Biomass-based biochar obtained by low-temperature pyrolysis in the presence of metal oxides: preparation, characterization and future applications

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Biochar, which is material obtained from biomass by thermochemical decomposition, is an environmentally friendly replacement for carbon materials. Its applications range from heat and energy production, agriculture and livestock farming to analytical chemistry and analysis. This carbon-enriched material can be obtained by using microwave-assisted pyrolysis, hydrothermal carbonization, pyrolysis, and gasification, thus changing the product's structure and properties. This research presents an environmentally and economically beneficial method for biochar synthesis from pine wastes in the presence of mineral additives and low-temperature pyrolysis. An increase in carbonization temperature leads to decreased product yield accompanied by increased pyrolysis co-product, bio-oil. The contents of O and H reduced are 12.90% and 11.00%, 7.60% and 3.60%, 2.67% and 1.98% for temperatures of 250, 350 and 400ºC, respectively. Accordingly, the O/C and H/C molar ratios reduce with increasing temperature. It is shown that biochar produced at higher temperatures is more aromatic and less hydrophilic. Herein, the sample obtained at 300ºC has a C-content of 76.59%; thus, its bulk polarity index [(O+N)/C] of 11.08 is the highest one among all samples investigated. Based on this, it is most likely that this biochar indicates lower aromatic nature and higher polarity of biochar. The FT-IR spectroscopy shows the carbonyl groups (C–O/C–O–C), carboxyl groups (–COOH), and hydroxyl groups (–OH) on the biochar surface.

Regarding phase composition, the XRD confirms the presence of dolomite [CaMg(CO3)2], calcite CaCO3, and quartz SiO2 in the biochar bulk. Besides this, it includes Fe by EDS analysis. Based on materials characterization results, demonstrating the high carbon content, high polarity index, and the nature of surface functional groups, this biomass-derived biochar is most likely to be used as a sorbent, soil amendment, and even as shown redox activity.