Available online at www.sciencedirect.com
ScienceDirect
RARE METALS
RARE METALS, Vol. 27, No. 2, Apr 2008, p. 153

Sorption behavior of iminodiacetic acid resin for indium

XIONG Chunhua and YAO Caiping

Department of Applied Chemistry, Zhejiang Gongshang University, Hangzhou 310035, China

Received 8 February 2007; received in revised form 19 March 2007; accepted 25 March 2007

Abstract

In(III) was quantitatively adsorbed by iminodiacetic acid resin (IDAAR) in the medium of pH = 4.52. The statically saturated sorption capacity of IDAAR is 235.5 $mg \cdot g^{-1}$. 1.0 $mol \cdot L^{-1}$ HCl can be used as an eluant. The elution efficiency is 97.9%. The resin can be regenerated and reused without apparent decrease of sorption capacity. The sorption rate constant is $k_{298} = 1.94 \times 10^{-5}\ s^{-1}$. The apparent sorption activation energy of IDAAR for In(III) is 20.1 $kJ \cdot mol^{-1}$. The sorption behavior of IDAAR for In(III) obeys the Freundlich isotherm. The enthalpy change is $\Delta H = 17.2\ kJ \cdot mol^{-1}$.

Keywords: iminodiacetic acid resin; indium(III); sorption; activation energy; enthalpy change

1. Introduction

The synthesis, characterization and sorption property of polymeric materials have been published in recent years [1-13]. Iminodiacetic acid resin (IDAAR) is a novel polymeric material containing the functional group $N(CH_2COOH)_2$. It has not only protons that can exchange with cations, but also oxygen and nitrogen atoms that can coordinate directly with metal ions. As a result, IDAAR can be widely used in the sorption of metal ions. In this article, the sorption properties of IDAAR for In(III) were investigated. A lot of basic sorption parameters were determined. The experimental results may be used in recovery, purification and refining In(III) in hydrometallurgy.

2. Experimental

2.1. Materials

IDAAR (purchased from Shanghai Resin Co., Ltd.) was activated before use. Standard solutions of In(III) and Zn(II) were prepared from metals In and Zn with a purity of 99.99% and hydrochloric acid (AR), respectively. Buffer solution with pH 2.6-6.0 was prepared from HAc-NaAc. Other reagents were of AR grade.

2.2. Instruments

The instruments used in this study included Shimadzu UV-2550 UV-VISIBLE spectrophotometer, Mettler Toledo Delta 320 pH meter, DSHZ-300A temperature constant shaking machine, THZ-C-1 temperature constant shaking machine, SK5200LH ultrasonic cleaning instrument, Elemental Analyzer Vario EL, and IR Nicolet 380.

2.3. Experimental method

2.3.1. Sorption equilibrium experiment

A desired amount of the treated resin was weighed and added into a conical flask, and then a desired volume of buffer solution with pH 4.52 was added. After 24 h, a required amount of standard solution of In(III) was added. The flask was shaken in a shaker at constant temperature. The upper layer of clear solution was taken for analysis when the sorption equilibrium was reached. The sorption capacity (Q), distribution coefficient (D) and sorption efficiency (E) were calculated as follows:

$$Q = (C_0 - C_e)V/W,$$

$$D = Q/C_e,$$

$$E = (C_0 - C_e)/C_0 \times 100\%,$$

$$\beta_{In(III)/Zn(II)} = D_{In(III)}/D_{Zn(II)}.$$

where, C_0 is the initial concentration of In(III) in solution ($mg \cdot mL^{-1}$), C_e is the equilibrium concentration of In(III) in solution ($mg \cdot mL^{-1}$), V is the total volume of solution (mL), W is the resin weight (g), and β is the separation coefficient.

Corresponding author: XIONG Chunhua **E-mail:** xiongch@163.com

2.3.2. Analytical method

A solution containing lower than 75 μg of In(III) was accurately added into a 25 mL colorimetric tube, and then 1 mL of 0.5 vol.% xylenol orange solution and 10 mL of pH 3.6 HAc-NaAc buffer solution were added. After the addition of redistilled water to the mark of the colorimetric tube, the absorbency was determined in a 1 cm colorimetric vessel at a wavelength of 500 nm and compared with the blank test.

The method of measuring the concentration of Zn(II) ion can be found in Ref. [14].

2.3.3. Elution test

20.0 mg of resin was added into a mixed solution composed of pH 4.52 buffer solution and desired amount of standard solution of In(III). After the equilibrium was reached, the concentration of In(III) in the aqueous phase was determined, and then the sorption capacity of the resin for In(III) was obtained.

The separated resin from residual aqueous phase was washed thrice with pH 4.52 buffer solution. The resin adsorbed In(III) was shaken with eluant. After the equilibrium was reached, the concentration of In(III) in aqueous phase was determined and then the efficiency of elution was obtained.

3. Results and discussion

3.1. Influence of pH on the sorption efficiency

The test was carried out with the above-mentioned method. The effect of pH on the adsorption behavior of IDAAR for In(III) is shown in Fig. 1. The results indicate that the sorption efficiency (E) was the highest at pH 4.52 and decreased by either raising or lowering pH. So all the following experiments were carried out at pH 4.52.

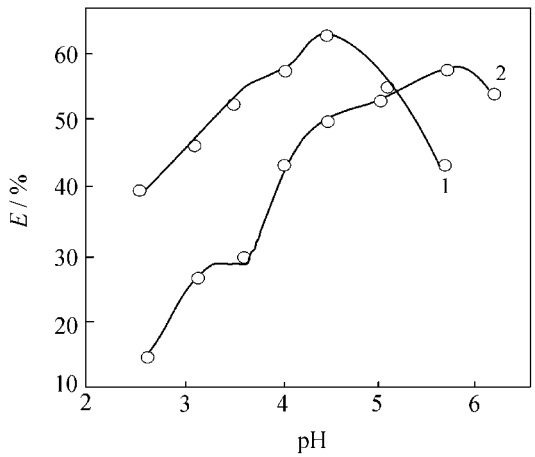

Fig. 1. Influence of pH on sorption efficiency: 1– In(III); 2 – Zn(II).

With pH = 2.6-3.7 (Fig. 1), the separation coefficient $\beta_{In(III)/Zn(II)}$ is 2.39-2.64. The result indicates that In(III) can be separated from Zn(II).

3.2. Determination of sorption rate constant of IDAAR

30.0 mg of resin was weighed accurately according to the experimental condition shown in Fig. 2. 0.25 mL of upper layer clear solution was taken out at intervals for the determination of residual concentration. After the remnant was kept at a constant and volume was corrected, a series of data was obtained and Fig. 2 was plotted. When the sorption amount is half that at equilibrium, the required time is $t_{1/2}$ = 9.8 h.

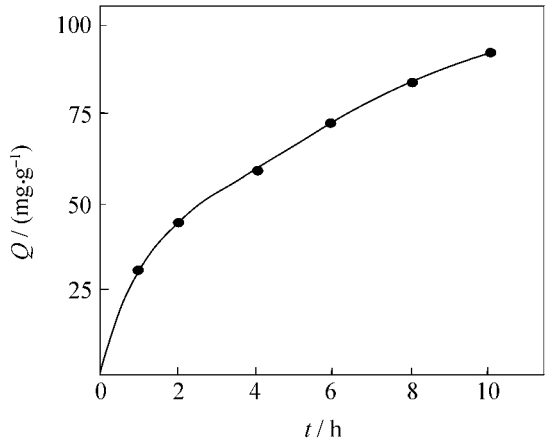

Fig. 2. Determination of sorption rate. $[In(III)]_0$ =275.0 mg·mL^{-1} and the mass of resin = 30.0 mg.

According to the Brykina method [15], the sorption rate constant k can be calculated from $-\ln(1 - F) = kt + B$, where $F = Q_t/Q_\infty$, Q_t and Q_∞ are the sorption amounts at certain time and at equilibrium, respectively. The slope of straight lines made by plotting $-\ln(1 - F)$ versus t (Fig. 3) yields the sorption rate constant k, which is $k_{288} = 1.38 \times 10^{-5}$ s^{-1}, $k_{298} = 1.94 \times 10^{-5}$ s^{-1}, $k_{308} = 2.51 \times 10^{-5}$ s^{-1}, and $k_{318} = 3.10 \times 10^{-5}$ s^{-1}, respectively. The correlation coefficient ($R^2 = 0.9937$)

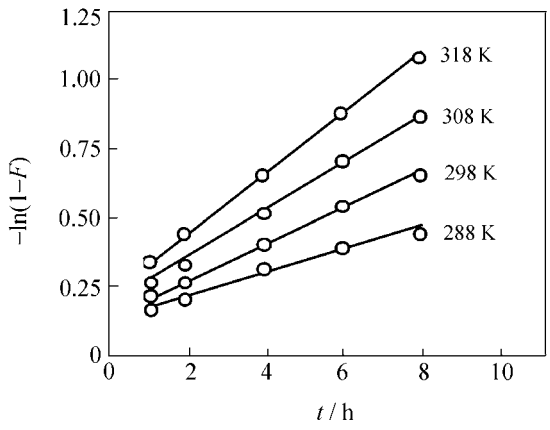

Fig. 3. Relationship of $-\ln(1 - F)$ to t. $[In(III)]_0$ = 225.0 mg·L^{-1} and the mass of resin = 30.0 mg.