Organic Coating on Biochar Explains Its Nutrient Retention and Stimulation of Soil Fertility

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Results and Discussion

Biochar is the product of O2-limited thermal treatment of biomass (pyrolysis) and is used in agriculture as a livestock feed supplement, compost additive and soil amendment as well as for manure treatment. It is applied to improve animal, plant and soil health, to reduce nutrient losses by volatilization or leaching, to prevent soil erosion, and to improve soil water retention, soil carbon content and the long-term fertility of agricultural soils. Biochar is very recalcitrant and can contribute to climate change mitigation by the sequestration of stable carbon and reduction of agricultural emissions of CO_2, N_2O and CH_4. Amending soil with biochar (pyrolyzed biomass) is suggested as a globally applicable approach to address climate change and soil degradation by carbon sequestration, reducing soil-borne greenhouse-gas emissions and increasing soil nutrient retention. Here we identify a complex, nutrient-rich organic coating on co-composted biochar that covers the outer and inner (pore) surfaces of biochar particles using high-resolution spectro (micro)scopy and FT-ICR mass spectrometry. Fast field cycling nuclear magnetic resonance, electrochemical analysis and gas adsorption demonstrated that this coating adds hydrophilicity, redox-active moieties, and additional mesoporosity, which strengthens biochar/water interactions and thus enhances nutrient retention. This implies that the functioning of biochar in soil is determined by the formation of an organic coating, rather than biochar surface oxidation, as previously suggested. We characterized the coating in situ with mass spectrometry and spectroscopic techniques across a range of both spatial and energy resolutions to identify the chemical and physical properties of the surface modification.

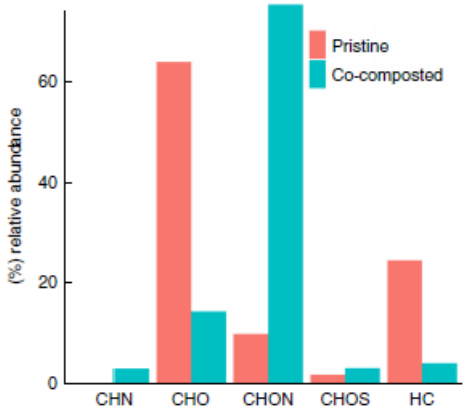

Fig. 1 In situ characterization of the organic coating by DAPPI FT-ICR MS. Relative abundance of C, H, O, N and S bearing compound classes on the surface of pristine and co-composted biochar according to desorption atmospheric pressure photoionization Fourier-transformed ion-cyclotron resonance mass spectrometry (DAPPI FT-ICR MS). DAPPI FT-ICR MS applied to biochar particles provides precise information on the elemental composition of compounds available for desorption on the biochar surface. According to DAPPI FT-ICR MS, co-composting increased the relative abundance of CHON (CWHXOyNz) class compounds and decreased the relative abundance of CHO (CxHyOz) class compounds (Fig. 3).

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References

[1] Hagemann, N., *et al.*, Nature Commun., 8(1089), 1-11 (2017).