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Supporting Information

Porous carrageenan-derived carbons for efficient ciprofloxacin removal from water

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A. Characterization of carbon materials

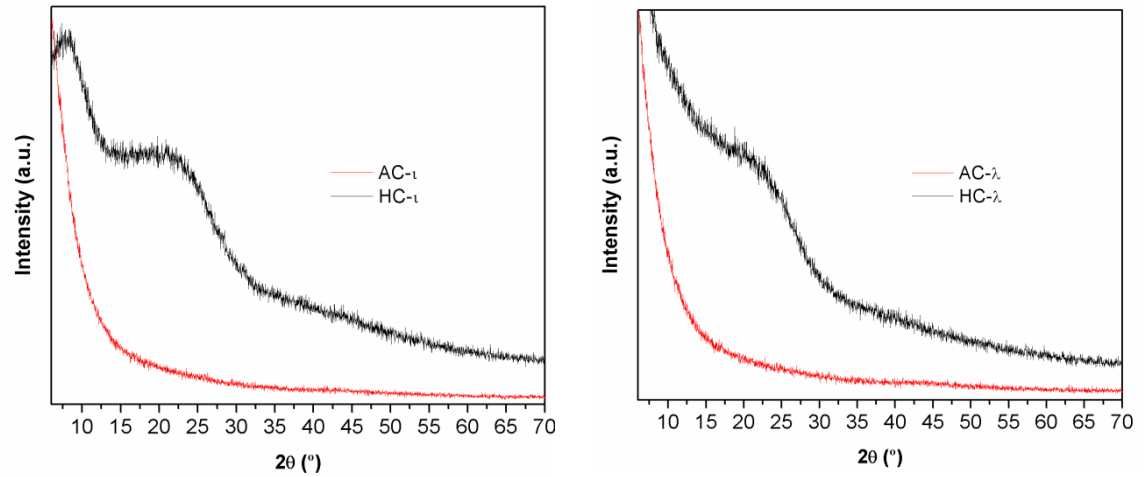


Figure S1. Powder XRD pattern of carrageenan (ι- and λ-type; left and right, respectively) derived carbons before (HC) and after activation (AC).

Table S1. Selected infrared bands (cm^{-1}) for the materials and respective assignments[a].

	Hydrothermal carbons			Activated carbons		
Assignment	**HC-κ**	**HC-ι**	**HC-λ**	**AC-κ**	**AC-ι**	**AC-λ**
ν(O-H)	3273 (vs)	3221 (vs)	3315 (vs)	--	--	--
ν(C-H) aliphatic	2926 (s) 2879 (s)	2922 (s) 2879 (s)	2926 (s) 2879 (s)	--	--	--
ν(C=O)	1693 (s)	1695 (s)	1695 (s)	--	--	--
ν(C=C) aromatic	1606 (vs)	1606 (vs)	1606 (vs)	1560-1520 (vs)	1560-1520 (vs)	1560-1520 (m)
δ(C-O)	1290 (vs)	1292 (vs)	1298 (vs)	--	--	--
C-H aromatic	798 (s)	798 (s)	798 (s)	--	--	--

[a] vs – very strong; s – strong; m– medium; ν – stretching vibration; δ – deformation vibration

B. CIP Adsorption Modelling

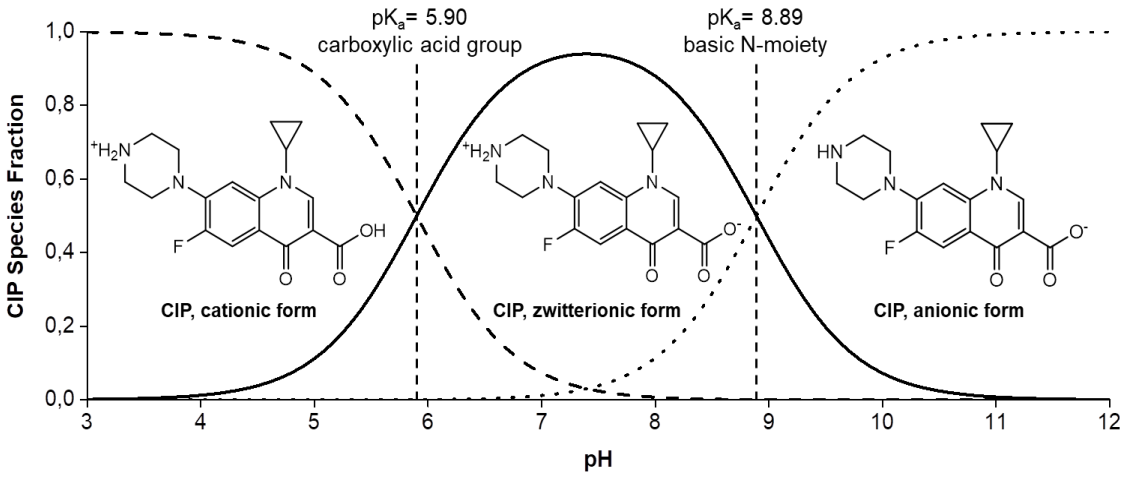


Figure S2. Speciation of CIP [1,2]

Table S2. Isotherm models and parameters [3–6].

Model	Equation (non-linear form)	Parameters
Langmuir	$q_e = \frac{q_L K_L C_e}{1 + K_L C_e}$	q_L is the monolayer adsorption capacity (mg.g^{-1}) K_L is the Langmuir isotherm constant (L.mg^{-1}), related to the affinity of binding sites.
Freundlich	$q_e = K_F C_e^{\frac{1}{n}}$	K_F is the Freundlich constant (mg$^{(1-1/n)}$.L$^{(1/n)}$.g^{-1}) 1/n is the heterogeneity factor; n is usually between 1 and 10 (dimensionless)
Sips	$q_e = \frac{N_T a C_e^m}{1 + a C_e^m}$	N_T is the total number of binding sites (mg.g^{-1}) a is related to the median binding affinity k (a=k^m) m is the heterogeneous index (dimensionless, 0<m<1)

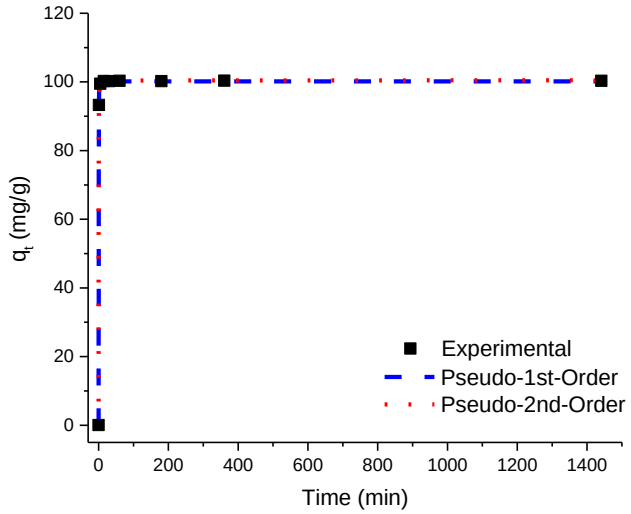
Table S3. Kinetic models and parameters. q_t and q_e (mg. g^{-1}) are the adsorption capacity at time t and equilibrium time, respectively [7,8].

Model	Equation (non-linear form)	Parameters
Pseudo 1st order	$q_t = q_e(1 - e^{-k_1 t})$	k_1 - equilibrium rate constant of pseudo 1st order adsorption (min^{-1}).
Pseudo 2nd order	$q_t = \frac{k_2 {q_e}^2 t}{1 + k_2 q_e t}$	k_2 - equilibrium rate constant of pseudo 2nd order adsorption (g.mg^{-1}.min^{-1}).

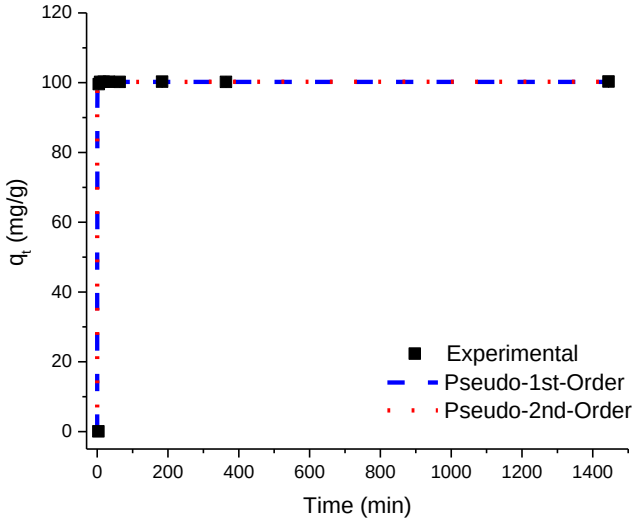
The goodness of the fittings was determined based on the calculation of the correlation coefficient (R^2) (S1) and Chi-square test value (χ^2) (S2), expressed by the following equations respectively:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad (S1) \qquad \chi^2 = \sum_{i=1}^{n}\frac{(y_i - \hat{y}_i)^2}{\hat{y}_i} \quad (S2)$$

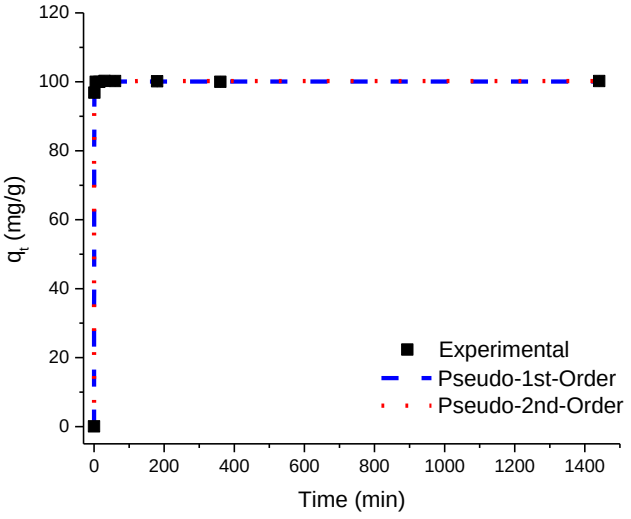
where y_i and $\hat{y}_i$ are the experimental and model predicted values respectively, $\bar{y}$ is the mean of the experimental data and n is the sample size.



(**a**)



(**b**)



(**c**)

Figure S3. Time profile of CIP adsorption capacity over 24h and corresponding kinetic model fitting using pseudo 1st and pseudo 2nd order equations: AC-κ (a), AC-ι (b), AC-λ (c).

References

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