Cu-loaded biochar derived from pyrolysis of contaminated Panicum virgatum: Encapsulation and Use for the removal of phenolic compounds from wastewater

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Abstract

The remediation of heavy metal polluted soil and water by means of plant biomass is regarded as an environmentally benign treatment approach; nevertheless, the disposal of such heavy metals-laden biomass represents a challenge. In this study, Panicum virgatum is selected as a biomass model due to its broad application in phytoremediation treatment. Cu (II)-impregnated biomass was obtained through a biosorption process, and the Cu (II) uptake was optimized by response surface methodology, followed by pyrolysis of the Cu (II)-contaminated biomass in a nitrogen atmosphere. This research hypothesis is that the encapsulation of metal-laden biochar, derived from pyrolysis of contaminated biomass, inside a polymer framework constitutes an improved method to value the biochar as a green adsorbent. Thus, the so-produced Cu-loaded biochar was encapsulated in alginate hydrogel bead via an ionotropic gelation technique for further investigation in wastewater treatment. The chemical structure and thermal stability of the produced beads were characterized using Fourier transform-infrared (FTIR) spectroscopy and thermogravimetric analysis (TGA). The effect of different adsorption parameters such as contact time, adsorbent dosage, initial concentration, temperature was examined using design of experiments for batch system optimization. The preliminary results of using the developed biochar-alginate hydrogel beads show a 15% of Bisphenol A (BPA) removal under 30 min adsorbent-adsorbate contact time. Further investigation is underway, and more results will be available and presented.

Keywords: Contaminated biomass, pyrolysis, batch adsorption, wastewater treatment, By-product utilization, biochar, alginate hydrogel

Introduction

Removal of metal-contaminated environment through plant remediation has drawn considerable focus in recent years. Thus, the phytoremediation has been regarded as an attractive, cost-effective, and sustainable remediation treatment [1]. Meanwhile, biomass acts as an adsorbent material for heavy metals in polluted aquatic media. Areco et al. (2013) reported that *avena fatua* biomass could successfully be utilized as an adsorbent for heavy metals [2]. Consequently, the proper handling and disposal of metal-enriched biomass resulting from phytoremediation are critical and crucial. Among the reported technologies, pyrolysis was identified as a promising and effective waste treatment technique since the contaminated biomass could be converted to three valuable by-products, including biochar, bio-oil, and gases [1]. To date, there have been limited studies investigating the reuse of metal-loaded biochar for the treatment of contaminated aquatic environments. Gong X et al. (2018) demonstrated the feasibility of reusing biochar obtained from the pyrolysis heavy metal-contaminated ramie residues as sorbent for methylene blue removal from wastewater.

Scientific relevance

The significance of this work is to investigate the reuse capability of Cu-laden biochar, encapsulated in alginate hydrogel beads, derived from pyrolysis of contaminated biomass for removal of phenolic compounds from aqueous solutions. To the best of our knowledge, no studies have been conducted regarding the application of biochar derived from contaminated biomass to remove Bisphenol A (BPA) where the idea of this work was born, therefore the phenolic compounds are also found in pyrolytic bio-oil which further consolidates the selection criteria of this toxic pollutant.

Materials and methods

Panicum virgatum (switchgrass) was washed and oven-dried at 104°C for 24h. the dried biomass was milled by a Thomas Wiley laboratory mill, and approximately 1 mm particles were stored for later use in pyrolysis experiments (Figure 1).

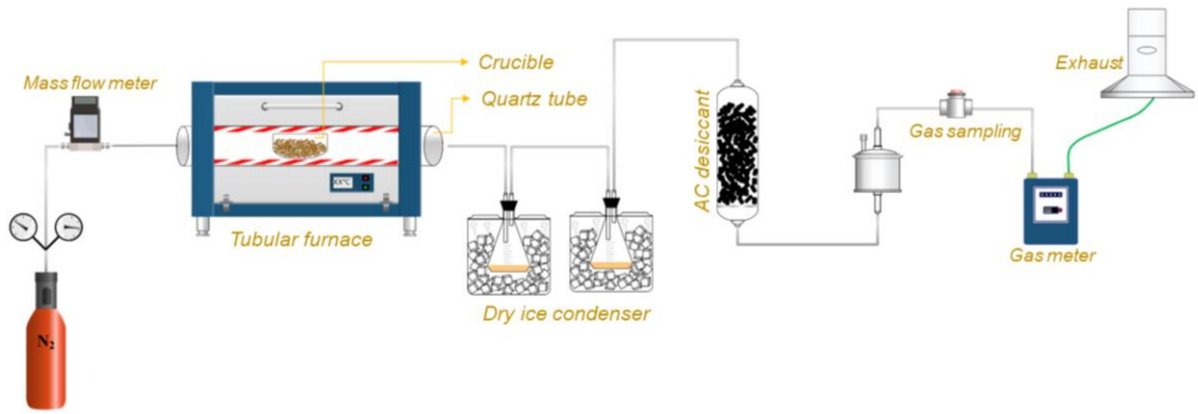

Figure 1. Schematic of pyrolysis apparatus at lab-scale

Preliminary results

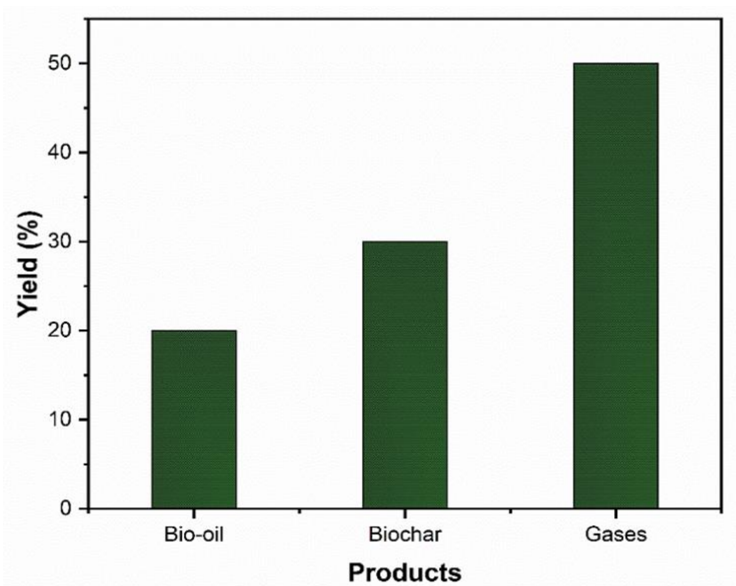

Figure 2. Product's yield obtained from pyrolysis of Cu-contaminated panicum virgatum (operating conditions: T= 800 °C, heating rate = 10°C/min with residence time of 15 min)

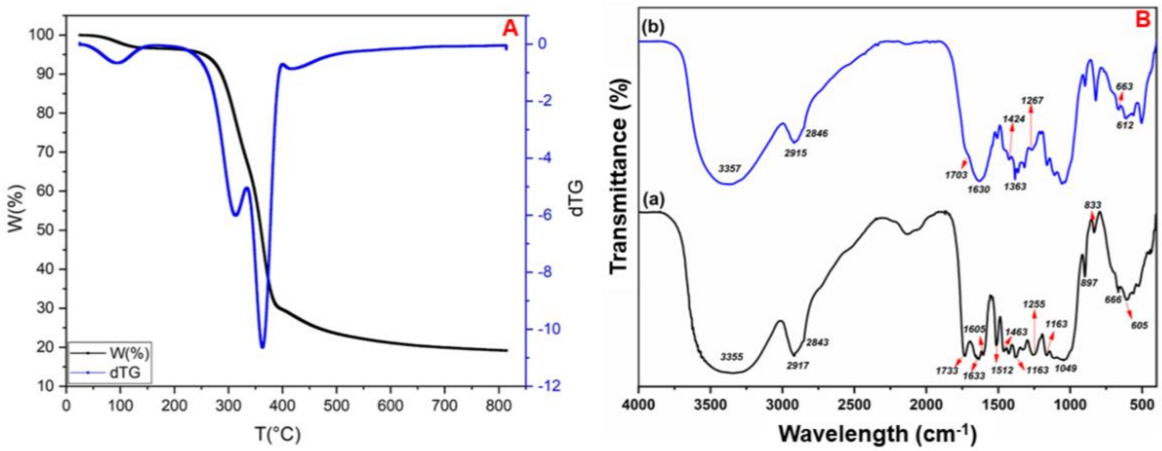

Figure 3. (A) TGA of panicum virgatum and (B) FTIR spectra of (a) uncontaminated and (b) contaminated panicum virgatum

References

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