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Advanced Application of Heavy Metals-laden Biochar after Wastewater Treatment for Supercapacitors

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Biochar is a C-rich material obtained from biomass pyrolysis. Biochar has been proven as an effective sorbent for the removal of metals in water and wastewater. The biochar after metal sorption (exhausted biochar) could be a potential hazardous waste which could lead to secondary pollution and be harmful to the surrounding environment. Until now, there is no research exploring the reuse of exhausted biochar. This study attempted to create a novel way of reuse by converting the metal-loaded biochar into supercapacitor.

Biochars were produced from wood chips, dairy manure and sewage sludge and subjected to loading of Ni(II), Co(II) and Mn(II) from aqueous solutions. The metal-loaded biochar underwent microwave or plasma oxidation treatments for fabrication as a supercapacitor. The specific capacitance of biochar supercapacitor increased with metal-loading, especially for the loaded biochar after treatment with microwave or plasma, in which the capacitance increased by over 2-5 times compared to the raw biochar supercapacitors. The increase of capacitance in the metal-loaded biochar supercapacitor was mainly attributed to the conversion of Ni(II), Co(II) and Mn(II) into NiO/NiOOH, CoO/Co_2O_3 and MnO/MnO_2, respectively, evidenced by X-ray diffraction and X-ray photoelectron spectroscopy. The biochar supercapacitors, especially oxidized metal-loaded biochar supercapacitors, exhibited the high stability of specific capacitance with only less than 2% loss after 1000 charge-discharge cycles.

This study demonstrated that metal-loaded biochar can be further utilized for generation of supercapacitor, providing a potential way for the reuse of exhausted carbonaceous sorbents. More importantly, the way created in this work may not only solve the metal-laden sorbent waste disposal but also expand utilization of biochar as an effective energy storage device, both of which has a great significance of environmental sustainability.