Column and Batch Study of Haloacetic Acids Adsorption onto Granular Activated Carbon

Ghomshe S.M.Tabatabaee[1], Mousavi S.M.[2*], Soltanieh M.[3] and Kordi A.K.Seif[4]
1. Department of Engineering, Science and Research Branch, Islamic Azad University, Tehran, IRAN
2. Department of Chemical Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, IRAN
3. Department of Engineering, Science and Research Branch, Islamic Azad University, Tehran, IRAN
4. Department of Chemical and Petroleum Engineering, Sharif University of Technology, Tehran, IRAN
*mmousavi@um.ac.ir

Abstract

The granular activated carbon (GAC) was used as an adsorbent for its ability to remove haloacetic acids (HAAs) from drinking water by batch and column experiments. Various thermodynamic parameters, such as ΔG^o, ΔH^o and ΔS^o have been calculated. The thermodynamics of HAAs onto GAC system indicates spontaneous and exothermic nature of the process. The ability of GAC to adsorb HAAs in a fixed bed column was investigated as well. The effect of operating parameters such as flow rate and inlet HAAs concentration on the sorption characteristics of GAC was investigated. The total adsorbed quantities, equilibrium uptakes and total removal percents of HAAs related to the effluent volumes were determined by evaluating the breakthrough curves obtained at different flow rates and different inlet HAAs concentrations for adsorbent. The data confirmed that the total amount of sorbed HAAs and equilibrium HAAs uptake decreased with increasing flow rate and increased with increasing inlet HAA_5 concentration. The Adams–Bohart model was used to analyze the experimental data and the model parameters were evaluated.

Keywords: Adams–Bohart model, Adsorption, Fixed bed column, Granular activated carbon, Haloacetic acid removal, Breakthrough curve.

Introduction

Chlorination is the most common disinfection method of drinking water. It is an effective way to kill many kinds of bacteria and other germs that may be harmful to one's health. Thought unquestionably important to the supply of safe drinking water, it also leads to the formation of undesirable organic-by-product (Disinfection-by-product, DBPs). The two main classes of these compounds are trihalomethanes (THMs) and Haloacetic acids (HAAs)[2,20]. Haloacetic acids are formed during disinfection of water that contains bromide ions and organic matter[17]. Haloacetic acids are formed when chlorine reacts with bromide (Br^-) and natural organic matter (NOM) in source waters[20]. Although there are nine HAA species, only five of them are regulated by the current Disinfectants/Disinfection By-Products (D/DBP) Rule due to limited formation and occurrence data for some of the species (Contact time of HAAs). The five HAAs are monochloro- and monobromoacetic acid, dichloro- and trichloroacetic acid, and dibromoacetic acid (ClAA, BrAA, Cl_2AA, Cl_3AA, and Br_2AA, respectively). HAAs are colorless, have a low volatility, dissolve easily in water, and are fairly stable. When consumed in drinking water, HAAs are rapidly absorbed into the bloodstream and are carried throughout the body. However over long periods of time, exposure to levels of HAAs at or above the maximum contaminant level can cause injury to brain, breast, nerves, liver, kidneys, eyes and reproductive systems[19]. Those HAA_5 of most concern have carcinogenic, reproductive and developmental effects on the basis of current knowledge, a number of CBPs (Chlorination-by-products) have been regulated by EPA, WHO and the European Union. These standards have been shown in table 1[24].

There are various methods to remove HAAs including chemical precipitation, membrane process, ion exchange, liquid extraction and electrodialysis. The adsorption technique is one of the preferred methods for removal of HAA_5 because of its efficiency and low cost[10]. Several treatment alternatives have been proposed for the removal of DBPs. Granular activated carbon (GAC) has been of a special interest due to its ability to remove a wide range of compounds such as odor as color causing compounds, NOMs, THMs, HAAs and other toxic compounds[10].

The objectives of the present study are to adsorb HAA_5 from aqueous solution by GAC using batch and four fixed-bed columns. In batch studies, the dynamic behavior of the adsorption was investigated on the effect of initial HAA_5 concentration, temperature and adsorbent dosage. The thermodynamic parameters were also evaluated from the adsorption measurements. The Langmuir and Freundlich were used to fit the equilibrium isotherm. The important design parameters such as flow rate of fluid and initial concentration of HAA_5 solution have been investigated. The breakthrough curves for the adsorption of HAA_5 were analyzed using Adams–Bohart model.

Material and Methods

Materials: The stock solutions of HAA_5 for these studies were obtained from Merck, Germany. All working solutions were prepared by diluting the stock solution with deionized water. Analytical reagents used for determination of HAA_5 concentrations were purchased from Merck, Germany.