Functionalization of commercial carbon for superior capacitance enhancement

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Commercially available microporous activated carbon (AC) was modified with oxygen and nitrogen moieties using a pre-oxidation treatment, followed by nitrogen-doping with ammonia gas. X-ray photoelectron spectroscopy (XPS) data showed nitrogen functional groups up to 8 at%. The functionalized high-surface-area AC powders were fabricated into a single particle layer (average size?) onto the surface of a glassy carbon electrode (GCE), and tested in a three-electrode configuration in acidic (1M H_2SO_4) and alkaline (6M KOH) electrolytes. Comparison of electrochemical performance metrics indicated that with single particle AC layer electrode structure, doped with 6 at. % O and 5 at. % N, the capacitance increased from 131 to 231 F/g in 1M H_2SO_4 electrolyte and 143 to 2331 F/g in 6M KOH electrolyte, with 90% capacitance retention after 2000 cycles. We attribute the significant capacitance enhancement to i) an increase in density of states (DOS) at the Fermi level and ii) formation of surface dielectric which contributes additional capacitance at frequencies below 0.1 Hz. This study demonstrated the possibility of significantly improving the capacitance for commercially available carbon for practical applications and provides unique insights into the electrochemical and physical processes taking place on the surfaces of functionalized activated carbon powders.

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