Electronic Supplementary Material (ESI) for Nanoscale.

(Supporting Information)

Sulphur doping: a facile approach to tune the electronic structure and optical properties of graphene quantum dots

Xueming Li,[a] Shu Ping Lau,*[b] Libin Tang,[bc] Rongbin Ji,[c] and Peizhi Yang*[a]

a. Solar Energy Research Institute, Yunnan Normal University, Kunming 650092, P. R. China

b. Department of Applied Physics, The Hong Kong Polytechnic University, Hong Kong SAR, P. R. China.

c. Kunming Institute of Physics, Kunming 650223, P. R. China

1. Chemicals

Fructose (≥99%) was purchased from Sigma-Aldrich. Sulphuric acid (98% *wt*.) was purchased from International Laboratory, USA. These chemicals were used without further purifying.

2. Supplementary Figures

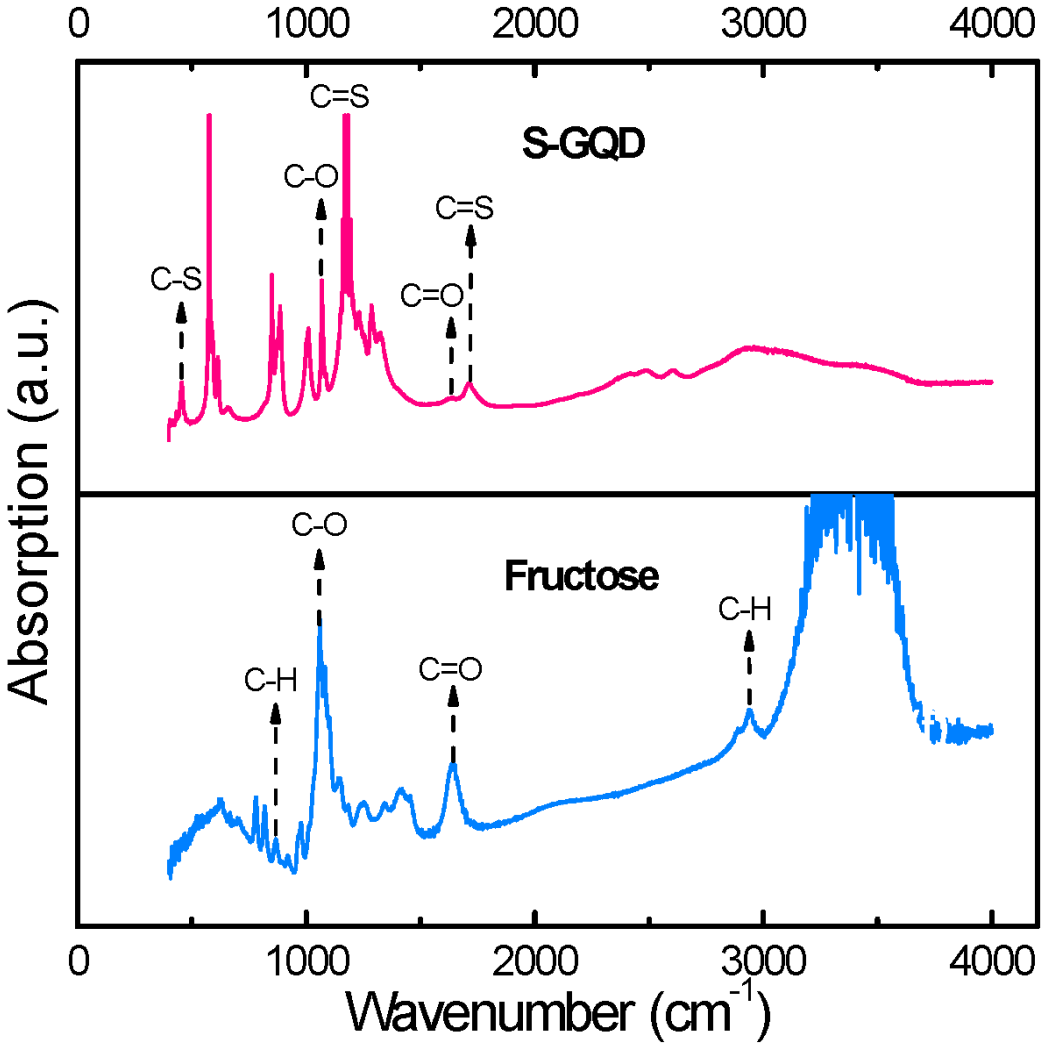

Figure S1. The FTIR spectra of the S-GQDs (top) and the source fructose (bottom).

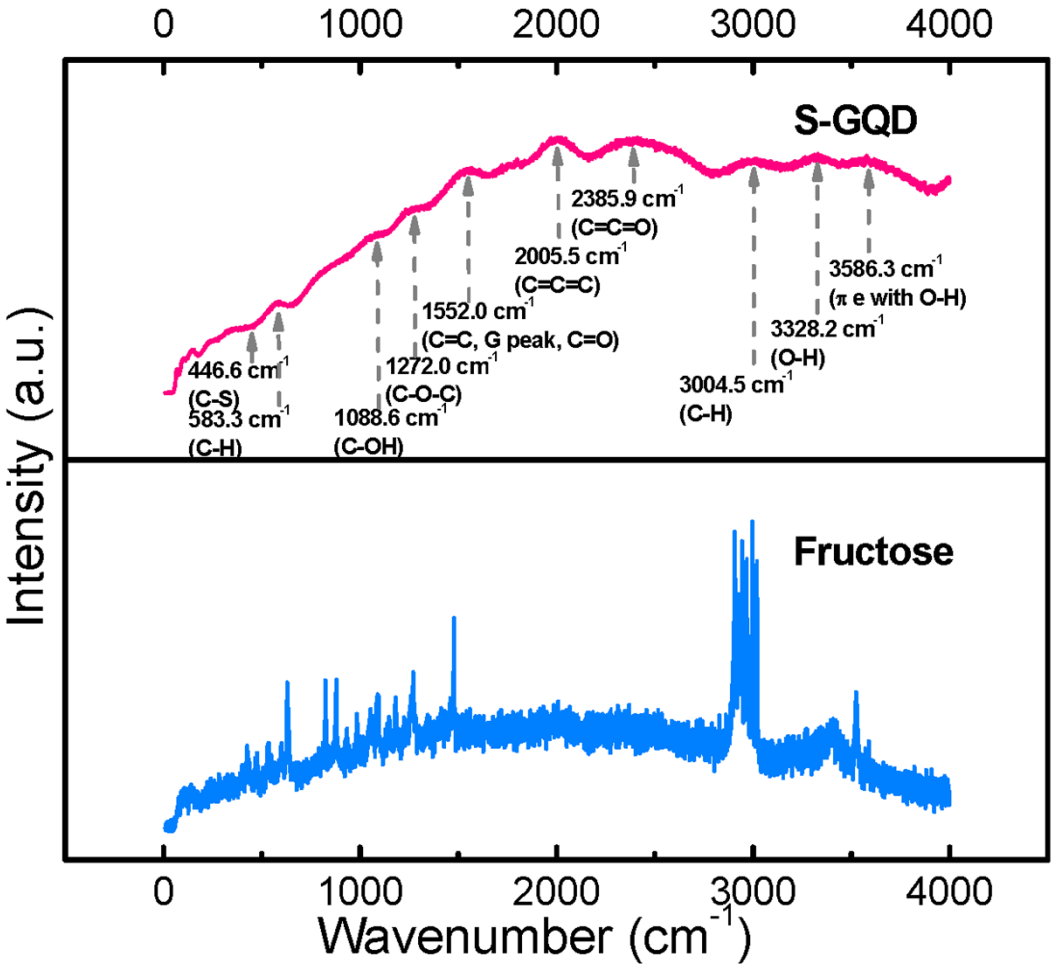

Figure S2. The Raman spectra of the S-GQDs (top) and the source fructose (bottom).

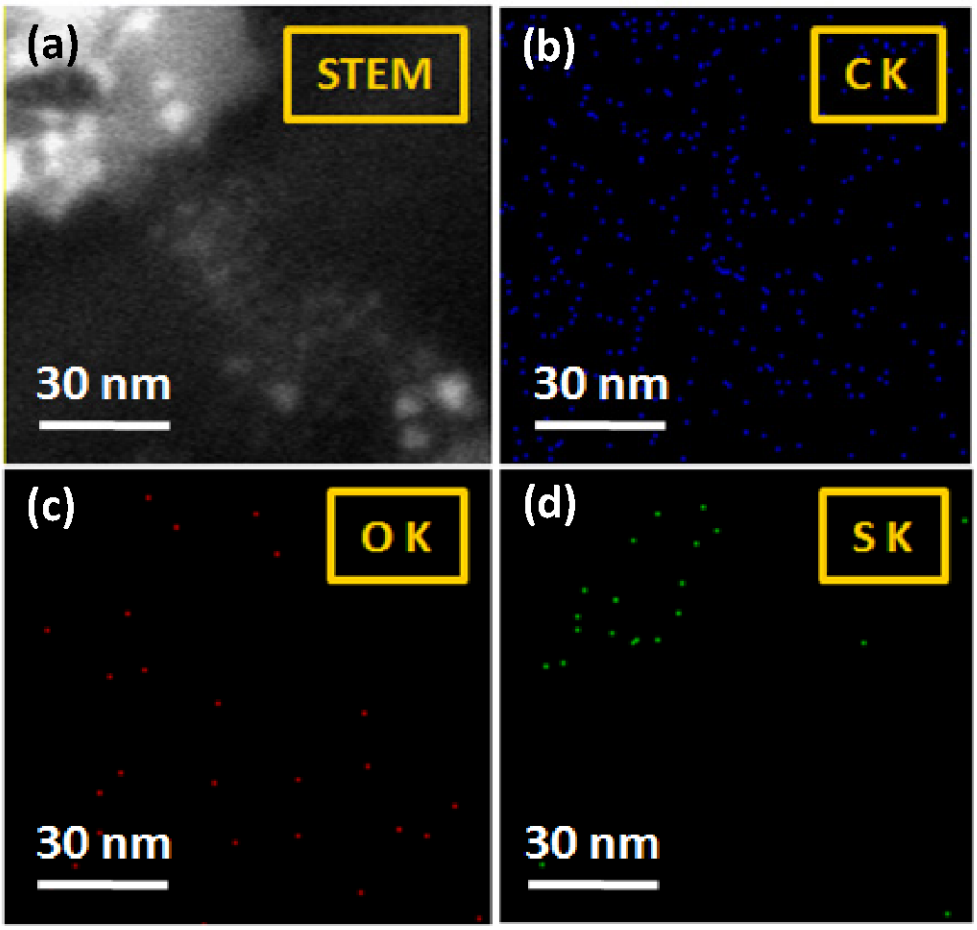

Figure S3. (a) STEM image of the S-GQDs assembled on Cu grid coated with ultrathin amorphous carbon film. (b) Elemental C mapping (in blue) of the image shown in panel (a). (c) Elemental O mapping (in red) of the image shown in panel (a). (d) Elemental S mapping (in green) of the image shown in panel (a).

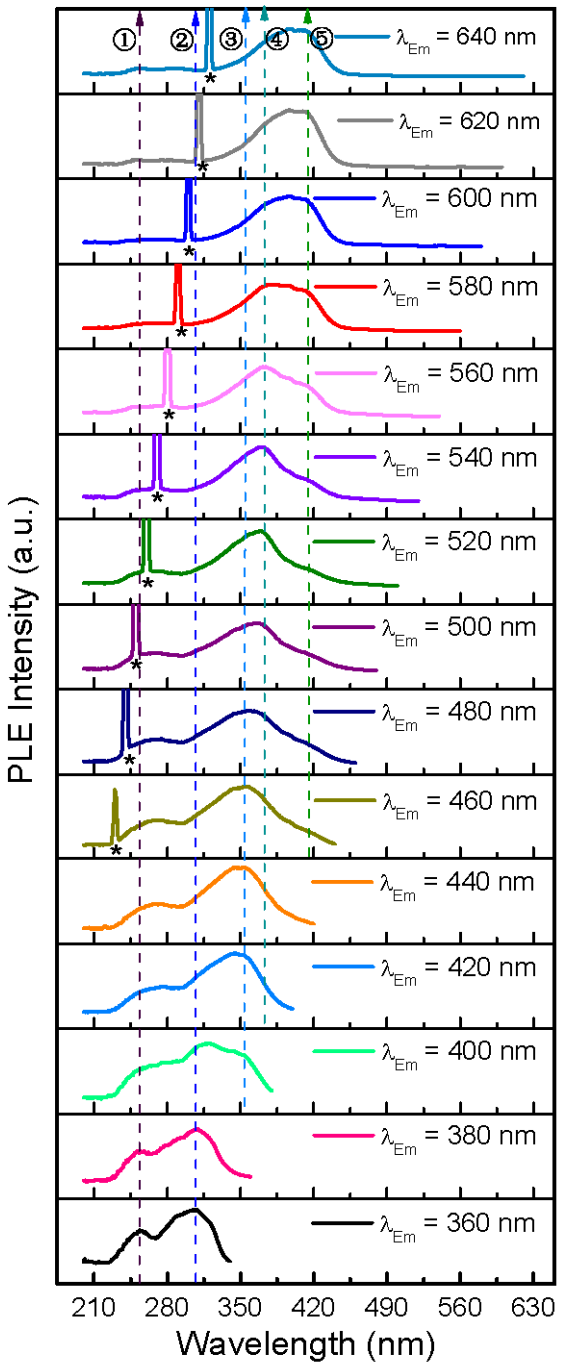

Figure S4. The PLE spectra of the S-GQDs recorded at various λ_{Em} (* is $\lambda_{Ex}/2$).

3. Supplementary Table

Table S1 The fitting parameters of PL decay curves for various λ_{Em}

λ_{Em} [nm]	τ_1 [ns]	τ_2 [ns]	τ_3 [ns]	B_1	B_2	B_3	R_1 [a]	R_2 [a]	R_3 [a]	A	χ^2	$<\tau>$ [ns] [b]
410	0.55	3.08	29.63	58703.02	4020.27	86.99	0.935	0.064	0.001	24.89	4.04	**0.75**
430	0.56	3.05	28.45	161000.23	11930.68	274.80	0.930	0.069	0.002	70.91	9.70	**0.78**
450	0.61	3.09	25.21	222435.14	16917.98	436.25	0.928	0.071	0.002	109.99	12.97	**0.83**
470	0.61	2.98	18.52	288853.63	29637.68	905.60	0.904	0.093	0.003	196.85	9.37	**0.88**
490	0.61	3.02	18.86	293968.97	28826.99	939.26	0.908	0.089	0.003	191.54	9.55	**0.88**
510	0.58	2.83	20.31	304790.44	27628.11	875.74	0.914	0.083	0.003	202.93	7.18	**0.82**
530	0.65	3.03	33.57	415088.69	22360.81	633.11	0.948	0.051	0.001	154.19	29.55	**0.82**
550	0.60	2.61	31.01	370878.09	25347.35	598.31	0.935	0.064	0.002	169.80	14.86	**0.77**
570	0.65	2.83	83.95	425290.28	18188.11	608.49	0.958	0.041	0.001	-58.94	49.58	**0.85**
590	0.58	2.56	103.60	384996.16	17902.91	611.97	0.954	0.044	0.002	-119.60	28.07	**0.82**
610	0.50	2.32	120.00	289038.84	16327.67	607.85	0.945	0.053	0.002	-176.77	9.44	**0.83**
630	0.48	2.24	96.37	191806.25	11425.17	397.44	0.942	0.056	0.002	-62.55	5.22	**0.77**
650	0.48	2.28	120.00	111100.05	6650.78	282.32	0.941	0.056	0.002	-83.30	3.14	**0.87**
670	0.53	2.53	78.81	76635.06	3124.25	111.64	0.959	0.039	0.001	-0.88	4.90	**0.72**
690	0.50	2.41	37.16	34843.90	1874.17	52.60	0.948	0.051	0.001	16.98	1.96	**0.65**
710	0.56	2.77	90.56	22224.54	812.62	39.04	0.963	0.035	0.002	-5.97	2.72	**0.79**

(a) The photoluminescence decay curves were fitted to a triple-exponential function: $I(t) = A + B_1 \cdot e^{(-t/\tau_1)} + B_2 \cdot e^{(-t/\tau_2)} + B_3 \cdot e^{(-t/\tau_3)}$, R_i is the relative ratio factor which is calculated by $R_i = B_i / (\sum_{i=1}^{3} B_i)$.

(b) τ_{average} is the average lifetime, τ_{average} is calculated according to $\tau_{average} = \sum_{i=1}^{3} R_i \cdot \tau_i$.