Supplementary Information

Graphene Quantum Dots-Driven Multiform Morphologies of β-$NaYF_4$:Gd^{3+}/Tb^{3+} Phosphors: The Underlying Mechanism and Their Optical Properties

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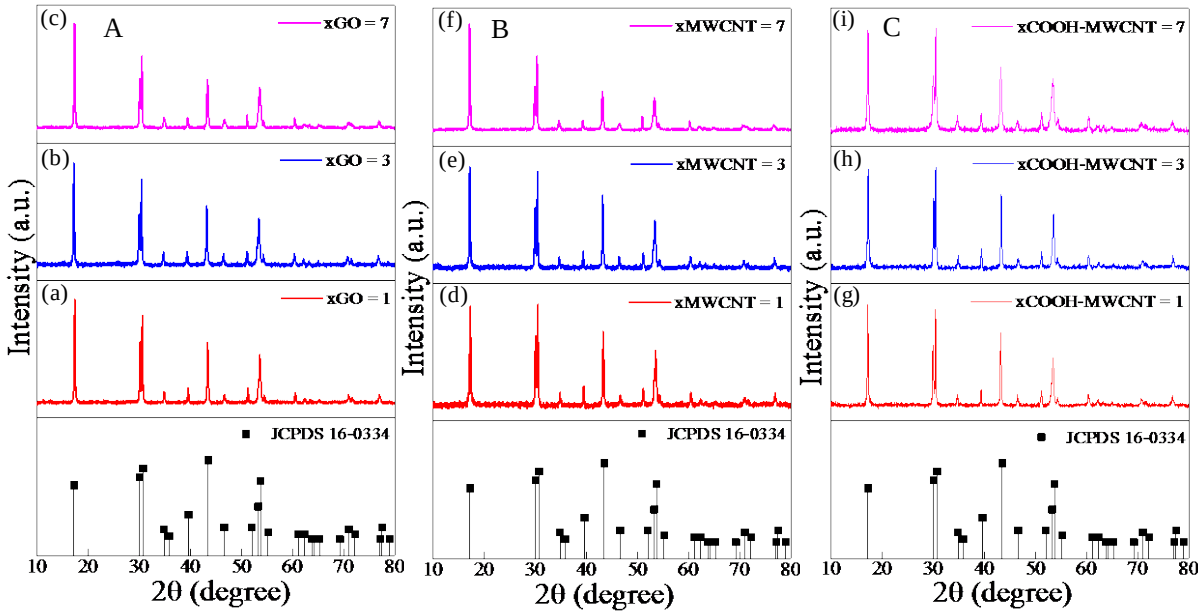

Figure S1. XRD patterns of β-$NaYF_4$:Gd^{3+}/Tb^{3+} incorporated with different graphitic carbon based materials is compared with the standard data of β-$NaYF_4$ (JCPDS -16-0334). Various columns show the following samples: β-$NaYF_4$:Gd^{3+}/Tb^{3+}-xGO (A), β-$NaYF_4$: Gd^{3+}/Tb^{3+}-xMWCNT (B), β-$NaYF_4$: Gd^{3+}/Tb^{3+}-x COOH-MWCNT (C), where respective values of x are mentioned in the panels. The incorporation of these foreign impurities do not induce any phase change in the β-$NaYF_4$ crystal structure.

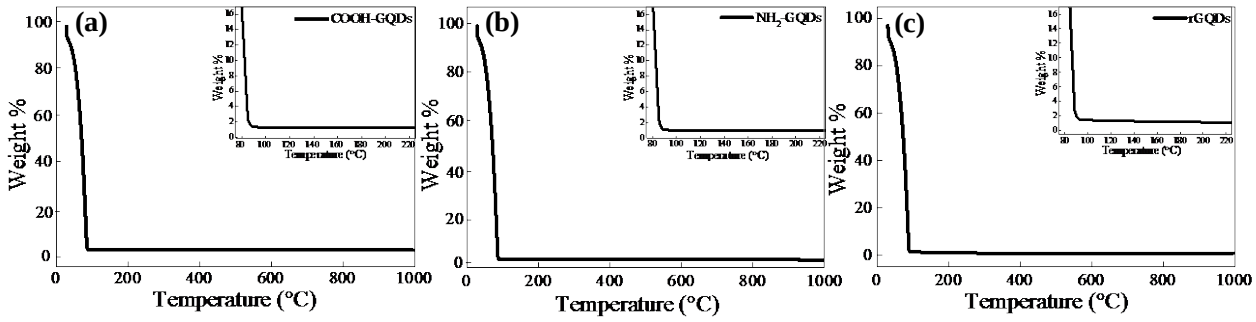

Figure S2. The TGA curves of (a) carboxylic-functionalized GQDs, COOH-GQDs, (b) amine-functionalized GQDs, NH_2-GQDs, and (c) reduced GQDs, rGQDs showing the weight fraction. In all the samples, 1 mL of suspension equals 10 mg of GQDs.

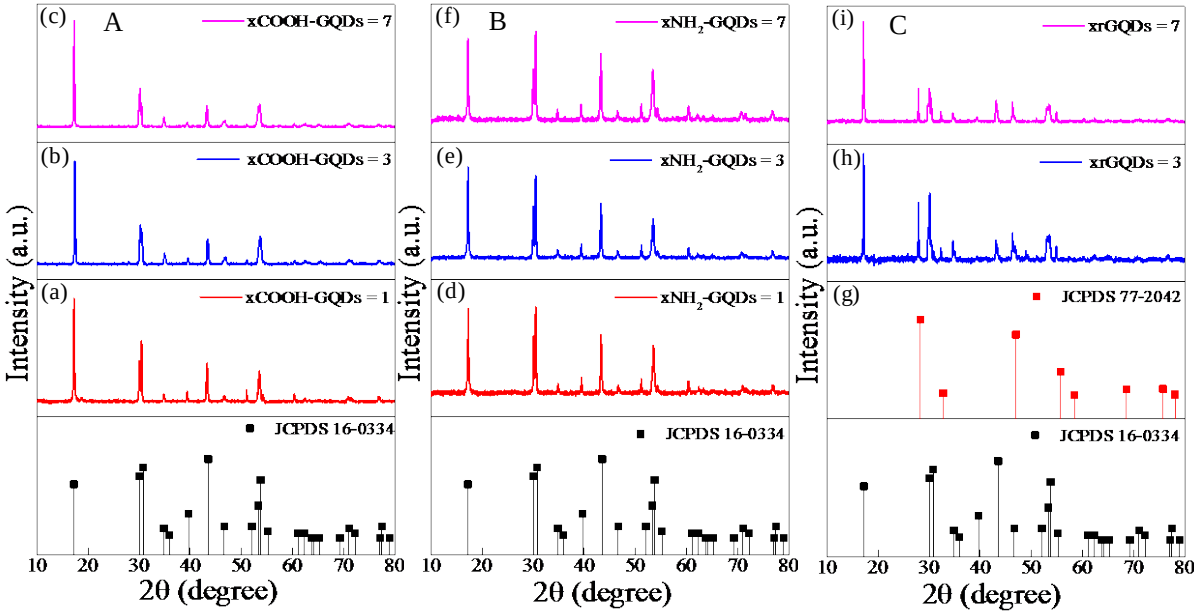

Figure S3. XRD patterns of β-$NaYF_4$:Gd^{3+}/Tb^{3+} incorporated with different types of functionalized-GQDs: β-$NaYF_4$: Gd^{3+}/Tb^{3+}-xCOOH-GQDs (A), β-$NaYF_4$: Gd^{3+}/Tb^{3+}-xNH_2-GQDs (B), β-$NaYF_4$: Gd^{3+}/Tb^{3+}-xrGQDs (C) are compared with the standard data of β-$NaYF_4$ (JCPDS 16-0334) and α-$NaYF_4$ (JCPDS 77-2042) in case of rGQDs where values of x are mentioned in the panels. There was no phase change occurred in case of the incorporation of COOH-GQDs and NH_2-GQDs while incorporation of rGQDs induced phase change in the β-$NaYF_4$ crystal structure.

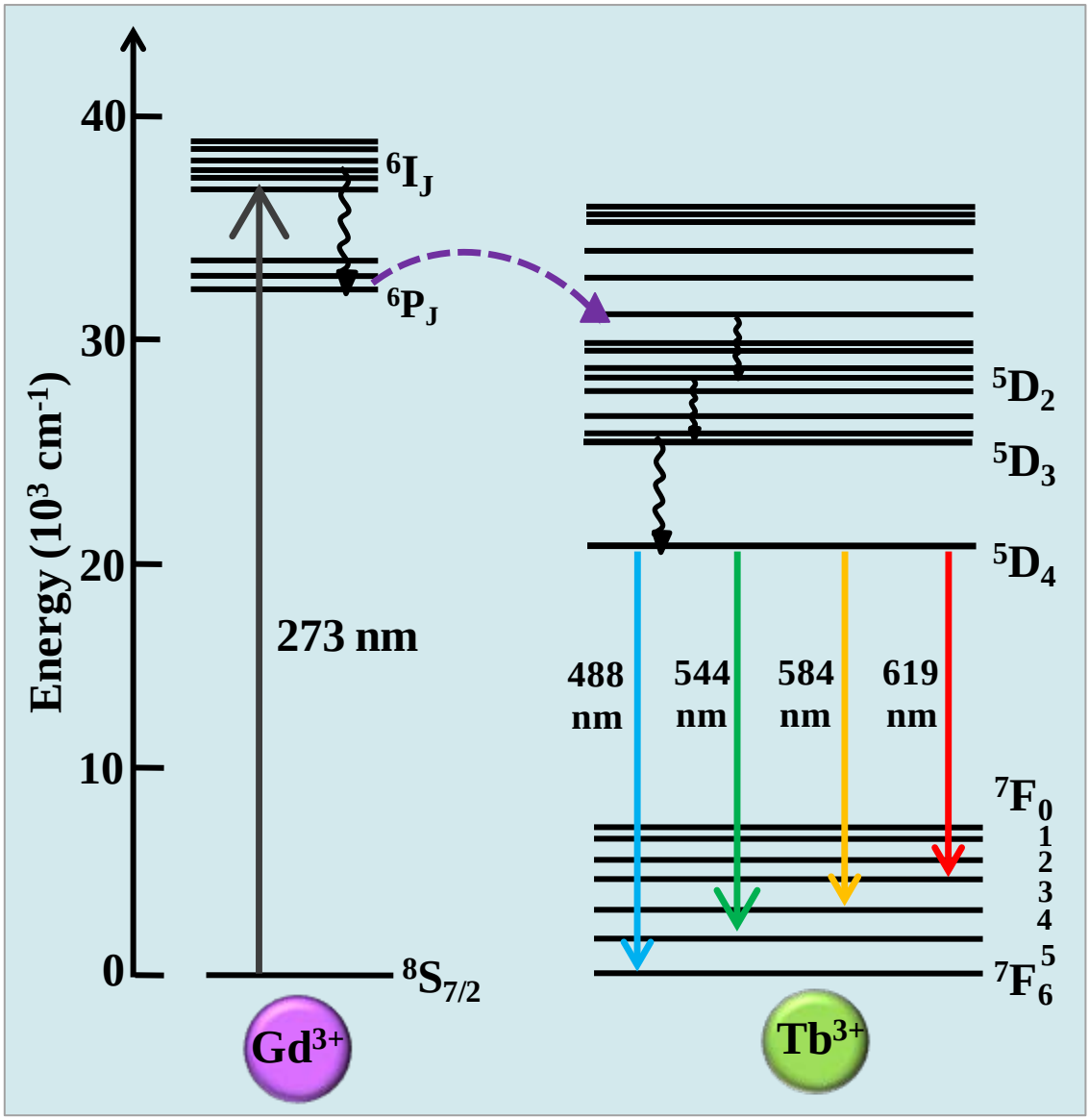

Figure S4. Partial energy level diagram showing the most probable energy-transfer pathway, non-radiative decay and emissive pathway in Gd^{3+}-Tb^{3+} pair under excitation of 273 nm. The full, dotted, and curly arrows represent emission, energy transfer, and multiphonon relaxation processes, respectively.