Electronic Supplementary Information

Rapid and mild acid-induced recovery of high-yield carbon quantum dots from commercial black liquor

Mengru Wei [a], Chongbo Cheng [a], Ping Lu [a], Chao Liu [b], Shiliang Wu [b], Jun Hu [a] *

[a] *School of Energy and Mechanical Engineering, Nanjing Normal University, Nanjing 210023, China*

[b] *Key Laboratory of Energy Thermal Conversion and Control, Ministry of Education, School of Energy and Environment, Southeast University, Nanjing 210096, China*

* Corresponding author. Jun Hu − School of Energy and Mechanical Engineering, Nanjing Normal University, Nanjing 210023, China; orcid.org/0000-0001-9250-8853; Email: junhu@njnu.edu.cn.

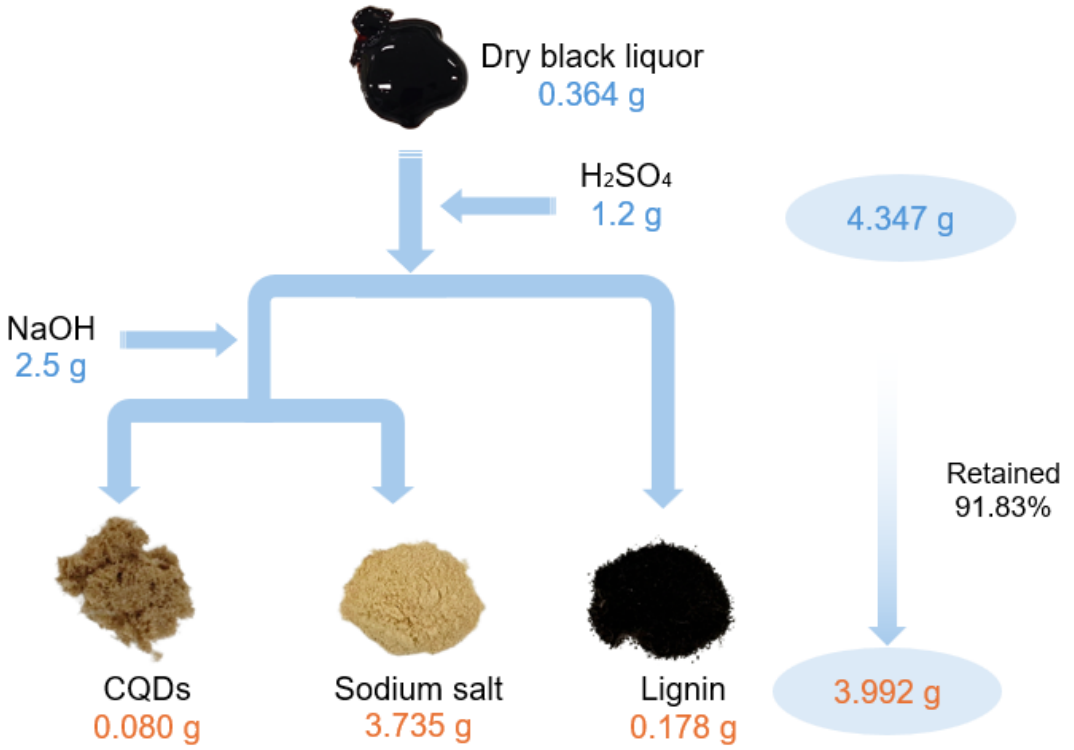

Fig. S1 Typical material flow for preparation of carbon quantum dots and lignin from BL-PR

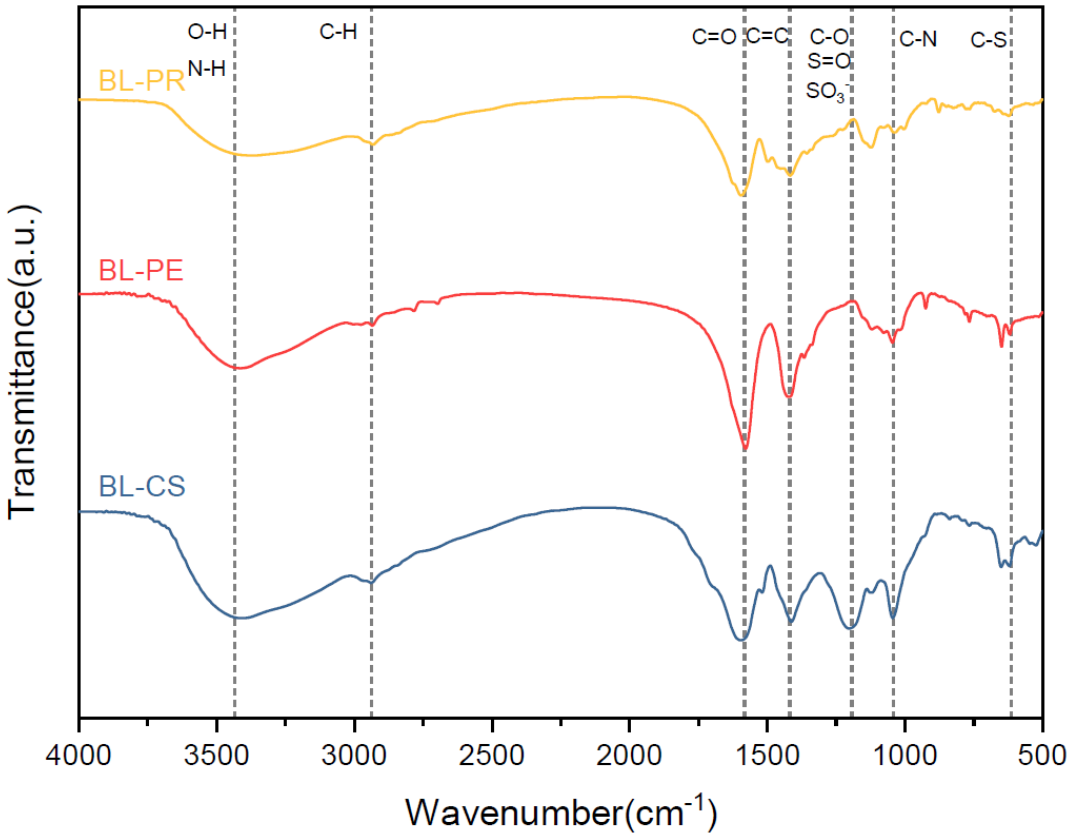

Fig. S2 FT-IR spectroscopy of the dry black liquors

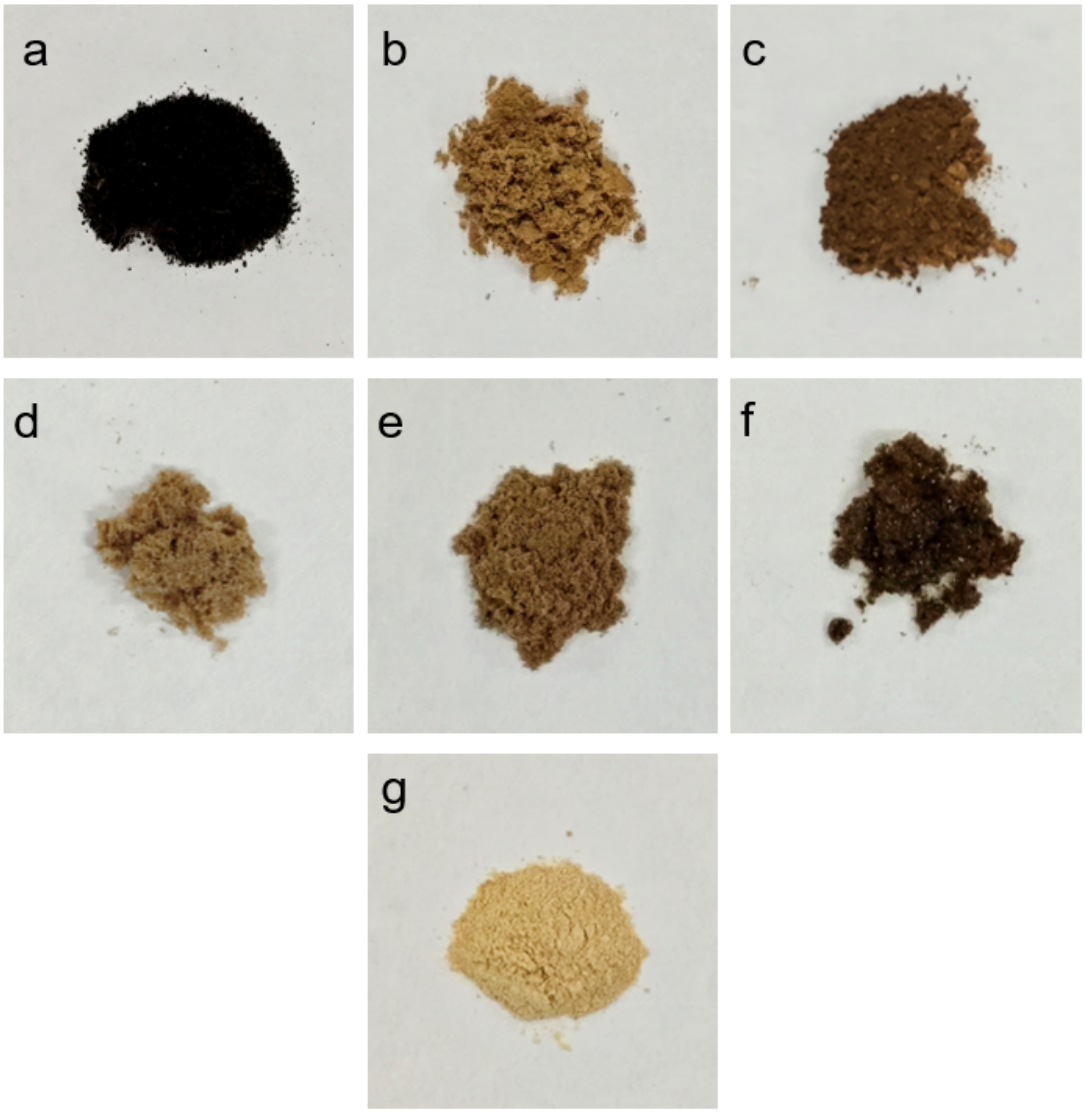

Fig. S3 Images of typical CQDs, lignin and sodium salt. (a) CQDs-PR-60-60, (b) CQDs-PE-60-60, (c) CQDs-CS-60-60, (d)Lig-PR-60-60, (e) Lig-PE-60-60, (f) Lig-CS-60-60, (g) sodium salt

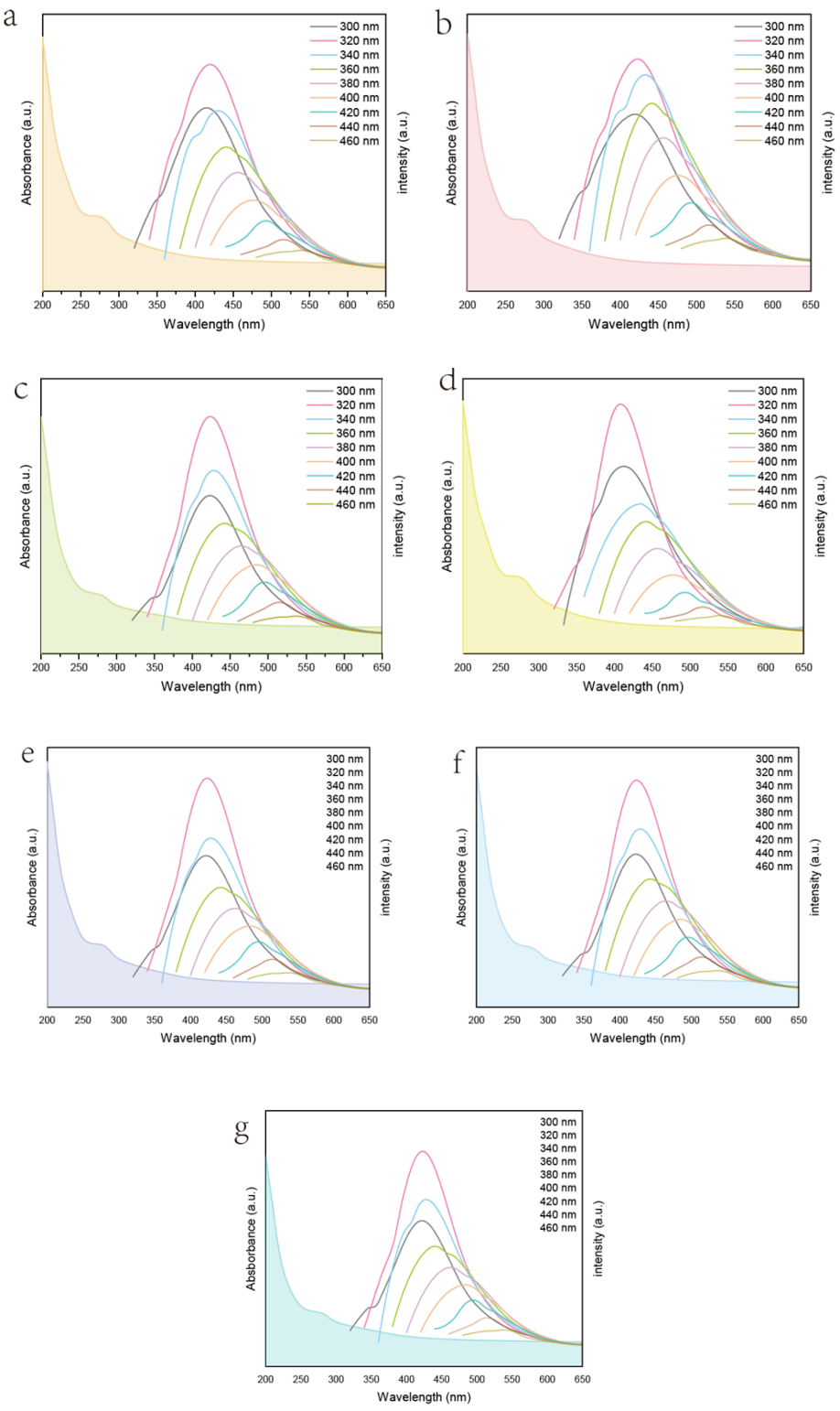

Fig. S4 Ultraviolet–visible absorption and fluorescence spectra carbon quantum dots. (a) CQDs-PR-20-60, (b) CQDs-PR-40-60, (c) CQDs-PR-60-60, (d) CQDs-PR-80-60, (e) CQDs-PR-60-20, (f) CQDs-PR-60-40, (g) CQDs-PR-60-80

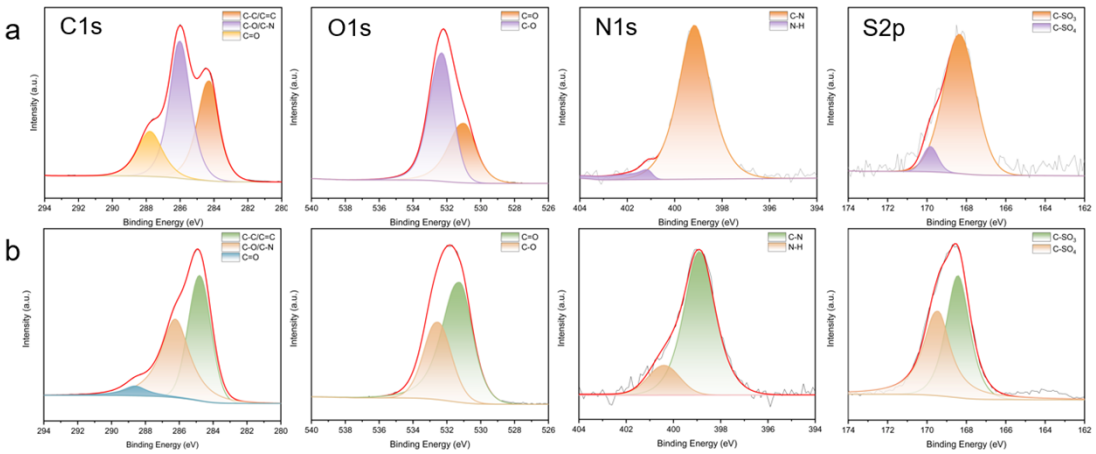

Fig. S5 High resolution C1s, N1s, O1s, and S2p spectra of CQDs-PE-60-60 (a) and CQDs-CS-60-60 (b).

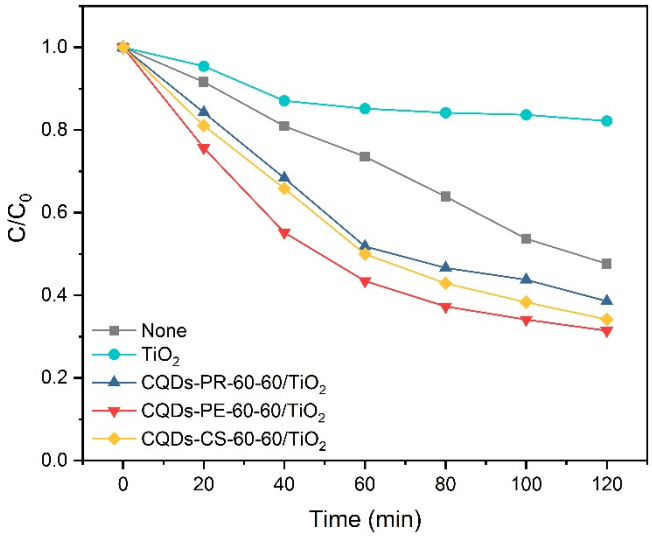

Fig. S6 Concentration ratio of OFX degraded by photocatalysis of different catalysts.

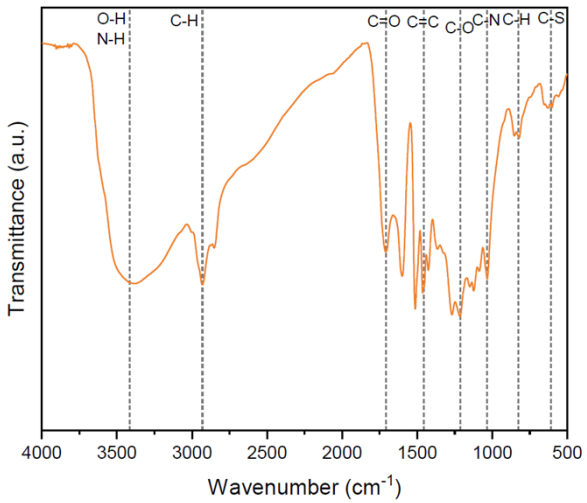

Fig. S7 FTIR spectra of Lig-PR-60-60.

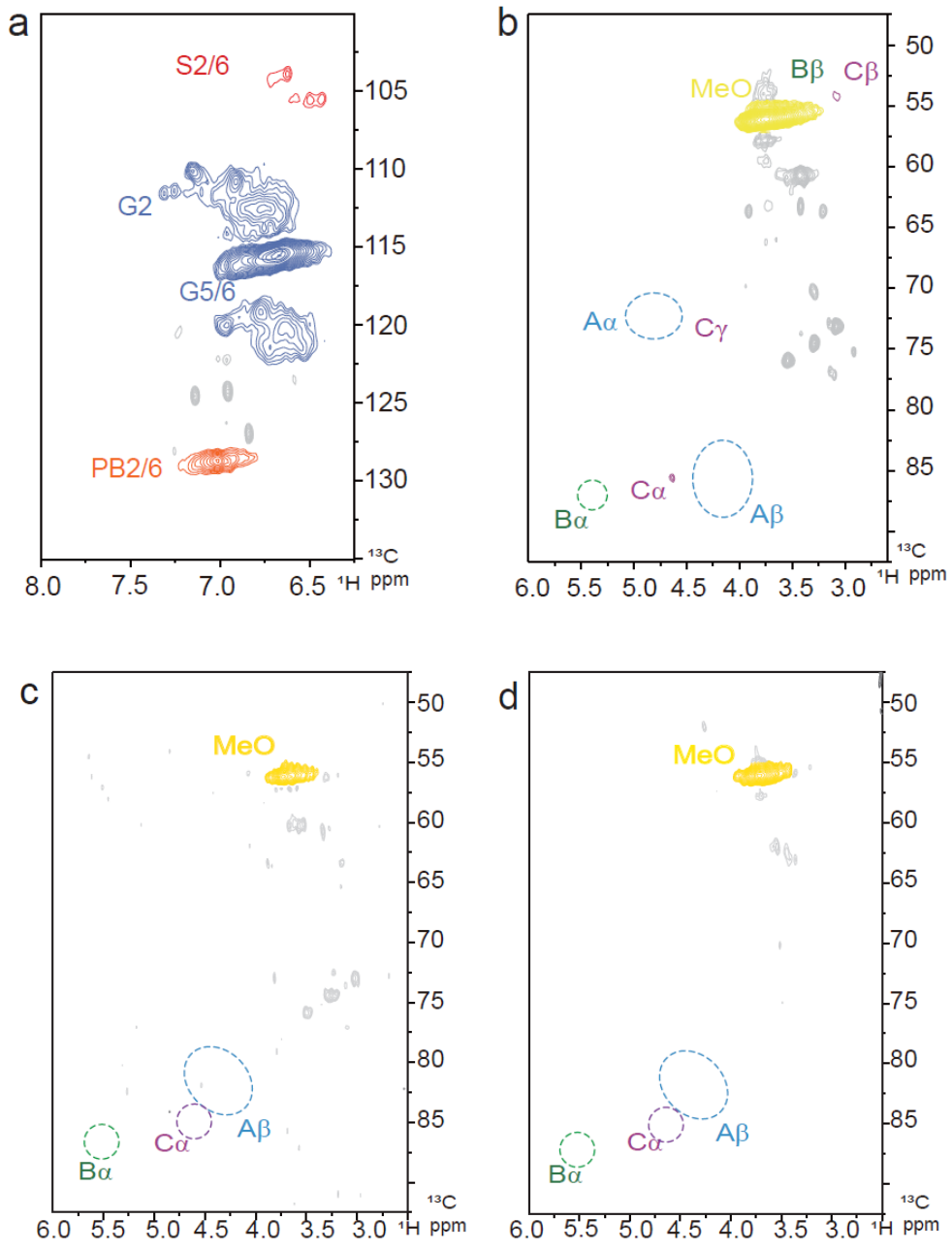

Fig. S8 HSQC spectra of Lig-PR-60-60 (a, b), Lig-PE-60-60 (b), and Lig-CS-60-60 (c).

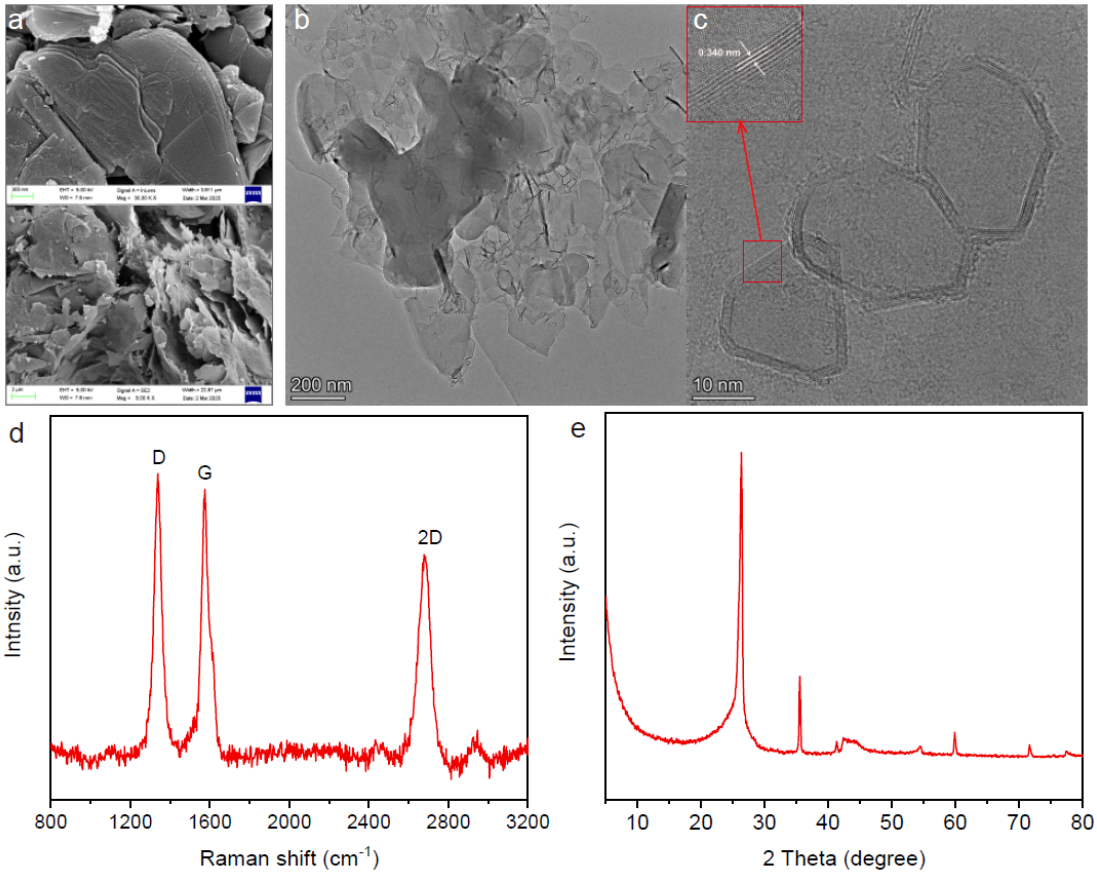

Fig. S9 SEM images (a), HRTEM images (b, c), Raman spectrum (d) and XRD pattern 725 (e) of Lig-PR-60-60-derived graphene.

Table S1 Elemental composition of dry black liquor (wt%)

Black liquor	N	C	H	S
BL-PR	0.26	36.36	4.10	2.63
BL-PE	0.59	31.84	4.05	0.42
BL-CS	0.60	33.03	3.83	6.93

Table S2 XRF Elemental composition of ash of black liquor (%)

Black liquor	Na	Mg	Al	Si	S	Cl	K	Ca	Fe
BL-PR	61.8	0.1	0.2	3.4	6.8	1.1	15.6	0.3	0.3
BL-PE	53.1	2.0	23.1	8.9	2.1	1.2	2.0	6.2	0.6
BL-CS	58.5	0.5	2.7	2.8	25.2	2.5	6.4	0.6	0.2

Table S3 Ratio analysis of the peaks in XPS spectra of CQDs

CQDs	CQDs-PR-60-60	CQDs-PE-60-60	CQDs-CS-60-60
C—C/C=C	25.74	21.29	31.69
C—O/C—N	21.59	28.34	29.78
C=O	6.88	11.12	3.49
Total C ratio	53.93	60.75	64.95
C=O	30.00	12.78	19.27
C—O	10.74	22.68	10.69
Total O ratio	40.74	35.46	29.96
C—N	0.69	2.91	1.57
N—H	1.20	0.24	0.35
Total N ratio	1.89	3.15	1.92
C—SO_3	1.81	1.68	1.59
C—SO_4	1.63	0.24	1.57
Total S ratio	3.44	0.64	3.16

Table S4 Mass yields of CQDs from

Materials	CQDs (wt%)
Cellulose	2.20
Xylan	3.27
Lignin	6.15
Cellulose-xylan	3.32
Xylan-lignin	12.74
Cellulose-lignin	6.39
Birch	7.42