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Ball-milled biochar for galaxolide removal: Sorption performance and governing mechanisms

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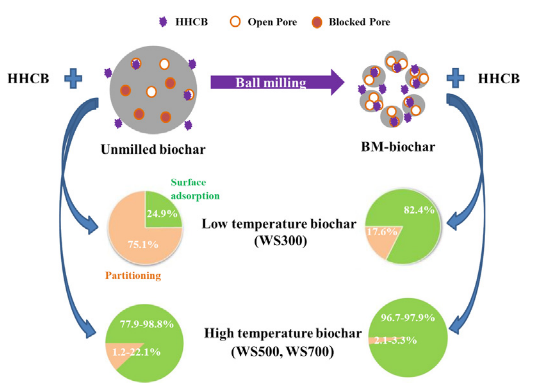
HIGHLIGHTS

- BM-biochars were synthesized combining the advantages of ball-milling and biochar technologies.
- Ball milling increased the external and internal surface area of biochars.
- Ball milling increased sorption ability of biochars to HHCB.
- 77.9% of HHCB removal was due to surface adsorption for WS500.
- 96.7% of HHBC removal was due to surface adsorption for BMWS500.

GRAPHICAL ABSTRACT



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ABSTRACT

The environmental risk of galaxolide (HHCB) spurs the need to develop efficient and economical removal technology. Although sorption is one of the best removal approaches, studies on sorption of HHCB by biochar were limited. With the purpose of combining the advantages of ball-milling and sorption technologies, six ball-milled biochars (BM-biochars) varied with biomasses and pyrolysis temperature were produced, characterized, and tested for HHCB removal from aqueous solution. At an initial HHCB concentration of 2 mg L^{-1}, the unmilled and BM-biochars adsorbed 330–746 and 609–2098 mg kg^{-1} of HHCB, respectively. The increase in sorption capacities (about 3-fold increase) was mainly ascribed to the increase in BM-biochar's external and internal surface area, pore volume and pore size, and the exposure of the graphitic structure. The removal of HHCB by the BM-biochars increased with increasing pyrolysis temperature. For lower temperature biochar (300 °C wheat straw biochar, WS300), hydrophobic partitioning played a major role in HHCB sorption onto unmilled biochar (log K_{oc}/log K_{ow} value of WS300 was 0.772 at a C_e of 1 mg L^{-1}). Ball milling reduced the hydrophobicity of 300 °C biochar, which diminished the HHCB sorption. However, increased surface area, pore volume, pore size, and graphitic structure provided additional sorption sites, resulting in enhanced HHCB uptake (log K_{oc}/log K_{ow} value of BMWS300 was 1.23 at a C_e of 1 mg L^{-1}). For higher temperature biochars (500 and 700 °C), ball milling mainly enhanced HHCB sorption onto high temperature biochars via surface adsorption, π-π interaction, and pore filling. For WS500, 77.9% of HHCB removal was due to surface adsorption. Ball milling increased this percentage to 96.7% for BMWS500. This work highlighted the potential of ball milling as an excellent engineering method to improve biochar's sorption properties.

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