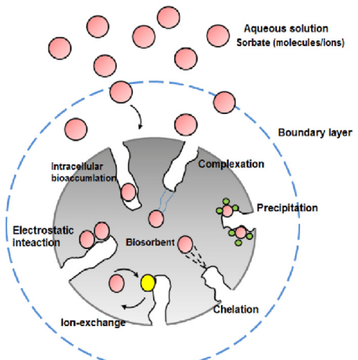


Figure 1. Different mechanism involved in the biosorption process

Materials and Methods

Adsorbents

- Green tea (GT) and powdered yellow corn cob (YC) with the conventional biosorbents powdered chitosan (CH) and marine brown algae (LN).
- Chitosan and brown algae commonly need a pre-treatment such as acid or base activation, demineralization, cross-linkage with calcium chloride, and deproteinization prior to their use as adsorbents. GT and YC adsorbents will be studied in their raw state.

Adsorption experiments

- Batch experiments were carried out in duplicates at room temperature combining variable masses of the adsorbents with 50 mL of a solution of thorium and uranium ions under orbital agitation at 200 rpm for 24 h.
- The adsorption time was determined by preliminary experiments. Initial solution pH was adjusted depending on the type of experiment.
- The suspensions were decanted, and the remaining concentrations of thorium and uranium ions were determined with UV-vis spectrophotometry (Agilent 8453) at a wavelength of 656 nm following the Arsenazo (III) method.

Analysis of the Data

The amount of the U(VI) and Th(IV) adsorbed on the adsorbents was expressed as Adsorption Capacity (q, mg of pollutant/g of adsorbent) and calculated according to the equation:

$$q = \frac{(C_i - C_{eq}) * V}{m}$$

A different way to express the adsorptive properties of a given adsorbent is also indicated by the Adsorption Percentage (%ADS) where the initial and final adsorbate concentration are compared and expressed as percentage as shown in the equation:

$$\%ADS = \frac{(C_i - C_{eq}) * 100}{C_i}$$

Results - SEM

Figure 2. Scanning electron micrographs of the adsorbents at different magnifications: CH (A and B), GT (C and D)

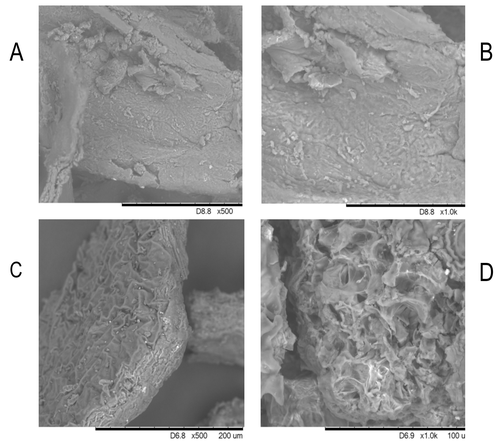
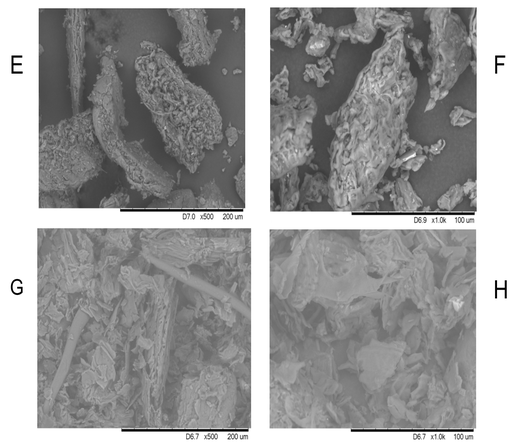


Figure 3. Scanning electron micrographs of the adsorbents at different magnifications: LN (E and F) and YC (G and H).



pH - Effect

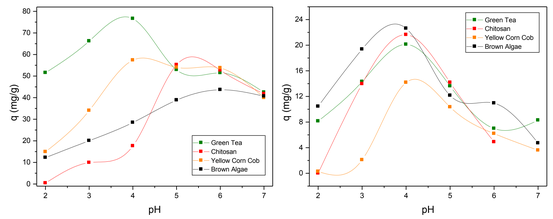


Figure 5: Effect of pH on Thorium (left) and Uranium (right) adsorption at room temperature.

Isotherms

Adsorption Isotherm	Parameters	GT	YC
Langmuir	q_{max} (mg/g)	176.48	181.97
	b (L/mg)	0.01	.024
	P-value	0.1>P>0.05	P>0.05
Freundlich	K (L/g)	26.52	22.55
	N	0.83	0.966
	P-value	P≈0.05	P≈0.05
Sips	q_{max}	128.89	114.7
	K	0.0038	$3.12x10^{-6}$
	n	1.387	4.26
	P-value	P>0.05	P≈0.05
Temkin	a_T	0.166	0.15
	b_T (J/mol)	80.47	49.2
	P-value	P>0.05	P>0.05

Table 1. Equilibrium constants and parameters for the adsorption of Thorium (IV) ions.

Adsorption Isotherm	Parameters	GT	CH	LN
Langmuir	q_{max} (mg/g)	175.3	796.44	597.07
	b (L/mg)	0.015	0.015	0.005
	P-value	P>0.05	P>0.05	P≈0.05
Freundlich	K (L/g)	7.924	31.1	6.34
	n	0.803	0.77	0.67
	P-value	0.1>P>0.05	0.1>P>0.05	0.1>P>0.05
Sips	q_{max}	68.19	316.7	76.25
	K	0.00015	0.0014	0.0008
	n	3.39	2.42	2.83
	P-value	0.1>P>0.05	0.1>P>0.05	0.1>P>0.05
Temkin	a_T	0.187	0.2027	0.2
	b_T (J/mol)	73.4	17.75	61.05
	P-value	0.1>P>0.05	P≈0.05	P>0.05

Table 2. Equilibrium constants and parameters for the adsorption of Uranium (VI) ions.

Desorption

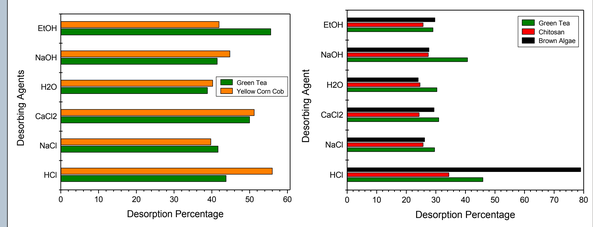


Figure 5: Desorption of Thorium (left) and Uranium (right) by cosolvents

Time-dependence of the Adsorption

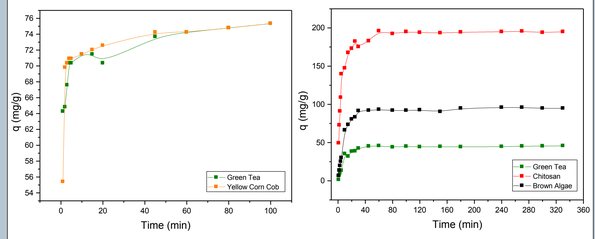


Figure 7: Time-dependence of the adsorption of Thorium (left) and Uranium (right)

Conclusions

- Biosorption is a "clean technology" that is always in the search for new adsorbents for the removal of contaminants.
- GT and YC are the best adsorbents for thorium ions, reaching a maximum adsorption capacity of 176.48 and 181.97 mg/g for GT and YC, respectively.
- Uranium was better adsorbed by CH, GT, and LN, reporting maximum adsorption capacities of 796, 44 and 597.07 mg/g, respectively.
- Scanning electron microscopy displays appropriate textural and morphological properties for all the adsorbents due to the heterogeneity of their surfaces. GT and YC are "free" domestic wastes that have potential adsorptive properties, are biodegradable and can be used in a broad type of pollutants.

Acknowledgment

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