One-step synthesis band-tunable N, S co-doped commercial TiO_2/ graphene quantum dots composite with enhanced photocatalytic activity

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Table 1. Lattice parameters and average crystallite size of samples.

Catalysts	lattice parameters (Å)		Crystallite size (nm)
	a=b	c	
P25	3.766	9.051	3.477
NST	3.770	9.266	3.491
NSTG(1:0.5)	3.772	9.334	3.497
NSTG(1:1)	3.778	9.410	3.506
NSTG(1:3)	3.764	9.058	3.476

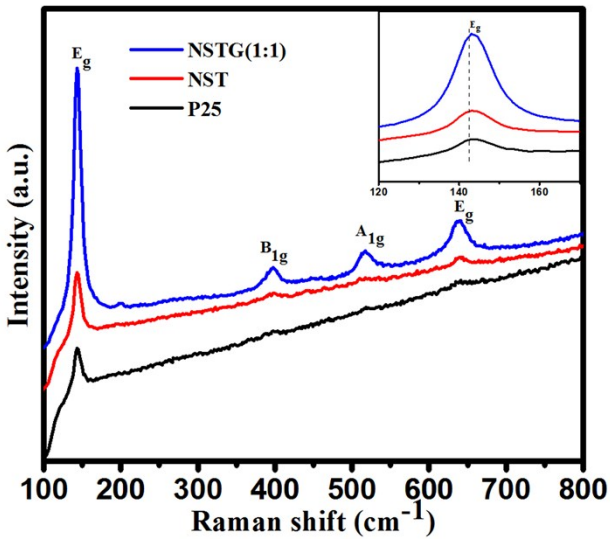

Fig. S1 Raman spectra of P25, NST and NSTG(1:1). Inset Raman spectra showing the blue shift of the E_g bands of the composites in the 120-170 cm^{-1}.

Raman spectra can provide information on the structure of as prepared samples. The Raman shift peaks at 144 cm^{-1} (E_g), 398 cm^{-1} (B_{1g}), 517 cm^{-1} (A_{1g}), and 638 cm^{-1} (E_g) can be corresponding to the characteristic peaks of the anatase phase as shown in the Fig. S1. The peak shift and broadening of the Raman spectra were analyzed using the most intense 144 cm^{-1} (E_g) peak. As seen in the inset of Fig. S1,

the main anatase Raman band that the peak position at about 144 cm^{-1} was sharpened and blue-shifted when the nitrogen and sulfur had been doped into the lattice of TiO_2. The blue shift is due to the size of sample diminishing. According to previous reports, the nitrogen is easier to replace oxygen and S^{6+} is easier to replace Ti^{4+} in the lattice of TiO_2.

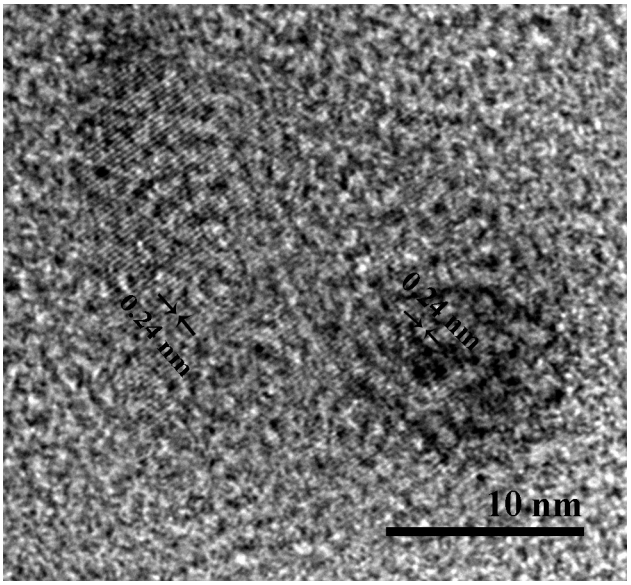

Fig. S2 High-resolution TEM images of N, S-GQDs

As shown in the Fig. S2, the high-resolution TEM image reveals that the lattice space of 0.24 nm corresponds to N, S-GQDs (1120), demonstrating the existence of N, S-GQDs. It is also an indirect proof of our experimental scheme that the synthesized material includes N, S-GQDs.

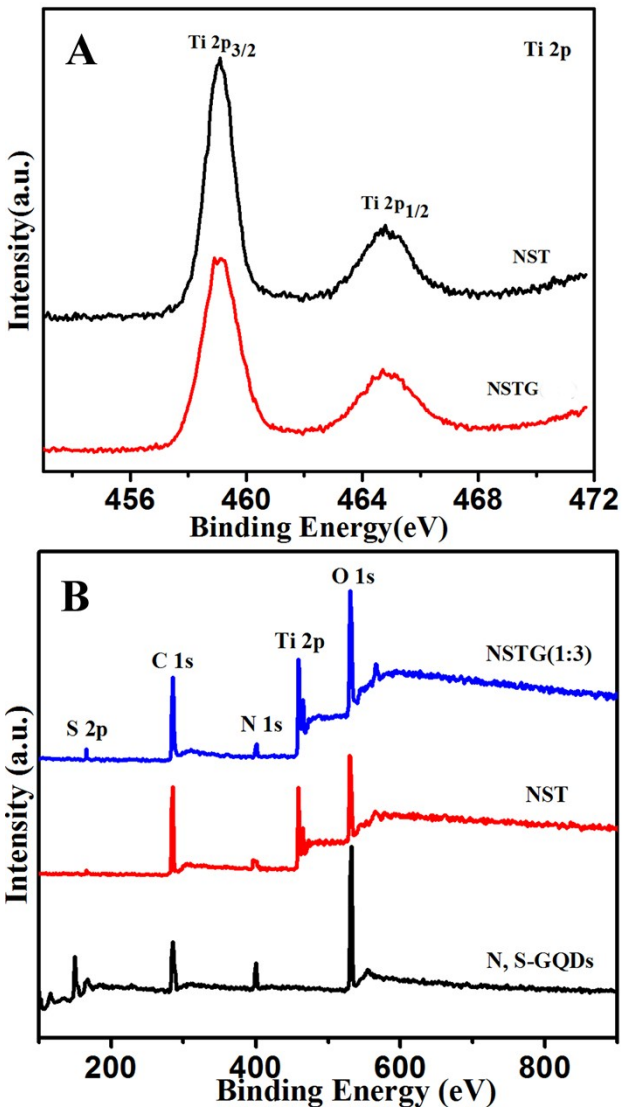

Fig. S3 (A) High-resolution XPS of Ti 2p for NST and NSTG and (B) XPS full survey spectra of N, S-GQDs, NST and NSTG(1:3)

In the Fig. S3A, the XPS spectra peaks for Ti 2p of NST and NSTG at 459.1 and 464.8 eV is attributed to the binding energies of the Ti $2p_{3/2}$ and $2p_{1/2}$ electrons. Fig. S3B displays the full XPS survey spectra of the N, S-GQDs, NST and NSTG. The prepared samples contain Ti, O, C, N and S with the binding energies corresponding to Ti 2p, O 1s, C 1s, N 1s and S 2p. The peaks at 169.2, 284.8, 400.1, 458.3 and 533.4 eV is corresponding to S 2p, C 1s, N 1s Ti 2p and O 1s, respectively. This indicates that the as prepared GQDs and TiO2 are doped with N and S atoms.

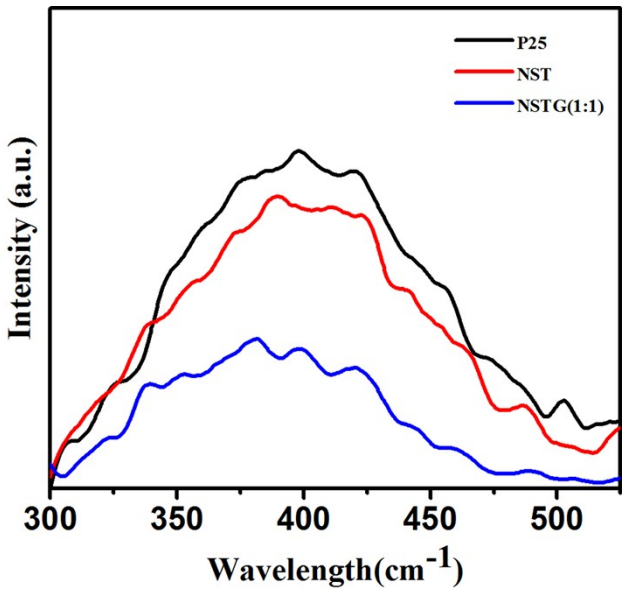

Fig. S4 PL spectra of P25, NST and NSTG(1:1) under UV-280 nm

The PL spectra for P25, NST and NSTG using the excitation light of 280 nm UV light. It is obvious that the PL intensity of the P25 is higher than NST, which indicates that N and S doping can effectively inhibit excited electron and hole recombination. The PL intensity of NST is higher than NSTG, which indicates that the N, S-GQDs is introducted into NST effectively. The NSTG composites can extend the more absorption response than NST, then increase the efficiency of electronic transition.