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Hydrogen peroxide modification enhances the ability of biochar (hydrochar) produced from hydrothermal carbonization of peanut hull to remove aqueous heavy metals: Batch and column tests

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HIGHLIGHTS

- H_2O_2 modification increases oxygen-containing functional groups on hydrochar.
- H_2O_2 modified hydrochar effectively removes aqueous heavy metals.
- H_2O_2 modified hydrochar can be used as an effective sorption media in filters.

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ABSTRACT

Biochar converted from agricultural residues can be used as an alternative adsorbent for removal of aqueous heavy metals. In this work, experimental and modeling investigations were conducted to examine the effect of H_2O_2 treatment on hydrothermally produced biochar (hydrochar) from peanut hull to remove aqueous heavy metals. Characterization measurements showed that H_2O_2 modification increased the oxygen-containing functional groups, particularly carboxyl groups, on the hydrochar surfaces. As a result, the modified hydrochar showed enhanced lead sorption ability with a sorption capacity of 22.82 mg g^{-1}, which was comparable to that of commercial activated carbon and was more than 20 times of that of untreated hydrochar (0.88 mg g^{-1}). When used as filter media in a packed column, the modified hydrochar was also much more effective in filtering lead than the unmodified one. The lead removal capacity of the modified hydrochar packed column was about 20 times of that containing untreated hydrochar. In a multi-metal system, the modified hydrochar column still effectively removed lead, as well as other heavy metals (i.e., Cu^{2+},Ni^{2+}, and Cd^{2+}) from water flow. Model results indicated that the heavy metal removal ability of the modified hydrochar follows the order of $Pb^{2+} > Cu^{2+} > Cd^{2+} > Ni^{2+}$. Findings from this work suggest that H_2O_2-modified hydrochar may be an effective, less costly, and environmentally sustainable adsorbent for many environmental applications, particularly with respect to metal immobilization.

1. Introduction

Biochar, an emerging carbon material produced mainly from low-cost biomass residuals, has received much attention recently in the science community because of its promising potentials in many environmental applications, including carbon sequestration, soil improvement, water treatment, and environmental remediation [1–3]. Although biochar can be produced using various thermal conversion methods, most of current research has been focused on biochar converted from slow or fast pyrolysis (i.e., dry pyrolysis) [4]. Only few studies have been conducted examining the potential environmental applications of biochars produced by alternative thermal conversion technologies such as hydrothermally produced biochar (hydrochar) [4–6].

Hydrochar refers to the solid char product from hydrothermal carbonization (HTC) of carbon-rich biomass in the presence of subcritical liquid water, which is also called hydrous pyrolysis or wet pyrolysis [7–9]. The HTC process usually employs relatively low

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