Journal of Colloid and Interface Science 433 (2014) 94–103

Contents lists available at ScienceDirect

Journal of Colloid and Interface Science

www.elsevier.com/locate/jcis

Chars from gasification of coal and pine activated with K_2CO_3: Acetaminophen and caffeine adsorption from aqueous solutions

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ARTICLE INFO

Article history:
Received 28 April 2014
Accepted 22 June 2014
Available online 3 July 2014

Keywords:
Gasification
Pine chars
Activated carbons
K_2CO_3 activation
Micropore size distribution
Surface chemistry
Acetaminophen adsorption
Caffeine adsorption

ABSTRACT

The high carbon contents and low toxicity levels of chars from coal and pine gasification provide an incentive to consider their use as precursors of porous carbons obtained by chemical activation with K_2CO_3. Given the chars characteristics, previous demineralization and thermal treatments were made, but no improvement on the solids properties was observed. The highest porosity development was obtained with the biomass derived char (Pi). This char sample produced porous materials with preparation yields near 50% along with high porosity development ($A_{BET} \approx 1500\ m^2\ g^{-1}$).

For calcinations at 800 °C, the control of the experimental conditions allowed the preparation of samples with a micropore system formed almost exclusively by larger micropores. A mesopore network was developed only for samples calcined at 900 °C. Kinetic and equilibrium acetaminophen and caffeine adsorption data, showed that the processes obey to a pseudo-second order kinetic equation and to the Langmuir model, respectively. The results of sample Pi/1:3/800/2 outperformed those of the commercial carbons. Acetaminophen adsorption process was ruled by the micropore size distribution of the carbons. The caffeine monolayer capacities suggest a very efficient packing of this molecule in samples presenting monomodal micropore size distribution. The surface chemistry seems to be the determinant factor that controls the affinity of caffeine towards the carbons.

1. Introduction

Adsorption based technologies, particularly those using activated carbons, have been widely applied in depollution processes both in gaseous and liquid phase, *e.g.* decontamination of flue gas from power plants and wastewater treatments [1–4]. The good performance and versatility of activated carbons result from the combination of a highly developed pore structure (high specific surface areas, and micro and mesopore volumes) and the presence of heteroatoms (*i.e.* other than carbon) that create a diversity of surface functional groups [5,6].

A more extensive use of activated carbons in decontamination technologies requires a decrease in the production costs which can be achieved by using cheaper precursors. Therefore, the scientific community has been exploring abundant and renewable carbonaceous wastes as starting materials for the production of low cost and high performance activated carbons. In the literature, there are numerous studies reporting the viability of, for example, coconut shell [7], sisal [8], cork [9], palm shell [10] and rice husk [11], as activated carbon precursors.

In the particular case of wastewater treatment, the efficient removal of pharmaceutical compounds by residue-based activated carbons is demonstrated in several studies developed in recent years, for instance in our research group [8,9,12,13]. In this sense, we have recently focused our studies on the use of an unexplored waste as activated carbon precursor, *i.e.* residues produced from gasification process [14,15].

Gasification is an energy production technology alternative to combustion, in which the main target is the production of a syngas (CH_4, H_2, C_nH_m, CO_2 and CO), that may be used for energy production (in motors, turbines or fuel cells) or be enriched in H_2 [16]. In this process there is also the production of two types of solid residues: char (recovered from the reactor bottom), and fly ash (collected from the cyclone).

Contrarily to pyrolysis and combustion residues, that have been extensively explored [17–21], the possible use of gasification

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http://dx.doi.org/10.1016/j.jcis.2014.06.043
0021-9797/