Abstract

Carbon Nanomaterials from Biomass Wastes [†]

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Biomass represents carbon that has been sequestered from the environment by plants through photosynthesis and nutrition. Burning biomass is a polluting process that releases greenhouse gases (CO_2, CO, NO_x) into the atmosphere, and it should be avoided globally. An environmentally friendly biomass conversion method with plenty capitalization opportunities is represented by hermetic hydrothermal carbonization with super-heated sub-critical water [1,2]. Between 110–250 °C, super-heated water acts similar to a mild acidic solvent and breaks the hemicellulose structure by dehydro/carboxylation into alcohols, aldehydes, (poly)phenols, aminoacids, organic acids, and other water-soluble molecules, and the remaining ligno-cellulosic solid is called hydrochar and has adsorbent properties. Temperatures over 250 °C favor decarbonylation, denitrogenation, and aromatization reactions, which lead to a nano(micro)porous biochar and carbon nanomaterials. The residual biomass obtained from wheat straws was submitted to hydrothermal carbonization at temperatures between 140–260 °C, autogenerated pressures between 20–80 atm, and 1:5–1:10 biomass:water mass ratios. The obtained carbon nanomaterials were analytically characterized by transmission electron microscopy (TEM), Fourier Transform Infra-Red spectroscopy (FT-IR), X-ray diffraction (XRD), nitrogen adsorption/desorption porosimetry, and thermogravimetric analysis (TGA). The TEM images showed carbon nanomaterials with different shapes, such as nanospheres, nanowhiskers, and carbon nanodots). FT-IR spectroscopy showed evidence of adsorption bands that were of higher intensities for hydrogen bonds and functional groups with oxygen at lower reaction temperatures and pressures. XRD analysis showed specific diffraction patterns for the graphitic carbon structures obtained at higher temperatures. Nitrogen adsorption/desorption analysis demonstrated high N_2 adsorption at $P/P0 < 0.1$, which indicates the presence of many micropores (<2 nm) as well as mesopores (2–50 nm) at $0.1 < P/P0 < 0.5$, with a total surface area of 10–15 m^2/g, which is 100 times higher than that of the initial raw materials. TGA showed evidence of a higher lignin-type carbon content with an increased reaction temperature. As a general conclusion, hydrothermal carbonization is a "green" and facile method of converting residual biomass into carbon nanomaterials with high porosity and a graphite-like structure.

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