Carbon black-derived graphene quantum dots as an efficient and a stable catalyst for I_3^-/I^- redox couple

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A microwave-assisted oxidative cleavage process was developed to prepare graphene quantum dots (GQDs) from carbon black. The evolution in size and thickness of the resulting carbonaceous products was studied. In one hour, GQDs with a size of less than 10 nm and thickness less than 2 nm were obtained. The GQDs exhibited an onset absorption at 290 nm and photoluminescence emission at 410 nm. These GQDs were further composited with mesoporous carbon aerogels (CA) by a filtering process to form GQD decorated CA composites (GQD/CA). The GQD/CA composite was applied as a catalyst electrode for reduction conversion of I_3^- to I^-, a critical electrolyte regeneration reaction in dye-sensitized solar cells (DSSC). Also investigated are Pt electrode, the expensive traditional counter electrode material for DSSCs, and plain CA electrode for comparison. Based on data derived from cyclic voltammograms and Tafel plots, the GQD/CA composite exhibited catalytic activities comparable to those of the Pt electrode and better than those of the plain CA electrode. The GQD/CA electrode however surpassed the Pt electrode in terms of long term stability. The reduction current dropped and the onset reduction potential increased significantly after 500 cycles for the Pt and plain CA electrodes, while the reduction current was maintained and the onset reduction potential increased only slightly for the GQD/CA electrode. The GQD/CA composite thus proves to be an inexpensive, an efficient, and a stable alternative for Pt as the counter electrode material for DSSCs.