Chemical Engineering Journal 211–212 (2012) 406–411

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Removal of antimony(III) from aqueous solution by graphene as an adsorbent

Yanqiu Leng, Weilin Guo *, Shengnan Su, Chunliang Yi, Liting Xing *

College of Resources and Environment, University of Jinan, Jinan 250022, China

HIGHLIGHTS

- Graphene exhibited better adsorption capacity for antimony(III) from aqueous solutions.
- The adsorption kinetic shows good compliance with the pseudo-second-order kinetic model.
- Graphene showed excellent reusability during five cycles adsorption–desorption.

ARTICLE INFO

Article history:
Received 21 July 2012
Received in revised form 17 September 2012
Accepted 18 September 2012
Available online 5 October 2012

Keywords:
Graphene
Antimony(III)
Adsorption
Reusability

ABSTRACT

In this work, graphene is suggested as an adsorbent to remove Sb(III) from aqueous solution. Graphene was obtained using a modified Hummers' method and then investigated its ability to remove Sb(III) in solutions. The graphene was characterized by X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET) surface area and Zeta potential measurement. The adsorption of Sb(III) onto graphene was carried out under various conditions, that is, the initial concentration, the contact time, the solution pH and temperature. The adsorption data were successfully modeled using Langmuir ($R = 0.977$) and Freundlich ($R = 0.985$) isotherms. The kinetics of adsorption was also investigated. The experimental data showed a good compliance with the pseudo-second-order kinetic model, indicating the process was controlled by the chemical process. The calculated adsorption capacity q_e (8.056 mg/g) is in accordance with the experimental data (7.463 mg/g). In addition, graphene showed excellent reusability with 0.1 mol/L of EDTA solution as desorbing agent and could be used as a potential adsorbent in wastewater treatment.

1. Introduction

Antimony (Sb), a hazardous substance, ubiquitously exists in environment due to natural processes and human activities. In the present day, it is widely used in a variety of industrial products, such as fire retardants, batteries, cable covering, pigments, ceramics, and glass [1]. Due to its broad applications, a large amount of Sb-containing compounds is released annually into the environment. Antimony is increasingly considered to be a toxic heavy metal with possible carcinogenic effect on human health [2]. It is known that prolonged exposure to Sb compounds can cause irritation to the respiratory tract and may lead to pneumoconiosis [3]. Environmental concerns have been aroused and research efforts about source origins, biogeochemical behavior, and health effects of Sb have increased recently [4]. Antimony and its compounds are considered as pollutants of priority interest by United States Environmental Protection Agency (USEPA) and the council of the European Communities, and the maximum admissible Sb concentration in drinking water regulated by USEPA was 6 μg/L [5].

Antimony can exist in four oxidation states (−3, 0, +3, and +5), but it is generally found in Sb(III) and Sb(V). The trivalent inorganic forms of antimony are the most common species, and are known to be 10 times more toxic than pentavalent one [4,6]. In the present study, a large number of methods, including reverse osmosis [7], solvent extraction [8], reduction and precipitation [9], ion exchange [10] and adsorption [11] have been used for the removal of antimony from aqueous solution. Among these methods, adsorption method is one of the most effective choices for the removal of heavy metal ions from aqueous solutions because of its low cost, simplicity, rapidness and high efficiency [11]. Zhao et al. demonstrated that sodium montmorillonite has a good adsorption capacity for antimony acetate, but the adsorption temperature is 120 °C which is too high to operate [12].

Graphene, a single atomtic layer of sp^2 carbon atoms, has attracted tremendous scientific attentions on account of its exceptional properties, such as extraordinary electronic and mechanical properties [13,14]. It has enormous applications in sensors, batteries, nanoelectronics, hydrogen storage and nanocomposites [15]. The large theoretical surface area (theoretical surface area of 2630 m^2/g) provided the excellent adsorption capacity of graphene [14]. Due to this property, many investigations have been carried on utilizing graphene as an adsorbent to remove contaminants from

* Corresponding authors. Tel./fax: +86 531 8276 9233.
E-mail address: chm_guowl@ujn.edu.cn (W. Guo).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.09.078