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Influence of the forming conditions on Black Carbon properties

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Black carbon (BC) is an important residue of wildfires in Quebec black spruce forests. Because of its recalcitrance, it is considered a valuable passive pool in the global carbon cycle. However, BC characteristics depend on its conditions of formation. The objective of this study was to characterize BC chemical and physical properties under varying fire severity. BC samples were produced, under controlled conditions, from fuels originating from mosses (Sphagnum spp. and Pleurozium shreberi), ericaceous shrubs (Ledum groenlandicum) and trees (Picea mariana), as they constitute the major types available in black spruce forests. In order to mimic a gradient of fire severity as it could occur in the field, we varied the maximum temperature (MT) from 75 to 800°C, and the duration of charring from 0.5 to 24 hours. Charcoalification was conducted either under partial (covered tins with holes) or complete pyrolysis (samples buried in sand bath). Samples were analyzed for aromaticity and porosity using elemental and proximate analyses, solid-state 13C nuclear magnetic resonance (NMR) spectroscopy, scanning electron microscopy (SEM) and surface area (SA) analysis. MT was the most significant factor affecting both chemical and physical changes. BC produced above 250°C started to show signs of condensation (H/C = 0.89; O/C = 0.36 average of all fuel types), which increased with MT (at 800°C, H/C = 0.20; O/C = 0.12 average for all fuels). Results from the 13C NMR spectroscopy highlighted that 350°C was the threshold temperature, at which point spectra were dominated by aromatic structures for all fuels. Specific SA first experienced a decrease (2.3 to 0.8 m^2/g) with increasing temperature, then increased drastically for MT above 350°C (10.6 to 435 m^2/g at 800°C). Porosity was also largely affected by the type of fuel. SEM micrographs showed a visible increase in porosity for all the BC produced above 250°C/350°C. All results demonstrate that increasing thermal treatment has major effects on BC properties, which in turn may determine its potential as a carbon sink and a catalyst of post-fire regeneration.