Optimization of zinc removal from aqueous solutions using titanate nanotube

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Pegah Pejmanzad[1,2*], Meisam Torab-Mostaedi[2], Tooraj Mohammadi[3]

Abstract

In this study, the batch removal of zinc (Zn(II)) from aqueous solutions using titanate nanotubes (TNTs) as an adsorbent is investigated. TNTs are synthesized via a hydrothermal process with specific surface areas of 194.1 m^2g^{-1} and pore volume of 0.21 cm^3g^{-1}. The influence of pH, adsorbent dosage, contact time and initial concentration of metal ions is studied. The maximum zinc adsorption occurs at pH 6, adsorbent dosage of 0.6 g/L and contact time of 90 min. It is recommended that further complimentary studies including equilibrium, kinetic and thermodynamic conduct to investigate the potential of TNTs for the removal of heavy metals from aqueous solution.

Pore size distribution prediction of activated carbon synthesized in different operating conditions

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Fateme Haghighatju[1] ,Hassan Hashemipour Rafsanjani[1*] ,Ali Ahmadpour[2]

Abstract:

Determination of pore size distribution of the porous materials is used for design and improvement of several systems including heterogeneous catalysts, mass transfer in porous materials, separation processes, removal of various pollutants, gas storage and physical adsorption. Three activated carbons are synthesized in a rotary reactor at different activation times. The adsorption isotherms of the samples are measured .The pore size distribution of the samples is determined using combined Saito and Foley method. An average potential function has been determined inside the cylindrical pores. The effect of activation time on the pore size distribution samples was investigated.

Hydrodynamic Study of Phenol Adsorption onto Commercial Activated Carbon in Fixed Bed Column

Behzad Ehsani, Ali Asghar Ghoreyshi, Ghasem najafpour*

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Abstract

Presence of phenol and its derivatives in most industrial effluents is a big hazard for human and environment. In this work, hydrodynamics of phenol adsorption on commercial activated carbon was studied in a fixed bed column with inner diameter of 1.25 cm and height of 30 cm. The shape of breakthrough curve and breakthrough time are very important to describe the performance of fixed bed column. The objective of current investigation was to determine the effect of different parameters on breakthrough curve, such as, initial concentration, flow rate and bed height. The obtained resutls indicated that by increasing initial concentration and flow rate, breakthrough carve became steeper. The obtained data also confirmed that the adsorption of phenol increased with increasing initial concentration and bed height. As flow rate increased from 5 to 7.5ml.min^{-1}, amount of uptake increased, afterward, by increasing flow rate from 7.5 to 10ml.min^{-1}, amount of adsorption decreased again. Removal percent also decreased with an increasing in inlet concentration and flow rate. Two kinetic models: Thomas and Yan models were applied to experimental data to predict the breakthrough behavior. Both models have good fitness with experimental data.

Pore size distribution prediction of activated carbon synthesized in different operating conditions

<u>Fateme Haghighatju</u>[1] ,Hassan Hashemipour Rafsanjani[1*] ,Ali Ahmadpour[2]

1. *Chemical Engineering Department, Shahid Bahonar University, Kerman, Iran*

2. *Chemical Engineering Department, Ferdowsi University of Mashhad, Mashhad, Iran*

*Corresponding Author's E-mail:h-hashemipour@uk.ac.ir

Abstract:

Determination of pore size distribution of the porous materials is used for design and improvement of several systems including heterogeneous catalysts, mass transfer in porous materials, separation processes, removal of various pollutants, gas storage and physical adsorption. Three activated carbons are synthesized in a rotary reactor at different activation times. The adsorption isotherms of the samples are measured .The pore size distribution of the samples is determined using combined Saito and Foley method. An average potential function has been determined inside the cylindrical pores. The effect of activation time on the pore size distribution samples was investigated.

Keywords: pore size distribution, saito foley, activated carbon

Research Highlights:

- Determination of PSD using isotherm data

- Synthesize of activated carbon

- Investigation of activation time on PSD of samples

1. Introduction

Activated carbons are porous carbonaceous materials that serve a broad range of practical application. The pore structure, as well as the specific surface area, of these materials can vary greatly with type of raw material, activation method and operating conditions. Activated carbons can contain pores in the macro- ($d > 50$ nm), meso (50 nm $> d > 2$ nm) and microporous ($d < 2$ nm) range [1]. The pore structure of a particular carbon is crucial to its practical application and so the determination of the pore size distribution (PSD) is an important characterization measurement. The measurement of the adsorption isotherm of N2 on the adsorbent, and the subsequent analysis of the data using the appropriate method obtains the PSD of the sample. The Dubinin-Astakhov (DA), Dubinin-Radushkevich (DR) and Horvath-Kawazoe (HK) methods are 'classical' methods to determine pore size distribution [2]. The HK method provides a mean by which the micropore and mesopore volume distribution by size is extracted. The original HK method is based on slit-shaped pores, however additions by Saito-Foley (SF) and Cheng-Yang extend the method to apply to cylindrical and spherical pores, respectively [2,3].

In this study, the PSD of several samples synthesized from Iranian coal are predicted using SF method. The samples were activated in different activation times and temperatures and the comparison of the PSD show the effect of operating parameter on the structural parameter of activated carbons.

2. Theory

Saito and Foley developed the cylindrical variation of the HK method. Two types, a line averaged and an area averaged model, were examined. The equation of cylindrical potential was taken from the works of Everett and Powl [3] :

$$\ln\left(\frac{p}{p0}\right) = 37.58 \sum_{k=0}^{\infty}\left[\frac{1}{2k+1}\left(1 - \frac{0.32}{rp}\right)^{2k}\left\{\frac{21}{32}\alpha k\left(\frac{0.32}{rp}\right)^{10} - \beta k\left(\frac{0.32}{rp}\right)^{4}\right\}\right] \tag{1}$$

Horvath and Kawazoe [1] introduced a simple method for calculation of the micropore size distribution from a single adsorption isotherm. Later, Jaroniec et al. [3] developed an equivalent procedure based on the adsorption potential distribution which is used in this study. In this procedure, with assumption of the condensation approximation, the pore volume distribution J(rp) $= \frac{dV}{drp}$ (where r_p is a pore width and V is the amount adsorbed expressed in cm^3 of liquid adsorbate per gram of the adsorbent) can be related to the adsorption potential distribution through the following equation:

$$J(rp) \equiv \frac{dV}{drp} = \left(\frac{dV}{dA}\right)\left(\frac{dA}{drp}\right) \tag{2}$$

The adsorption potential A is equal to the change in the Gibbs free energy of adsorption with the minus sign: $A = -\Delta G = RT\ln(p_o/p)$. The pore size ($r_p$) is defined as a distance between the walls of the pore rather than the distance between the centers of atoms, which form first layers of the opposite pore walls. The differential adsorption potential distribution function *X(A)* is defined as

$$X(A) = -\frac{dV(A)}{dA} \tag{3}$$

3. Experiments

The selected coal sample is a bituminous coal from Goltoot mine which is located in the Kerman province in Iran. The proximate analysis of the as-received coal sample is shown in Table 1. The proximate analysis was carried out with LECO instrument model MAC-400 and sulfur analysis with LECO instrument model SE-32. The coal with particle size 0.35-0.7 mm was selected as raw material. Washing in heavy media is used for ash washing of the coal samples with the final ash content about 8%. This low ash coal is used as raw material for the experiments. The process of pre-oxidation, charring and activation of the coal sample carried out in a rotary kiln reactor. The reactor was a quartz glass tube with a 25 mm diameter and 100 mm length heating zone. The charring step of the samples as heating of oxidized coal at temperature 410 ^oC in the nitrogen flow stream during for 1 hr are good enough to yield a char without softening and swelling at high operating condition of the activation process. Pore development during activation within carbon matrix of char is the most important step for char activation. By these experiments, the effects activation time on porous structure of activated carbon are studied. The adsorption isotherm was measured by nitrogen adsorption at temperature 77 K with Autosorb AP-1 apparatus (Quantachrome Corp.).

4. Results and discussion

Activation of the char sample was carried out in temperature 830°C at different activation times 3.5, 5.5 and 7.5 hr. The isotherm data of the three synthesized samples were shown in Figure 1. On the basis of Eq. (2), the pore volume distribution *J(r_p)* can be calculated by multiplying the adsorption potential distribution by the negative derivative of the adsorption potential with respect to the pore width: $-(dv/dr_p)$. Therefore, the latter quantity needs to be obtained for a specified pore size range and pore geometry. Using the isotherm data and equations 1 and 2, the programming code in Matlab software was prepared to calculate PSD of the samples based on the SF method. The results are shown in Figure 2.
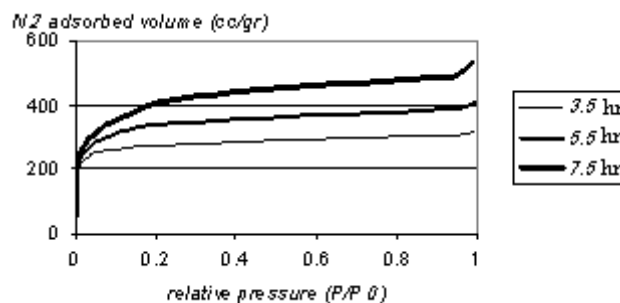
Fig.1. N$_2$ adsorption isotherms of the activated carbon produced by the steam activation
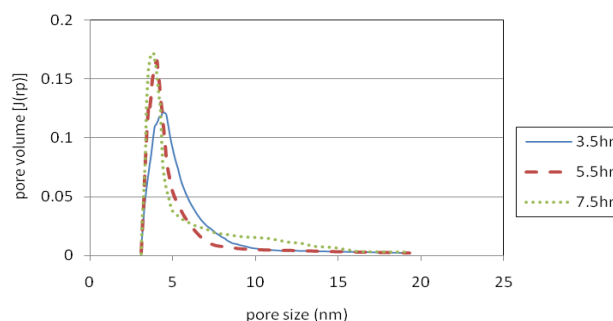

Fig.2. SF pore size distributions calculated from the adsorption isotherms

The PSDs show that increasing activation time is preferred to develop the smallest mesopore with higher volume. This improves the surface area and porosity of the activated carbon.

5. Conclusions

The activated carbons synthesized in different activation times show different PSD calculated using SF method. Improvement in activation time causes improvement is volume of the smallest mesopore.

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