Chemical Engineering Journal 218 (2013) 333–340

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Removal of bromide from water by adsorption on silver-loaded porous carbon spheres to prevent bromate formation

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HIGHLIGHTS

- Ag loaded porous carbon spheres (SLPCSs) are eminent in removing bromide from water.
- The adsorption fit well with Langmuir model and pseudo-second-order kinetic model.
- The performance of SLPCS improves with increasing temperature.
- The feasible pH value for Br^- removal is between 4 and 7, and the optimal value is 5.
- The Br^- adsorption can be impeded by Cl^-, I^-, NO_3^-, SO_4^{2-} and humic acid.

ARTICLE INFO

Article history:
Received 25 October 2012
Accepted 22 December 2012
Available online 29 December 2012

Keywords:
Adsorbent
Nanoparticle
Bromide removal
Activated carbon
Bromate removal
Silver-loaded porous carbon spheres

ABSTRACT

Bromate is a potential toxin that can be formed from bromide during the disinfection of drinking water by ozone. The performance of silver-loaded porous carbon spheres (SLPCSs) for removing the bromate precursor, bromide (Br^-), was investigated under a range of conditions. The saturated SLPCS were then regenerated and tested to determine reusability. Porous carbon spheres (PCSs) were also prepared by carbonization of spherical poly(vinylidene chloride) and their ability to remove bromide compared with SLPCS. SLPCS were more efficient adsorbents than PCS because of the presence of silver and their adsorption capacity reached as high as 1.20 mg/g at 25 °C under the experimental conditions used. The removal of Br^- by SLPCS was determined by batch and rapid small-scale column tests to assess the kinetic and dynamic adsorption behaviors. The equilibrium adsorption data fit well with the Langmuir isotherm and the Br^- adsorption process followed a pseudo-second-order kinetic model. Both removal efficiency and adsorption capacity improved with increasing temperature. The feasible range of pH for Br^- removal was between 4 and 7 and optimal performance was attained at pH 5. The presence of competitive species, such as Cl^-, I^-, NO_3^-, SO_4^{2-} and humic acid, resulted in poor Br^- adsorption, with their impact following the order: $I^- > SO_4^{2-} > NO_3^- > Cl^-$. In the presence of competitive species, the impact of pH was minor, except for the I^- anion. Regenerated SLPCS retained satisfactory performance.

1. Introduction

Bromate, formed from bromide dissolved in water during the ozonation process, is carcinogenic and mutagenic to humans [1–3]. To avoid bromate damage, many countries strictly control its concentration in drinking water. There are three main routes to bromate removal: namely, removal of bromide before ozonation, control of bromate formation during ozonation process, and direct removal of bromate after ozonation [3–10]. Amongst these, removal of bromide from drinking water sources prior to the ozonation disinfection process is considered to be a fairly effective and feasible method.

Many studies have been conducted on bromide removal. Electrochemical treatment is sufficient for removing bromide through oxidation, but it generates byproducts in the process [6]. Nanofiltration can also be used to remove this ion with good quality, but the high cost limits its large-scale application [11]. Coagulation is also considered to be an effective alternative for removing bromide. However, the treatment of sludge after coagulation must be considered seriously, as it contains most of the removed bromide, which is harmful to the environment.

Activated carbon is an effective adsorbent material widely used in water treatment. Corresponding research into the reduction and removal of various compounds from water are often presented, but

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http://dx.doi.org/10.1016/j.cej.2012.12.059