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Removal of metformin from aquatic matrices using cork-based adsorbents

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Metformin is considered an emerging micropollutant, belonging to the pharmaceutical class, and is widely used in the treatment of type 2 diabetes. Due to its incomplete metabolism and extensive prescription for chronic disease management, it has been frequently detected in aquatic environments. Even at trace concentrations, it may cause endocrine disruptions in aquatic biota and lead to the formation of toxic by-products during water treatment.[1,2] In this context, the present study aimed to evaluate the efficiency of metformin removal from aqueous matrices through the adsorption process, using activated carbons produced from cork residues.

The methodology involved the preparation of the adsorbents via physical activation (CF) and chemical activation using potassium hydroxide (KOH) (CQ), followed by characterization in terms of carbonization yield, moisture and ash content, point of zero charge (pH_{PZC}), presence of acidic and basic surface functional groups, and Fourier-transform infrared spectroscopy (FTIR). Metformin quantification was carried out by high-performance liquid chromatography with diode array detection (HPLC-DAD). Studies on drug removal, adsorption kinetics, activation energy estimation, and evaluation of operational parameters influencing the process, such as adsorbent dosage, pH, and initial metformin concentration, were conducted.

The results demonstrated that the type of activation applied to each carbon significantly influenced the physicochemical properties of the materials, as well as their adsorption performance. According to the kinetic studies, adsorption equilibrium was reached within the first minutes for CQ, while for CF it was more gradual. In equilibrium studies, the Freundlich and Langmuir isotherm models were applied. For CF, both models showed a good fit, with a predominance of the Freundlich model, indicating a slightly heterogeneous surface and favorable adsorption. For CQ, the Langmuir model provided a better fit, with a high maximum adsorption capacity, suggesting monolayer adsorption on a more homogeneous surface.[3,4]

From the study carried out, the activated carbons produced from cork residues demonstrated high performance as promising materials for the removal of metformin in aqueous media, particularly those obtained through chemical activation, achieving a removal efficiency of approximately 99.0% under optimized alkaline pH conditions (pH 11). The use of this residue as a raw material highlights the potential of renewable-origin adsorbents in water treatment processes, contributing to the valorization of an abundant by-product in Portugal and to the development of more environmentally sustainable solutions, in line with the principles of a circular economy.

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