Elaboration of hybrid materials *Posidonia Oceanica*-Zinc using precipitation and alternating current for wastewater purification

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In this study, we elaborated a hybrid material from *Posidonia Oceanica* fibers and the Zinc ion "Zn^{2+}", at different percentages (1, 2 and 4%) by the precipitation and alternating current (AC). The physico-chemical characterization of the pure biomass and the hybrid materials was studied using the zero charge point and Boehm methods. Moreover, IR spectroscopy, Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) were applied. Mathematical modelling of Brouers-Sotolongo kinetics was performed to describe the retention process. The process was optimized as a function of the quantity of methyl orange: MO (anionic dye) adsorbed on Posidonia Oceanica and the hybrid materials developed. The results showed the effectiveness of the hybrid materials designed to eliminate the MO, speed up the biosorption process and improve the performance of the Posidonia Oceanica fibers.

Based on the findings from the analysis of acid-base properties, FTIR, SEM, and EDX of both the biomass and hybrid materials, it can be inferred that the metal nanostructures were attached to the surface of *Posidonia Oceanica* fibers. The greatest quantities of adsorbed dyes were obtained by the hybrid materials prepared using the alternating current. The amount of MO adsorbed increased from 0.768 $mg.g^{-1}$ for pure Posidonia Oceanica to 0.941 $mg.g^{-1}$ for Posidonia oceanica-4% Zn^{2+} AC.

Finally, stochastic mathematical modelling of Brouer-Sotolongo kinetics was applied to describe the pollutant retention process.

Keywords: Biosorption; *Posidonia Oceanica*; Hybrid material; Methyl orange.

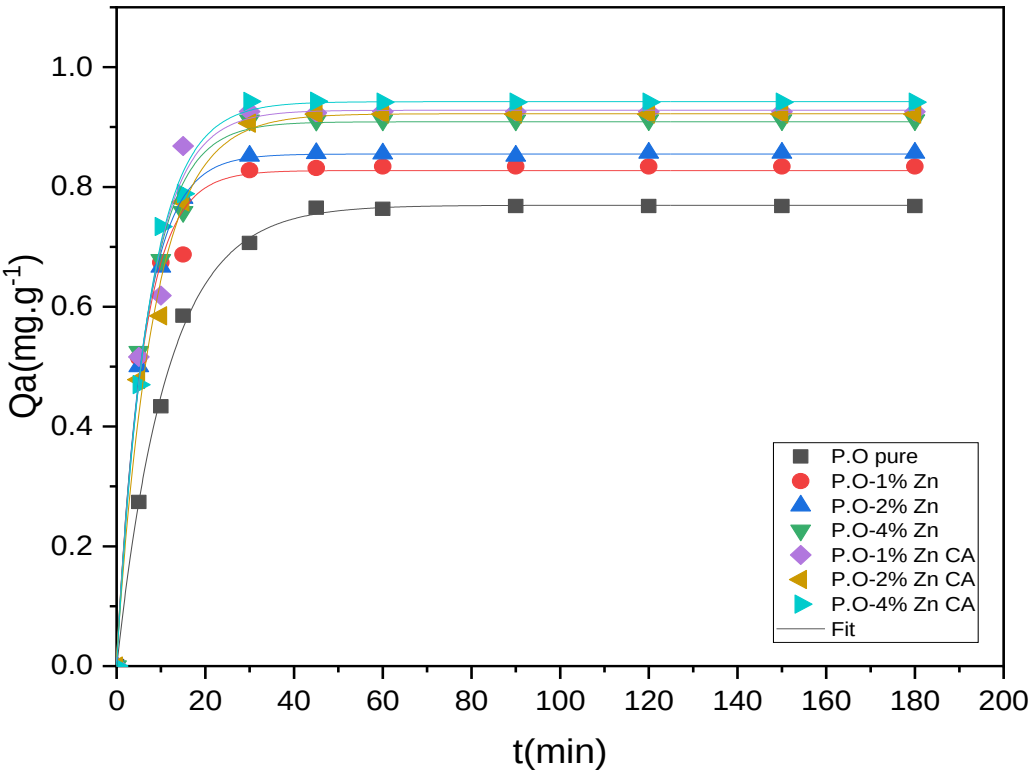

Figure 1. Retention kinetics of methyl orange (MO) on different materials used P.O; pH = 2, Ci = 10 mg.L^{-1}, m = 0.1 g, T = 298 K. (a) by the precipitation and electrochemical methods.

Figure 1 show the retention kinetics of methyl orange (MO) on different materials used *Posidonia Oceanica*; (pH = 2, Ci = 10 mg.L^{-1}, m = 0.1 g, T = 298 K) by two different methods of preparing hybrid materials. The incorporation of Zn^{2+} ions into the *Posidonia Oceanica* structure also increases the availability of active sites for adsorption. The investigation highlighted the effective application of hybrid materials based on *Posidonia Oceanica* fibers for MO textile dye biosorption, particularly showcasing the superior performance of the hybrid material (*Posidonia Oceanica*-4% Zn^{2+}) synthesized by precipitation. The alternating current performs better than the precipitation method from a kinetic point of view.

Table 1 shows that Posidonia Oceanica has a basic character with a value of 7.47. The addition of zinc mainly decreases the carboxylic and phenolic groups and increases the basic groups. In addition, it was observed that the basic functional groups increased at the surface of Posidonia Oceanica, which coincides with an increase in pHpzc.

Table 1. Surface groups of different adsorbents

Adsorbents	Acidic function ($\times10^{-4}$mmol.g^{-1})				Basic function ($\times10^{-3}$mmol.g^{-1})	pH_{pzc}	Surface Nature
	carboxylic	Lactonic	Phenolic	Total			
Posidonia Oceanica pure	0.397	0.205	0.952	1.554	1.572	7.47	Basic
Precipitation							
Posidonia Oceanica-1% Zn^{2+}	0.311	0.23	0.791	1.332	1.648	7.69	Basic
Posidonia Oceanica-2% Zn^{2+}	0.263	0.293	0,552	1.108	1.794	7.85	Basic
Posidonia Oceanica-4% Zn^{2+}	0.194	0.385	0.431	1.01	1.879	7.93	Basic
Alternating current							
Posidonia Oceanica-1% Zn^{2+} +AC	0.29	0.251	0.642	1.183	1.664	7.89	Basic
Posidonia Oceanica-2% Zn^{2+} +AC	0.211	0.432	0.512	1.155	1.881	7.93	Basic
Posidonia Oceanica-4% Zn^{2+} +AC	0.163	0.494	0.372	1.029	1.912	7.95	Basic