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Kinetics of Fluoride Adsorption onto Bone Char

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1. Introduction

The level of fluoride in drinking water is a very important factor in evaluating the quality of water for human consumption. Several methods have been applied to remove fluoride from drinking water. The current treatment methods are chemical precipitation with calcium and aluminum salts, ion exchange using polymeric resins, adsorption on activated alumina, reverse osmosis and electrodialysis [1]. Nowadays, bone char has been reconsidered as a potential adsorbent for defluoridation of drinking water because of its high fluoride adsorption capacity. Adsorption of fluoride on bone char has been studied in previous works [2] and it has been reported that fluoride can be effectively removed from water solutions by adsorption on bone char.

In this study a diffusional model was developed to interpret the adsorption rate of fluoride from an aqueous solution on bone char. The model was derived by making a mass balance in the liquid solution and in the bone char. The aim of this work is to study the overall rate of adsorption of fluoride on bone char assuming that pore volume diffusion is the rate controlling step.

2. Experimental Methods

The granular bone char (BC) used in this work is manufactured from cattle bones by the company APELSA, Guadalajara, Mexico. The BC was washed several times with deionized water and dried in an oven at 100 °C for 24 h. The textural properties of the BC are surface area 104 m^2/g, average pore diameter of 11.1 nm and pore volume of 0.30 m^3/g.

The fluoride concentration in an aqueous solution was determined by a potentiometric method using an Orion, Model SA720 potentiometer with a fluoride ion selective electrode. Experimental adsorption equilibrium data were obtained in a batch adsorber consisting of a 500 mL polyethylene container and the mass of fluoride adsorbed onto bone char at equilibrium was estimated by performing a mass balance of fluoride in the solution.

A rotating basket adsorber was used to carry out the rate of diffusion experiments. The experimental concentration decay data, the concentration of fluoride vs time, was expressed in dimensionless, $\phi = C_A/C_{A0}$, where ϕ is the dimensionless concentration, C_A is the concentration of fluoride at any time and C_{A0} is the initial concentration of fluoride.

3. Results and Discussion

The experimental adsorption equilibrium data were fitted to the isotherm models of Freundlich, Langmuir and Prausnitz-Radke. The Prausnitz-Radke isotherm best fitted the experimental adsorption data.

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The experimental effective pore volume diffusivity, D_{ep}, was evaluated by matching the experimental concentration decay data with the predicted concentration decay from a numerical solution of the diffusional model. The experimental fluoride concentration decay data and the fluoride decay predicted with the best value of D_{ep} ($D_{ep} = 3.71\times10^{-6}$ cm2/s) are plotted in Fig. 1 for the run 2. As it is shown in this figure, the diffusional model predicted reasonably well the experimental concentration decay data.

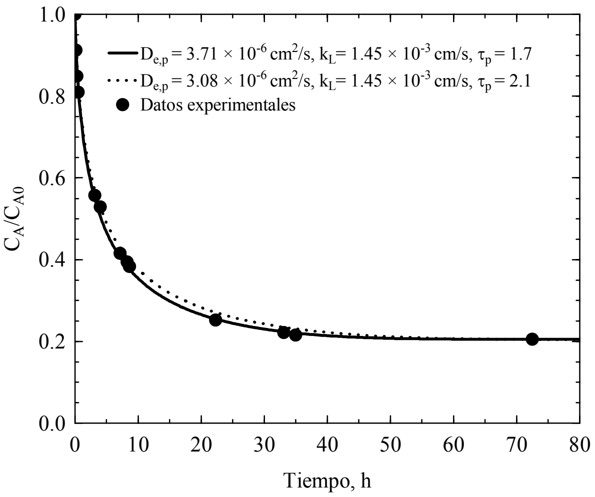

Fig. 1: Concentration decay curves for fluoride adsorption on GBC. The lines represent the diffusional model predictions. Run No. 2.

The tortuosity of BC can be estimated using the equation reported by Leyva-Ramos and Geankoplis [3] and substituting the experimental values of $D_{e,p}$ for fluoride reported in Table 1, the value of the void fraction for this carbon (ε_p=0.46) and molecular diffusivity of fluoride, $D°_{AB} = 1.39\times10^{-5}$ cm^2/s. The values of the tortuosity factor varied from 1.7 to 2.3. The average tortuosity of BC was considered to be 2.1. This value results in an effective pore volume diffusivity of 3.08×10^{-6} cm^2/s (Figure 1).

3. Conclusions

The concentration decay data were interpreted by a diffusional model which takes into account adsorption, external mass transfer and intraparticle diffusion. This diffusional model fitted reasonably well the experimental data and the effective diffusion coefficient was evaluated by matching the experimental concentration decay data with a numerical solution of the diffusional model. It was concluded that the overall rate of adsorption of fluoride on bone char is predominantly controlled by the intraparticle diffusion and it is solely due to pore volume diffusion.

References

[1] M. Tahaikt, I. Achary, M.A. Mekouchi Sahli, Z. Amor, M. Taky, A. Alami., A. Boughriba, M. Hafsi, Desalination 167 (2004) 357.

[2] I. Abe, S. Iwasaki, T. Tomiko, N. Kawasaki, T. Nakamura, S. Tanaka, J. Colloid Interf. Sci. 275 (2004) 35-39.

[3] R. Leyva-Ramos, C.J. Geankoplis, Can. J. Chem. Eng. 40(5) (1994) 262-271.