

Supporting Information

Red emissive carbon dots: Synergistic interplay between core and surface states

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Table S1. Elemental percentage atomic compositions of r-CDs.

Samples	C(286.2 eV)	O(532.2 eV)	N(400.8 eV)	S(164.3 eV)	Others	PLQY(%)
r-CDs@Water(no column)	61.2%	22.6%	16.2%	0.2%	-	2%
r-CDs@Water(column)	49.5%	47.7%	1.6%	-	1.3%	11%
r-CDs@DMSO(no column)	57.5%	29.7%	11.7%	1.2%	-	29%
r-CDs@DMSO(column)	71.8%	17.4%	4.5%	2.3%	4%	40%

Table S2. High-resolution XPS scan of the C1s peak for carbon dots.

Sample	C-C/C=C	C-N/C-O	C=O/C=N	C(O)-OH	PLQY(%)
r-CDs@Water(no column)	37.4%	-	47.5%	15.1%	2%
r-CDs@Water(column)	83.2%	11.3%	5.5%	-	11%
r-CDs@DMSO(no column)	31.6%	35%	33.4%	-	29%
r-CDs@DMSO(column)	66.9%	26.8%	6.3%	-	40%

Table S3. High-resolution XPS scan of the O1s peaks.

Sample	C-OH/C-O-C	C=O	PLQY(%)
r-CDs@Water(no column)	29.4%	70.6%	2%
r-CDs@Water(column)	81.6%	18.4%	11%
r-CDs@DMSO(no column)	40.9%	59.1%	29%
r-CDs@DMSO(column)	-	100%	40%

Table S4. High-resolution XPS scan of the N1s peak for carbon dots.

Sample	Pyridinic-N	Nitro(NO ₂)	Pyrrolic-N	Graphitic-N	PLQY(%)
r-CDs@Water(no column)	-	-	38.8%	61.2%	2%
r-CDs@Water(column)	72.7%	27.3%	-	-	11%
r-CDs@DMSO(no column)	62.1%	-	37.9%	-	29%
r-CDs@DMSO(column)	100%	-	-	-	40%

Table S5. High-resolution XPS scan for S2p for carbon dots.

Sample	C-S	Sulfoxide, S=O	Sulfone, (-SO ₂ -)	Sulfate, (SO ₄ ²⁻)	PLQY(%)
r-CDs@Water(no column)	55%	20.3%	-	24.7%	2%
r-CDs@Water(column)	-	40.7%	59.3%	-	11%
r-CDs@DMSO(no column)	-	91.7%	-	8.3%	29%
r-CDs@DMSO(column)	29.2%	-	70.8%	-	40%

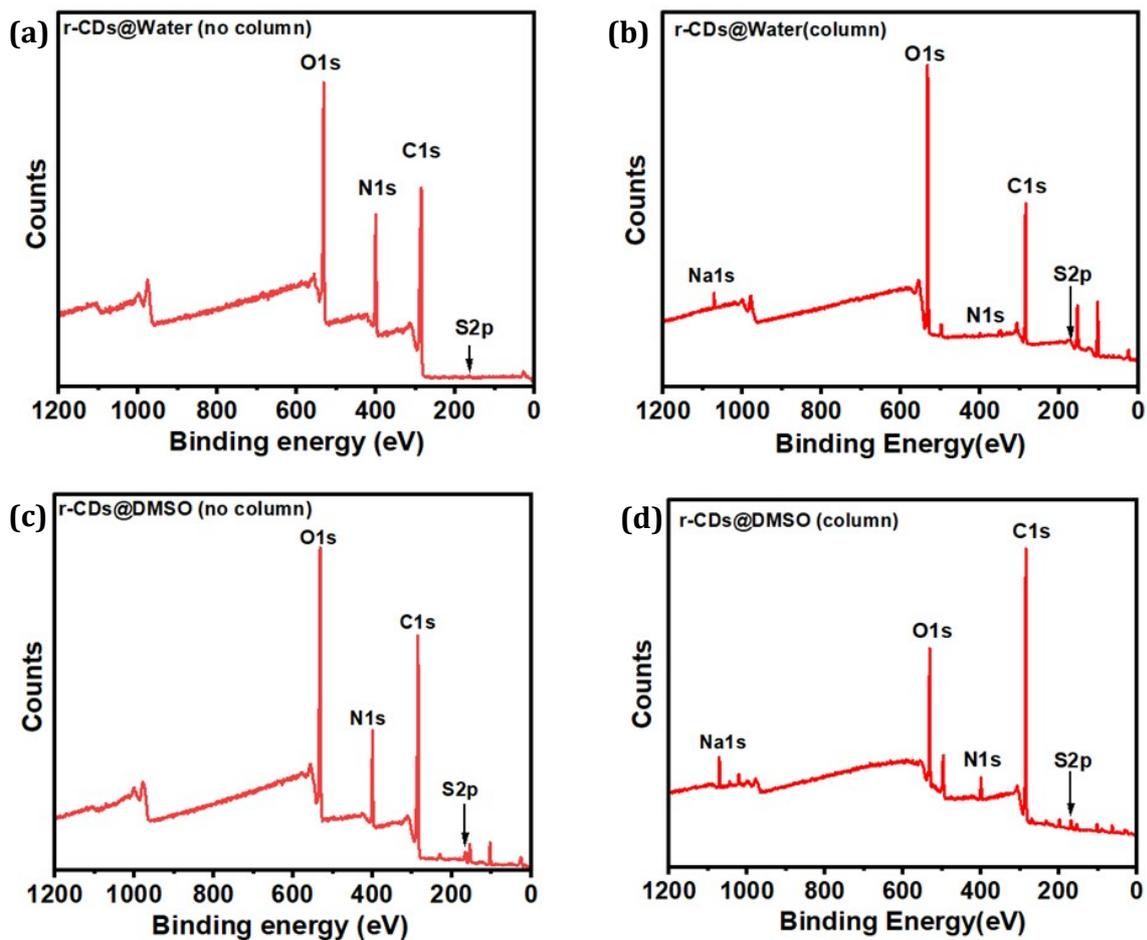


Fig. S1. The full XPS scan of the four r-CDs samples.

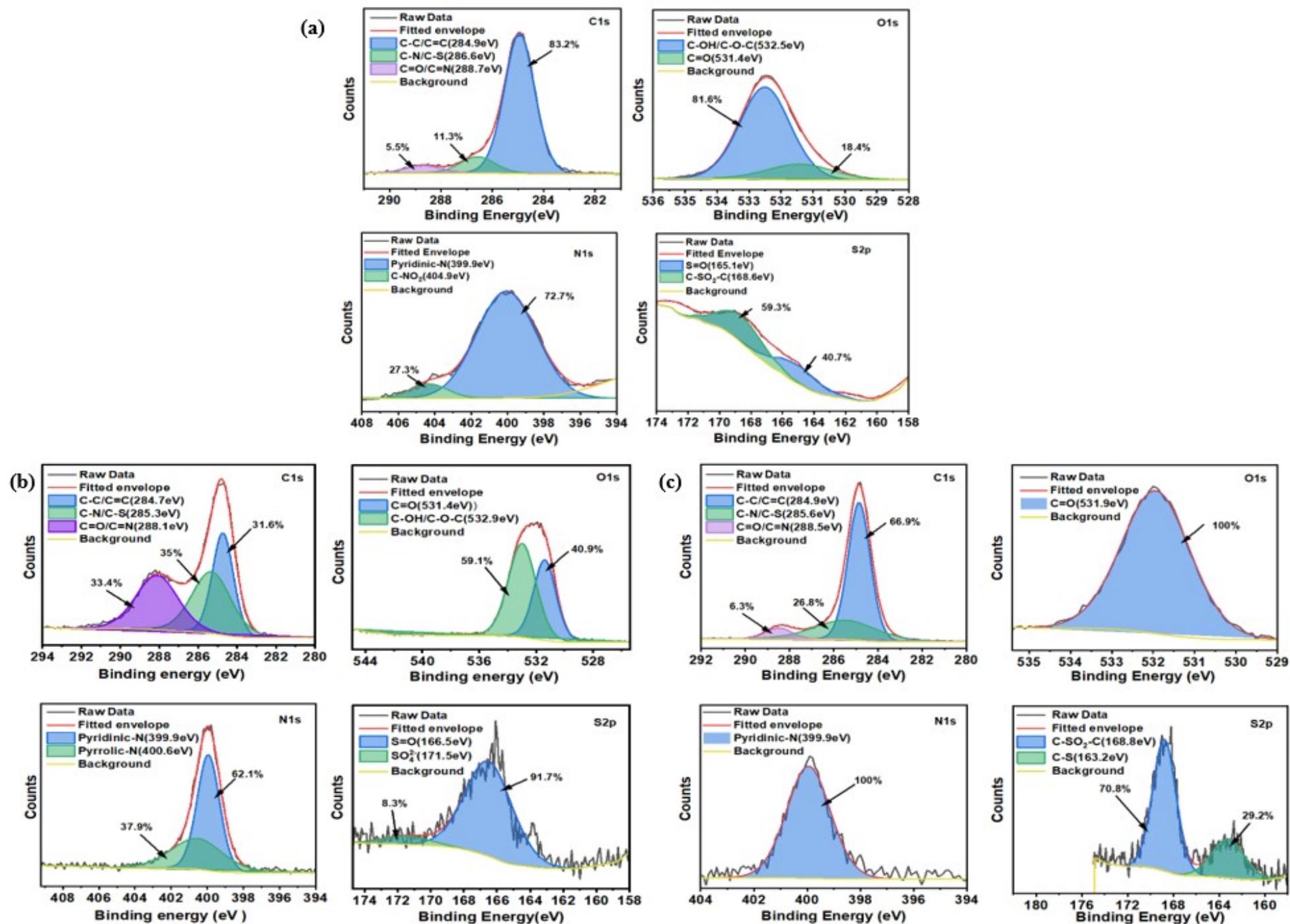


Fig. S2. XPS survey data for (a) r-CDs@Water(no column), (b) r-CDs@DMSO(no column), (c) r-CDs@DMSO(column), respectively showing percentage compositions of the chemical bonds.

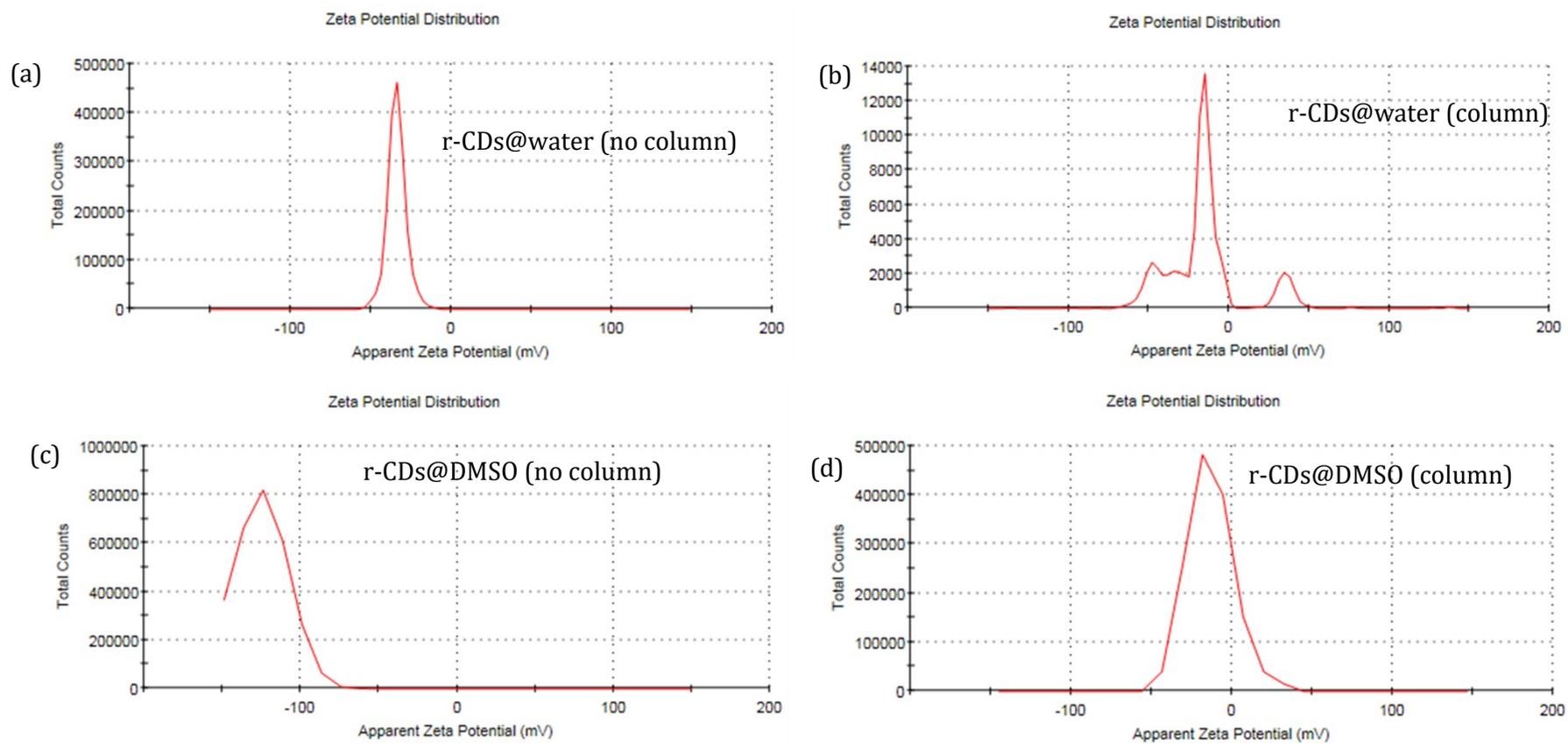


Fig. S 3. Zeta potentials of the r-CDs samples.

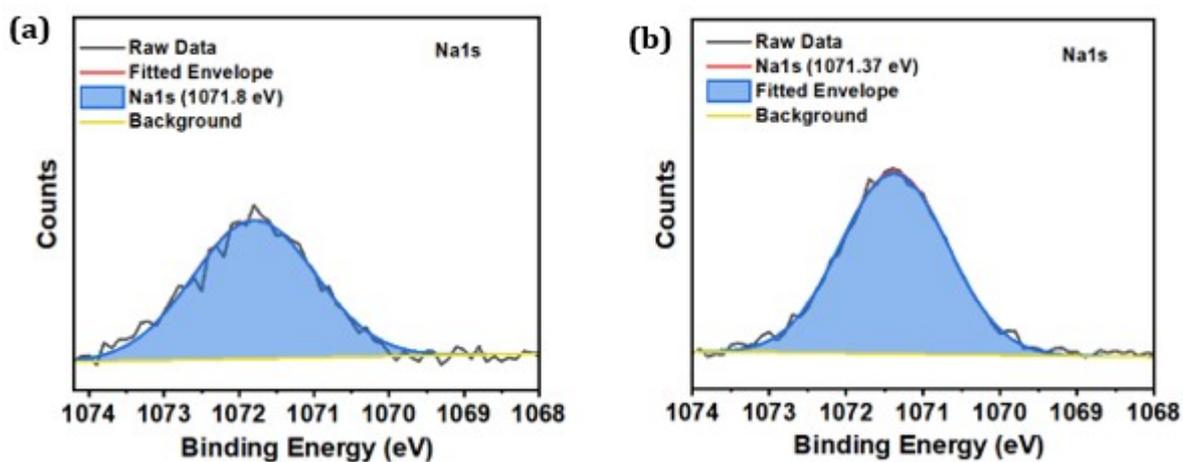


Fig. S4. High-resolution Na1s spectra of (a). r-CDs@Water(column) and (b). r-CDs@DMSO(column).

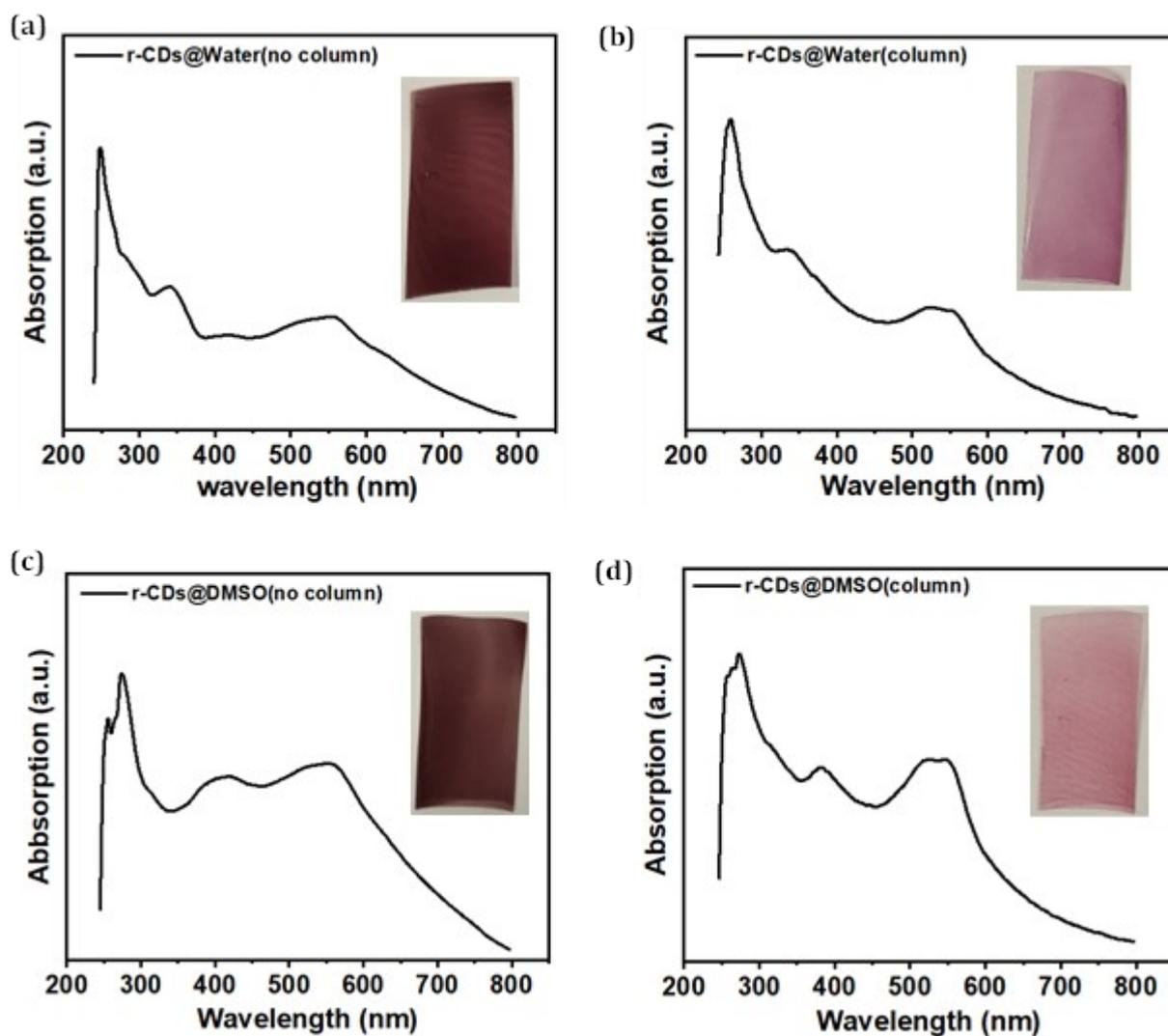


Fig. S5. Solid-state UV-vis spectra of the r-CDs samples. The insets in each image panel show the fabricated r-CDs@PMMA films.

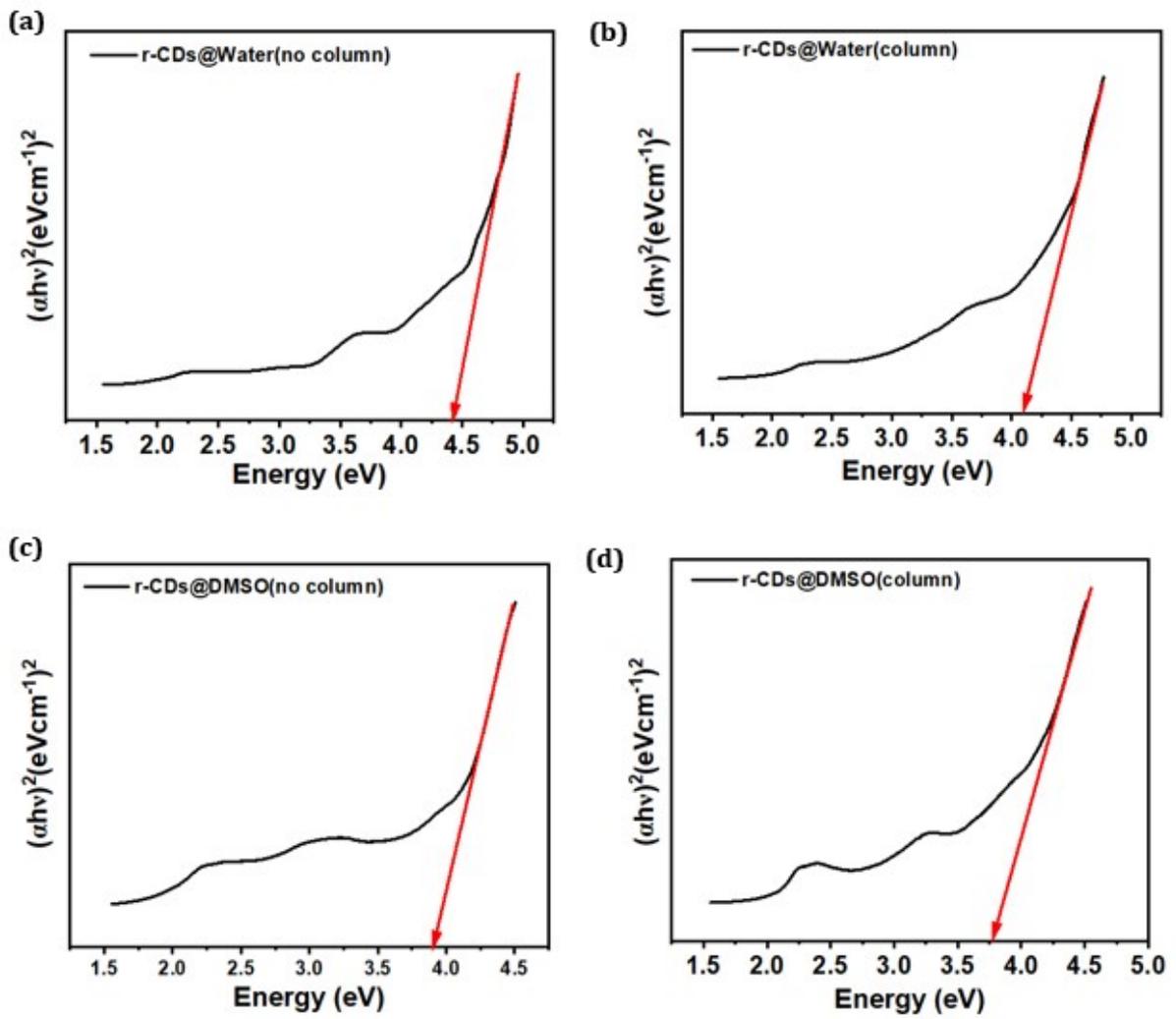


Fig. S 6. Tauc plots of the r-CDs samples showing the optical gaps extrapolated from the steep linear region (black line). The red arrow line indicates the extrapolated optical gap energy values on the x-axis.

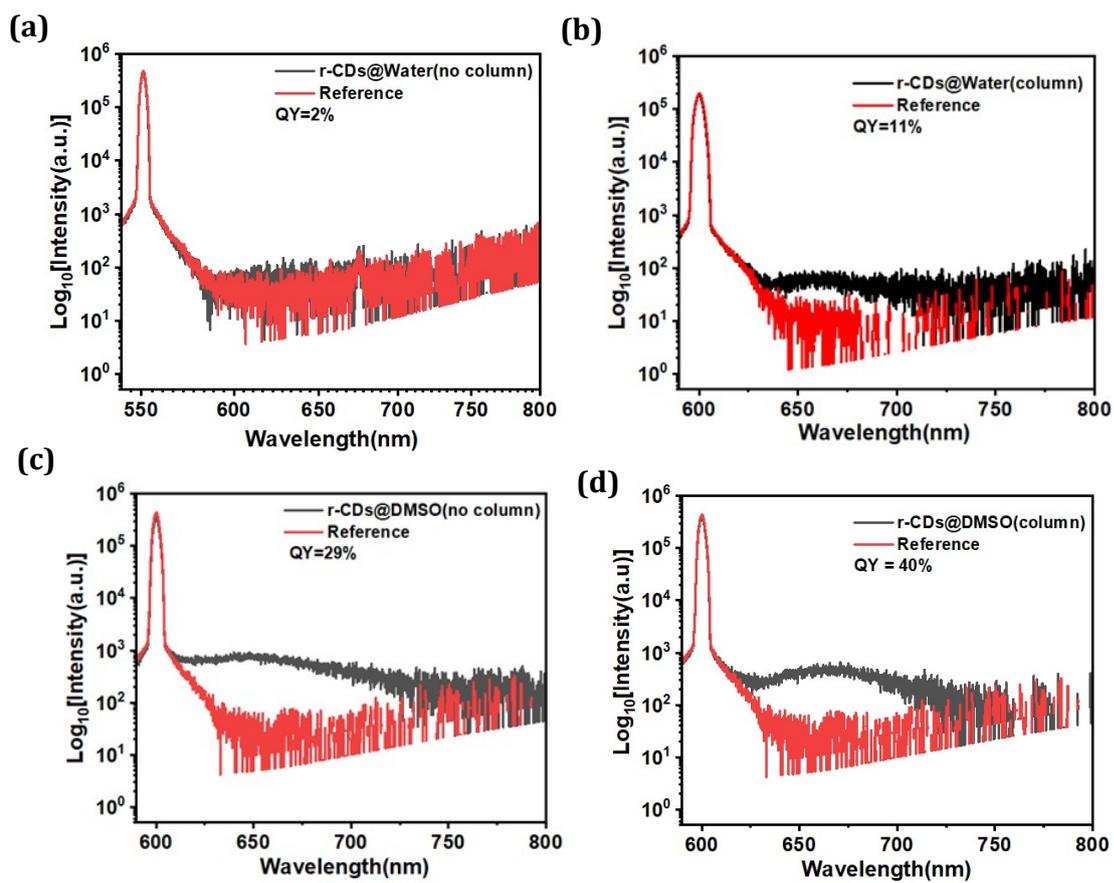


Fig. S 7. PLQY measurements of r-CDs samples.

Table S 6: Fit parameters of deconvolved high-resolution XPS spectra of r-CDs@Water (no column) and r-CDs@Water (column).

r-CDs@Water (no column)						
Name	Peak BE eV	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
C1s	284.77	1.78	11828.12	37.43	1	
C1s Scan A	287.08	3.37	14980.89	47.48	1	
C1s Scan B	289.17	3.37	4755.04	15.09	1	
r-CDs@Water (column)						
Name	Peak BE eV	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
O1s	531.41	1.66	7376.86	29.42	1	
O1s Scan A	532.53	3.02	17682.41	70.58	1	
r-CDs@Water (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
N1s	400.08	1.54	4892.35	38.76	1	
N1s Scan A	400.91	2.92	7725.32	61.24	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
S2p	164.08	3.37	318.61	54.96	1	
S2p Scan A	172.13	2.58	117.25	20.32	1	
S2p Scan B	167.19	3.37	142.99	24.71	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
C1s	284.94	1.39	29289.61	83.24	1	
C1s Scan A	286.58	1.58	3966.51	11.28	1	
C1s Scan B	288.7	1.6	1923.3	5.48	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
O1s	532.5	1.87	62570.15	81.57	1	
O1s Scan A	531.4	2.41	14147.82	18.43	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
N1s Scan A	404.91	3.37	571.93	27.35	1	
N1s	399.92	3.37	1524.69	72.65	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
S2p	165.14	3.37	568.97	40.69	1	
S2p Scan A	168.58	3.37	827.75	59.31	1	
r-CDs@Water (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
Na1s	1071.8	1.91	4528.72	100	1	

Table S 7: Fit parameters of deconvolved high-resolution XPS spectra of r-CDs@DMSO (no column) and r-CDs@DMSO (column).

r-CDs@DMSO (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
C1s	284.73	1.28	14926.3	31.57	1	
C1s Scan A	285.32	2.36	16561.17	35.04	1	
C1s Scan B	288.12	2.54	15753.87	33.39	1	
r-CDs@DMSO (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
O1s	531.4	1.86	23313.92	40.92	1	
O1s Scan A	532.99	2.29	33616.01	59.08	1	
r-CDs@DMSO (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
N1s	399.94	1.47	9119.59	62.11	1	
N1s Scan A	400.55	3.37	5561.51	37.89	1	
r-CDs@DMSO (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
S2p	166.51	3.37	2272.21	91.71	1	
S2p Scan A	171.49	3.37	204.86	8.29	1	
r-CDs@DMSO (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
C1s	284.85	1.19	36369.12	66.87	1	
C1s Scan A	285.47	3.37	14592.73	26.84	1	
C1s Scan B	288.48	1.36	3411.59	6.29	1	
r-CDs@DMSO (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
O1s	531.94	1.96	27156.94	100	1	
r-CDs@DMSO (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
N1s	399.95	1.93	5006.21	100	1	
r-CDs@DMSO (column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
S2p	168.78	2.41	2429.47	70.82	1	
S2p Scan A	163.21	3.37	1004.21	29.18	1	
r-CDs@DMSO (no column)						
Name	Peak BE	FWHM eV	Area (P) CPS.eV	Atomic %	Q	
Na1s	1071.37	1.64	6841	100	1	