Chemical Engineering Journal 217 (2013) 205–211

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Removal characteristics of copper by marine macro-algae-derived chars

Hye Jung Cho [a], Kitae Baek [b], Jong-Ki Jeon [c], Sung Hoon Park [d], Dong Jin Suh [e], Young-Kwon Park [a,f,*]

[a] Graduate School of Energy and Environmental System Engineering, University of Seoul, Seoul 130-743, Republic of Korea
[b] Department of Environmental Engineering, Chonbuk National University, Jeonju 561-756, Republic of Korea
[c] Department of Chemical Engineering, Kongju National University, Cheonan 331-717, Republic of Korea
[d] Department of Environmental Engineering, Sunchon National University, Suncheon 540-950, Republic of Korea
[e] Clean Energy Research Center, Korea Institute of Science and Technology, Seoul 136-791, Republic of Korea
[f] School of Environmental Engineering, University of Seoul, Seoul 130-743, Republic of Korea

HIGHLIGHTS

- Biochars derived from *Undaria pinnatifida* proved to be useful for the removal of copper.
- Physical activation with steam enhanced the adsorption of Cu.
- The pseudo-second order kinetic model explained well the adsorption kinetic data.

ARTICLE INFO

Article history:
Received 26 June 2012
Received in revised form 26 November 2012
Accepted 28 November 2012
Available online 7 December 2012

Keywords:
Macro-algae
Undaria pinnatifida
Pyrolysis
Char
Adsorption
Ion exchange
Cu

ABSTRACT

The char derived from the fast pyrolysis of macro-algae biomass, a brown alga *Undaria pinnatifida*, proved to be useful for the removal or recovery of copper from aqueous solutions. Even at a low dose of 0.1 g char/L, a high adsorption capacity was obtained. Physical activation with steam enhanced the adsorption of Cu, but chemical activation with a KOH solution decreased the adsorption capacity. A pseudo-second order kinetic model was used to explain the adsorption kinetics. The physically-activated char showed a Langmuir type of isotherm, and had a maximum adsorption capacity of 125.85 mg Cu/g. Based on the adsorption capacity, even at a low copper concentration, the char derived from the fast pyrolysis of *U. pinnatifida* is a valuable adsorbent for recovering copper from aqueous solutions.

1. Introduction

Copper (Cu) is one of most common heavy metals found in the environment and industrial wastewater because of its widespread use [1–5]. Generally, Cu could be removed by chemical precipitation as a form of $Cu(OH)_2$; however, the process produces large volume of sludge to be disposed. The chemical precipitation is not effective to treat low concentration of metal [6]. Recently, adsorption technology has been investigated to remove metals from water and wastewater because of the cost-effectiveness and easy operation [6,7]. Many researchers reported that various materials including biomass and industrial by-products could be applied to remove toxic metals or metalloids as adsorbents [1–5,7–9]. Additionally, biomass, such as wood, organic waste including sludge from wastewater/water treatment facilities and agricultural residue, has been used for oil production by fast pyrolysis [10–12]. More recently, seaweeds and marine/fresh micro-algae have attracted attention because of the huge amounts in marine environments. In addition, in Korea, macro-algae, such as brown algae, tangles, laver and sea lettuce, have been used as food for a long time. Recently, application of macro-algae to synthesis of bio-oil was also reported [13]. A by-product is generated by the pyrolysis of biomass; the most common by-products are gases and char. Pyrolytic gases can provide heat for the pyrolysis reactor, and char can be used for the production of activated carbon [14–16].

Activated carbon and/or char can remove a range of pollutants from an aqueous stream and air including volatile organic compounds, formaldehyde, polyaromatic hydrocarbons, halogenated compounds, heavy metals and oxyanionic compounds [17–19].

* Corresponding author at: Graduate School of Energy and Environmental System Engineering, University of Seoul, Seoul 130-743, Republic of Korea. Tel.: +82 2 2210 5623; fax: +82 2 2244 2245.
E-mail address: catalica@uos.ac.kr (Y.-K. Park).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.11.123