

THE APPLICATION OF PYROLYSIS BIOCHAR FOR WASTEWATER TREATMENT

S. Kaliaguine, Department of Chemical Engineering, Laval University, Québec, Canada
Serge.kaliaguine@gch.ulaval.ca

Raouf Bardestani, Department of Chemical Engineering, Laval University, Québec, Canada

Key Words: Pyrolysis; Biochar; Oxidation; Cation exchange; Lead

Pyrolysis as a common method of biocrude oil and biochar productions, is the thermal conversion of biomass under limited concentration of oxygen. Biochar, the solid product of pyrolysis process, is largely used in the applications connected with surface density of acidic functional groups (FGs) and biochar specific surface area (SSA), such as adsorption, catalysis, and soil amendment. In this work, the application of pyrolysis biochar in the adsorption of lead cations from aqueous solutions was investigated. Biochar was provided by Pyrovac Inc. (Québec, Canada) from shredded wood comprising 20% volume of spruce/fir and 80% pine (stem of *Pinus strobus* without bark). The pyrolysis was performed at 475°C for 1 h under atmospheric pressure, resulting in a biochar yield of 27.8% on a feedstock anhydrous basis.

Our results showed that, as expected, untreated biochar has a very low tendency to adsorb lead cations, owing to the low surface density of oxygen-containing FGs. In order to increase the cation exchange capacity (Q) of the biochar, mild air oxidation was implemented under the following conditions: $m_{\text{char}} = 2 \text{ g}$, $T = 200^\circ\text{C}$, $t = 60 \text{ min}$, $Q_{\text{air}} = 165 \pm 10 \text{ cm}^3 \text{ min}^{-1}$. Mild air oxidation then increased the total concentration of acidic surface FGs from 2.2 to 6.8 mmol g^{-1} , which was quantified using Boehm titration. This improvement upon the simple mild air oxidation, thus, increased the biochar adsorption capacity of Pb^{2+} under equilibrium adsorption conditions of $m_{\text{char}} = 0.5 \text{ g}$ per 50 cm^3 , $C_{\text{Pb}^{2+}} = 1000 \text{ ppm}$, $\text{pH} = 5$, and $t = 48 \text{ h}$, from 2.5 to 44 mg g^{-1} . These results are comparable with those of biochar chemically modified by using acids, bases, and salts such as H_2SO_4 , KOH , and KMnO_4 , as reported in literature¹⁻³.

The external surface of biochar was investigated by XPS and SEM/TEM analyses. The deconvolution of C_{1s} XPS photo-line showed that the most significant increase in the XPS peak area upon oxidation was obtained for the one attributed to carboxylic FGs, from 1.7 to 8.2%. Comparing XPS peak areas of oxidized biochar before and after the equilibrium adsorption, suggested that carbonyl and carboxylic FGs on the outer surface of oxidized biochar, as well as aromatic rings, participated in Pb^{2+} removal. SEM showed that biochar surface was loaded with lead cations, heterogeneously, especially at the edge of particles surface ducts.

References

- (1) Ding, Z.; Hu, X.; Wan, Y.; Wang, S.; Gao, B. Removal of lead, copper, cadmium, zinc, and nickel from aqueous solutions by alkali-modified biochar: Batch and column tests. *J. Ind. Eng. Chem.* 2016, 33, 239–245.
- (2) Wang, S.; Gao, B.; Li, Y.; Mosa, A.; Zimmerman, A. R.; Ma, L. Q.; Harris, W. G.; Migliaccio, K. W. Manganese oxide-modified biochars: Preparation, characterization, and sorption of arsenate and lead. *Bioresour. Technol.* 2015, 181, 13–17.
- (3) Wongrod, S.; Simon, S.; Guibaud, G.; Lens, P. N. L.; Pechaud, Y.; Huguenot, D.; van Hullebusch, E. D. Lead sorption by biochar produced from digestates: Consequences of chemical modification and washing. *J. Environ. Manage.* 2018, 219, 277–284.