Diameter-Dependent Photoluminescence Energy Observed in Color Centers of Air-Suspended Single-Walled Carbon Nanotubes

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Color centers in single-walled carbon nanotubes attract interest because of their single-photon emission at room temperature in the telecom range [1, 2]. However, the lack of vapor-phase reaction route for forming color centers hinders the use of the excellent optical properties of air-suspended carbon nanotubes. We herein demonstrate the functionalization of air-suspended carbon nanotubes using iodobenzene as a precursor. The chemical reaction procedure is rationally designed to maintain the suspended structure and fluorescent properties of carbon nanotubes. The formed phenyl group serves as a color center and exhibits localized exciton emission peaks E_{11}^{*} and E_{11}^{*-} in addition to the free exciton emission peak E_{11}. We characterize over 12 different chiralities, covering nanotubes with diameters d ranging from 0.981 to 1.29 nm, to elucidate the reactivity and optical property of the color centers. We find that the reactivity of iodobenzene scales as $1/d$, where the inherent strain on the curvature of nanotubes promotes the reaction. The trapping potential of E_{11}^{*} and E_{11}^{*-} are both close to the singlet-triplet splitting. The minimum value of $g^{(2)}(0)$ in the photon correlation verifies the photon antibunching at the color centers. These findings should lead to further development of quantum photon sources that utilize color centers in carbon nanotubes.

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