SYNTHESIS AND CHARACTERIZATION OF NOVEL SORBENT FOR BORON REMOVAL

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Abstract

Excess intake of boron containing water can pose serious problems on human beings. Traditional technologies are limited by insufficient efficiency especially for trace boron removal. In this study, a novel sorbent was developed. A series of batch sorption experiments was conducted to investigate the boron sorption behaviors of the synthesized chitosan based sorbent. Our results show, comparing to raw chitosan, the boron uptake capacity of modified chitosan is significantly enhanced and the sorption capacity is determined to be 11.82 mg B/g sorbent. The equilibrium time of boron sorption can be achieved in less than 10 h. At a dose of 1.3 g/L, boron in seawater can be lowered to 0.5 mg/L to meet the WHO standard for drinking water.

Key words: Atom transfer radical polymerization; Boron; Chitosan; Sorption

1. Introduction

Boron is widely distributed in our environment, existing naturally in water, soils, plants and animals, or coming from human activities. Generally, boron is found in the form of boric acid or borate salts. Long-term consumption of water with increased boron content can cause nausea, headache, diarrhea, kidney damage, reproductive and nervous system disease, and even death [1, 2]. Consequently, the World Health Organization (WHO) has declared that the water quality for drinking water must meet the 0.5 ppm boron guideline [3]. The strict regulations bring about a great challenge to traditional water treatment technologies such as chemical precipitation, electrocoagulation, membrane process, adsorption on activated carbon (AC) and solvent extraction. However, these technologies are insufficient efficiency under normal conditions, especially for trace boron removal [4-6]. Polymers with high content of OH functional groups are able to bind boron in aqueous solutions. The aim of the study was to design and synthesize an innovative sorbent with good affinity for boron. Moreover, boron sorption behavior on the synthesized sorbent was investigated by batch experiments including isotherm, kinetics etc. The results from this work will be used for the preliminary understanding of the process, which is helpful for future optimization and modeling simulation.

2. Experimental

An innovative sorbent was prepared. Sorption kinetic experiments were conducted for determination of equilibrium time. Solution pH was initially controlled at 7. 0.5 gram of sorbents was added to boron solution with initial concentration at 5 mg/L. Samples were

taken at appropriate time intervals and boron concentrations were determined by ICP-ES.

In isotherm experiments, 40 ml of boron solution with various initial concentrations was prepared. A solution of pH 7 was adjusted initially. The airtight bottles were rotated on a shaker for 20 h to reach equilibrium. At the end of the experiments, 20 ml samples were extracted and filtered for analysis of boron concentrations.

3. Results and discussion

3.1. Sorption Kinetics

The rate of boron uptake on the synthesized sorbent is shown in Fig. 1. Most of boron adsorption rapidly takes place in the first 2 h, followed by a slightly slower process. The equilibrium can be attained within 10 h.

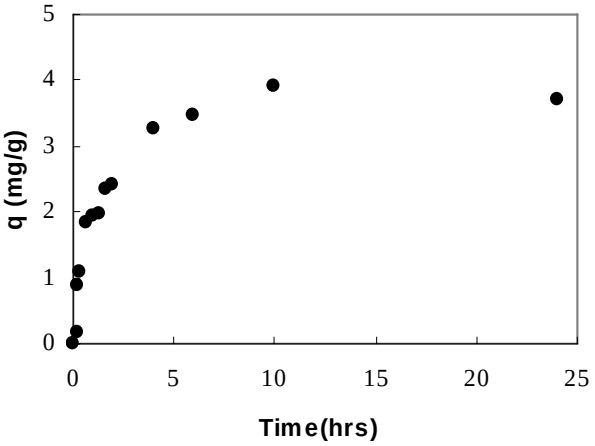

Fig. 1: Boron sorption kinetics by modified chitosan. m = 0.5 g/L.

3.2. Sorption Isotherm

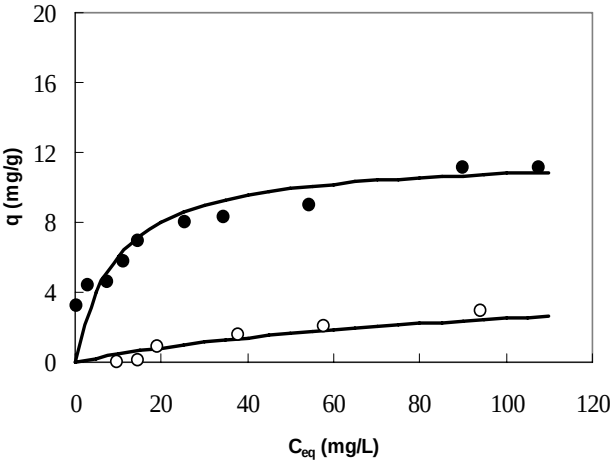

Fig. 2: Boron sorption isotherms by raw chitosan and modified chitosan. ○ Raw chitosan, ●Modified chitosan, — Langmuir fitting, m = 0.5 g/L.

The sorption isotherm on boron was investigated over a range of 2 to 120 ppm using 0.5 g/L dose of the sorbent (see Fig. 2). Obviously, the boron sorption of raw chitosan is very low in the range of 0 to 3 mg/g; and boron sorption capacity is definitely enhanced after modification, which is around 11.82 mg/g.

3.3. Boron Sorption from Seawater

In order to understand the sorption efficiency of newly synthesized sorbent to the actual water samples, seawater locally collected was used in sorption experiments. As shown in Fig. 3, boron initial concentration in West Coast seawater is about 4 mg/L. At 1.3 g /L of sorbent dose, boron concentration is below 0.5 mg/L to meet WHO standard.

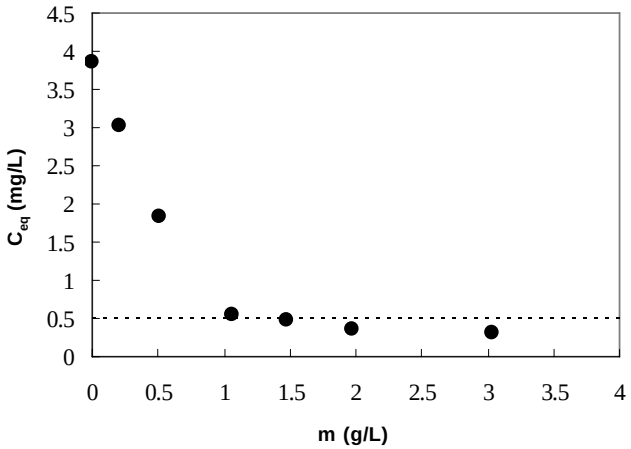

Fig. 3: Boron sorption from the coastal seawater

4. Conclusions

In this study, a new functional polymer sorbent is successfully prepared. Sorption of boron can reach equilibrium within 10 h. Isotherm study indicates the sorption can be well fitted by Langmuir isotherm model, as well as the sorption capacity of boron is around 11.82 mg/g, much higher than that of unmodified chitosan. The synthesized sorbent showed a potential applicability for boron removal from seawater.

References

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