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ORIGINAL PAPER

Cr(III) dynamic removal in a fixed-bed column by using a co-gasification char

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Abstract
A char (GC) obtained from the co-gasification of rice husk and polyethylene was used in a fixed-bed column with continuous flow for Cr(III) removal assays from synthetic and industrial wastewaters. For comparison purposes, a commercial activated carbon (CAC) was also used. The best experimental conditions in the continuous removal assays were the following ones: Cr(III) inflow concentration = 5 mg L^{-1}, feed flow rate = 3 mL min^{-1}, mass of adsorbent in the column = 0.8 g, and inflow temperature = 50 °C. Under these conditions, the highest uptake capacities were 1.60 and 2.14 mg g^{-1} in the synthetic solution, and 3.25 and 7.83 mg g^{-1} in the industrial wastewater, for GC and CAC, respectively. These results are different from those obtained under batch conditions in which GC performed better than CAC. Cr(III) removal by both adsorbents occurred due to precipitation, but CAC presented a slightly higher amount of Cr(III) removed due to its highest porosity. The regeneration of GC and CAC was also studied, but both adsorbents showed no capacity to be used in more than one cycle. This study highlighted the importance of studying Cr(III) removal under continuous conditions, as the removal mechanisms may be completely different from the batch assays, affecting the adsorbents' performance.

Keywords Chars · Cr(III) recovery · Fixed-bed column · Rice wastes · Wastewater

Introduction

Gasification is a thermochemical process that occurs in a partial oxidation environment under a sub-stoichiometric amount of oxygen. Through gasification, wastes can be thermally converted into high-added value products. Syngas is the main energy product of gasification, being composed of CO, H_2, CH_4, and a mixture of other minor gases (Guo et al. 2016). However, a carbonaceous solid by-product, with a relatively high ash content, commonly known as char, is also produced (You et al. 2017). This char can be used as-produced or activated for catalytic and adsorption applications (Benedetti et al. 2018; Buentello-Montoya et al. 2019).

In the last decade, an increasing interest in using chars in wastewater treatment has been noticed in the literature (Fu and Wang 2011; Peng et al. 2014; Inyang et al. 2016; Bernardo et al. 2017; Li et al. 2020). The specific properties of chars that make them useful as adsorbents of pollutants include a relatively porous structure, functional groups, and/or mineral clusters over the surface (You et al. 2017). As adsorbents, chars resemble some properties of activated carbons which are frequently used for the removal of diverse pollutants from water and wastewaters. Compared to the commercial activated carbons, chars are cheaper and with effective adsorption capacity. The feedstocks for char production are abundant and of low-cost, being mainly obtained from agroforestry biomass and solid bio-wastes (Palanivelu et al. 2020).

Given the high potential of chars as metal adsorbents through precipitation, complexation, electrostatic attraction, and ion exchange mechanisms (Abbas et al. 2018), the authors previously studied the removal of Cr(III) from

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