Adsorption mechanism of radioactive cesium and iodine to oak black carbon

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Plenty of radioactive cesium and iodine is volatilized to atmosphere at early stage of severe nuclear accidents. They enter adjacent subsurface environments through wet and/or dry deposition processes. Although black carbons (BC) are ubiquitous materials in soil and groundwater system, their geochemical sorption properites for radionuclides were rarely studied. The goal of this study is to determine the sorption properties and mechanisms of natural BC for cesium and iodine.

The BC materials were produced through pyrolysis in a laboratory using a xylem of oak trees with different ramp rate and final temperature. The BC was characterized by elemental analysis, BET, SEM, NMR, FTIR and XPS, and used for sorption batch experiments with cesium and iodine. Atomic ratio (H/C and O/C) and BET increased with rise of final temperature regardless of ramp rate. Cesium was sorbed strongly to low temp-produced BC, while the iodine sorption reaction was remarkable with high-temp produced BC. The sorption distribution coefficients reached approximately 400 and 1,000 kg L^{-1} at low dissolved concentration for cesium and iodine, respectively (C_{iw}=10 μg L^{-1}). These sorption properties are caused by different sorption mechanisms between cesium and iodine. The FTIR and XPS results indicated that cesium was predominantly reacted with oxygen-containing fuctionalities on the BC surface. In contrast, iodine uptake occurs through covalent bonding with carbon atom in aromatic structures of BC. The chemical structure and fuctionalities could be significantly controlled by final temperature of BC production rather than temperature-rise conditions. These results implied that diverse BC materials in soils and sediments play an important role on the distribution and geochemical fate of radiocesium and iodine.