2. Igor Winkler, Volodymyr Diychuk. Adsorption of toluene from the mixed water–toluene system on medicinal activated carbon // Canadian Journal of Chemistry. – 2014. v. 92, N5. – P. 392-396.

NRC Research Press

ARTICLE

Adsorption of toluene from the mixed water–toluene system on medicinal activated carbon

Igor Winkler and Volodymyr Diychuk

Abstract: An experimental investigation of adsorption of toluene from the aqueous phase on medicinal activated carbon revealed that the process runs by the mechanism of preactivated adsorption. Kinetics of the initial stages of adsorption can be adequately represented by the empirical Elovich adsorption model. An insufficient amount of the adsorbent can cause an unexpected jump in the toluene equilibrium concentration in water caused by transferring this substance from the toluene phase into water through the process of additional adsorption on the coal surface. Adsorption constants and "imaginary" adsorption values have been determined for a series of toluene contents.

Key words: toluene, aqueous phase, activated carbon, adsorption, Elovich equation.

Résumé : Une étude expérimentale de l'adsorption de toluène à partir d'une phase aqueuse sur du charbon actif médicinal a montré que le processus se déroule selon le mécanisme d'adsorption préactivée. La cinétique des étapes initiales d'adsorption peut être convenablement représentée par le modèle empirique d'adsorption d'Elovich. Une quantité insuffisante d'adsorbant peut entraîner une augmentation rapide et inattendue de la concentration d'équilibre du toluène dans l'eau en raison du transfert de ce dernier de la phase toluénique vers la phase aqueuse par le processus d'adsorption supplémentaire sur la surface de charbon. Les valeurs de la constante d'adsorption et d'adsorption « virtuelle » ont été déterminées pour différentes concentrations de toluène. [Traduit par la Rédaction]

Mots-clés : toluène, phase aqueuse, charbon actif, adsorption, équation d'Elovich.

Introduction

Activated carbon (AC) is a well-known adsorbent, which is used widely in many scientific and commercial applications for adsorption of a wide range of compounds (preliminary organic) from the gaseous and liquid phases. Adsorption of some inorganic compounds, toluene, benzene, and other volatile organic compounds (VOC) is being investigated in the context of decontamination of industrial wastewaters and waste gases,[1–4] concentrating these compounds before reuse,[5–8] as a matter of the adsorption mechanism determination,[9–11] and in some other directions. Usually, primary attention is paid to the investigation of the effect of a different modification of carbon on VOC adsorption and its mechanism.

In the context of decontamination and reclamation of water after organic pollution spills, AC can be very useful, since it is inexpensive and may not require any secondary decontamination being used as a fuel component for the solid-fuel boilers and burnt together with the adsorbed organic pollutants.

The experimental data related to investigations of various gas-phase adsorption systems are much wider than the results in the field of liquid-phase adsorption equilibrium research. Different adsorption mechanisms (Langmuir, Freundlich, Elovich, etc.) are referred to as the best-fitting models for VOC adsorption on AC from the gaseous and liquid phases. In our opinion, the characteristics of the AC preparation and its parameters are the key factors governing the adsorption mechanism and predetermining relevance of the adsorption process models.

A number of investigations deal with gaseous VOC adsorption on various AC-based materials. Liu et al.[12] reported the influence of some noble metals on toluene adsorption on AC fibers and proposed the most effective fiber material composition.

Adsorption of toluene on AC in the liquid phase at 60 °C has been thoroughly investigated[13] and the classical Langmuir monolayer model has been found to be incompatible for this system. Another study[14] of gas-phase toluene adsorption on modified AC fiberglass material proved that the semiempirical Dubinin–Astakhov model is a relevant approach to describe the experimental data.

Yun et al.[14] also reported the non-Langmuir character of toluene adsorption on AC and also emphasized the stimulating influence of the oxygen-deficient hydrophobic surface spots on the process of adsorption. Therefore, the monolayer Langmuir model is generally mentioned as incompatible with the process of toluene adsorption, while some empirical models (referring to toluene concentration mostly as the exponential function) are widely involved in the description of this process.

Among others, the semiempirical Elovich equation is widely used to describe the adsorption kinetics mechanism. In this model, the temporal changes of the adsorbate concentration are represented by the exponential function of its concentration. This model can represent adequately adsorption dynamics for many processes in nature.[15]

Theoretical background of toluene–water–adsorbent equilibrium

Toluene is poorly dissoluble in water, since it is an aromatic compound with relatively weak polarization of bonds. According to the "Chemist' Reference Book",[16] its solubility is about 0.43–0.5 g/L at 20 °C. Therefore, 0.5–0.6 mL/L toluene forms the satu-

Received 20 January 2014. Accepted 20 March 2014.

I. Winkler and V. Diychuk. Yu. Fedkovych National University of Chernivtsi, 2 Kotsyubynsky St., Chernivtsi, 58001, Ukraine.
Corresponding author: Igor Winkler (e-mail: igorw@ukrpost.ua).

Can. J. Chem. 92: 1–5 (2014) dx.doi.org/10.1139/cjc-2014-0030

Published at www.nrcresearchpress.com/cjc on 21 March 2014.