

## Adsorption of Metal Cations using Low-Cost Biochar Modified by HNO<sub>3</sub> and KMnO<sub>4</sub>

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**Abstract:** A low-cost biochar (CP) derived from carbonization of palm kernel cake residue was modified with HNO<sub>3</sub> (CPHNO<sub>3</sub>) and KMnO<sub>4</sub> (CPMn) in order to improve the selectivity for adsorption of metal cations such as Fe(III), Fe(II), Ca(II) and/or Zn(II) from aqueous solution. The physicochemical properties of the as-prepared adsorbents were investigated by pH<sub>pzc</sub>, FT-IR, Boehm titration, TG-DTG and SEM techniques. It is found that all modified adsorbents exhibited negative charge surface properties (based on pH < pH<sub>pzc</sub>) with the existence of high carboxylic group and lone electron pairs (Lewis bases), leading to excellent adsorption capacity of metal cations (Lewis acids) via electrostatic force and creation of coordinate covalent bond. The synergistic effects between carboxylic groups and MnO<sub>2</sub> on CPMn surface resulted in better capacity than CPHNO<sub>3</sub> in metal adsorption process. The highest capacities for adsorptions of Fe(III), Fe(II), Ca(II) and Zn(II) using CPMn were 52.4, 60.2, 4.5 and 16.3 mg/g, respectively. For comparison, Fe(II) was found to be more easily adsorbed on modified adsorbent than the other types of metal cations. This research is expected to understand the adsorption behaviors of metal cations using the as-prepared adsorbent.

**Keywords:** Biochar; Palm kernel cake; Metal cation; Adsorption; MnO<sub>2</sub>