

Supplementary Material

Comparison of Carbon Dots Prepared from Collagen Peptide Using Conventional Hydrothermal and Microwave Methods

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1. Characterization of the Structure and Composition of Fish Scale Collagen Peptide

Table S1. Amino acid composition of fish scale collagen peptide

Amino acid	Number of residues/1000 amino acid residues
Aspartic acid	43.01
Threonine	18.71
Serine	37.93
Glutamate	79.00
Proline	100.97
Glycine	326.39
Alanine	91.41
Cysteine	4.58
Valine	19.73
Methionine	7.73
Isoleucine	9.46
Leucine	24.20
Tyrosine	3.36
Phenylalanine	10.17
Lysine	5.59
Histidine	21.86
Arginine	58.67
Hydroxyproline	137.26

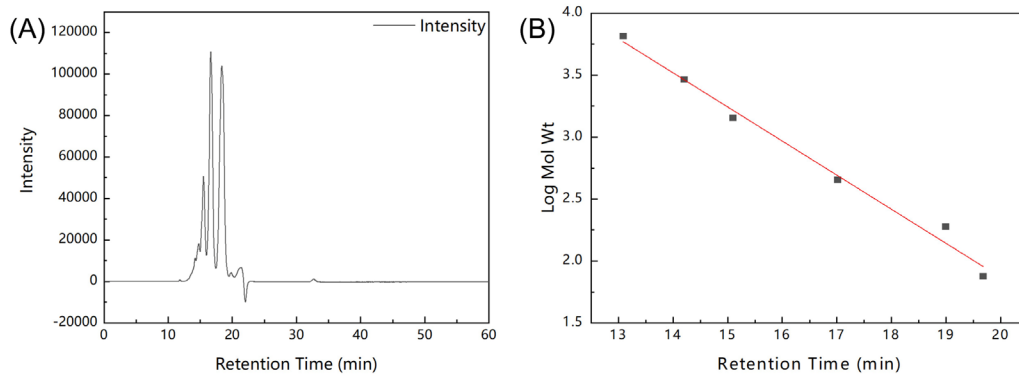


Figure S1. Gel permeation chromatography elution profile of fish scale collagen peptides

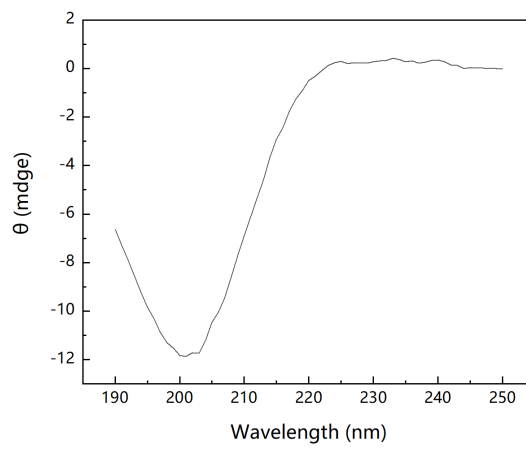


Figure S2. Circular dichroism chromatogram of fish scale collagen peptide

2. Single-factor analysis and orthogonal-experiment optimization reaction parameters for CDs

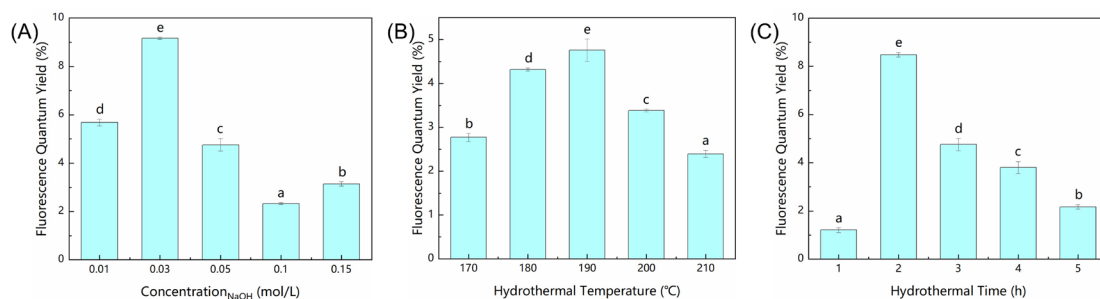


Figure S3. The effect of NaOH concentration (A), hydrothermal temperature (B) and hydrothermal time (B) on the quantum yield of CDs-HT. The results were presented as mean \pm standard deviation ($n=3$). The differences between means were evaluated by Duncan's multiple-range test, means that contain different letters are significantly different at $P<0.05$.

Table S2. The experimental design based on $L_9(3^4)$ orthogonal array and experimental results of preparation conditions for CDs-HT

No.	A (NaOH concentration)	B (Hydrothermal time)	C (Empty column)	D (Hydrothermal temperature)	Quantum yield (%)
1	0.01	1		180	4.43
2	0.01	2		190	3.21
3	0.01	3		200	1.15
4	0.03	1		200	5.94
5	0.03	2		180	1.83
6	0.03	3		190	9.21
7	0.05	1		190	3.04
8	0.05	2		200	8.38
9	0.05	3		180	4.35
K_1	8.80	13.42		10.62	
K_2	16.98	13.43		15.48	
K_3	15.78	14.72		15.47	
k_1	2.93	4.47		3.54	
k_2	5.66	4.48		5.16	
k_3	5.26	4.91		5.16	
R	8.18	1.29		4.86	

K , Sum of quantum yield for the factors at each level; k , The mean values for the factors at each level; R , $K_{\max}-K_{\min}$.

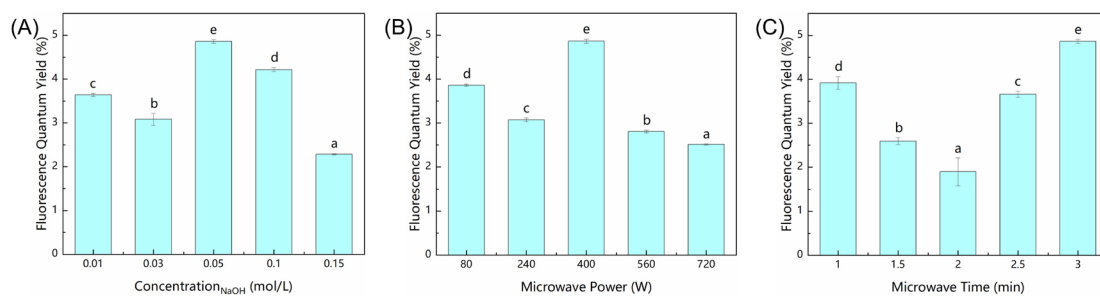


Figure S4. The effect of NaOH concentration (A), microwave power (B) and microwave time (C) on the quantum yield of CDs-MW. The results were presented as mean \pm standard deviation ($n=3$).

The differences between means were evaluated by Duncan's multiple-range test, means that contain different letters are significantly different at $P<0.05$.

Table S3. The experimental design based on $L_9(3^4)$ orthogonal array and experimental results of preparation conditions for CDs-MW

No.	A (NaOH concentration)	B (Microwave time)	C (Empty column)	D (Microwave power)	Quantum yield (%)
1	0.03	2.0		240	3.64
2	0.03	2.5		400	3.34
3	0.03	3.0		560	3.37
4	0.05	2.0		560	2.97
5	0.05	2.5		240	2.62
6	0.05	3.0		400	4.86
7	0.1	2.0		400	3.37
8	0.1	2.5		560	2.60
9	0.1	3.0		240	4.28
K_1	10.34	9.98		10.53	
K_2	10.46	8.55		11.57	
K_3	10.24	12.51		8.94	
k_1	3.45	3.33		3.51	
k_2	3.49	2.85		3.86	
k_3	3.41	4.17		2.98	
R	0.22	3.95		2.63	

K , Sum of quantum yield for the factors at each level; k , The mean values for the factors at each level; R , $K_{\max}-K_{\min}$.

3. Fluorescence stability of CDs

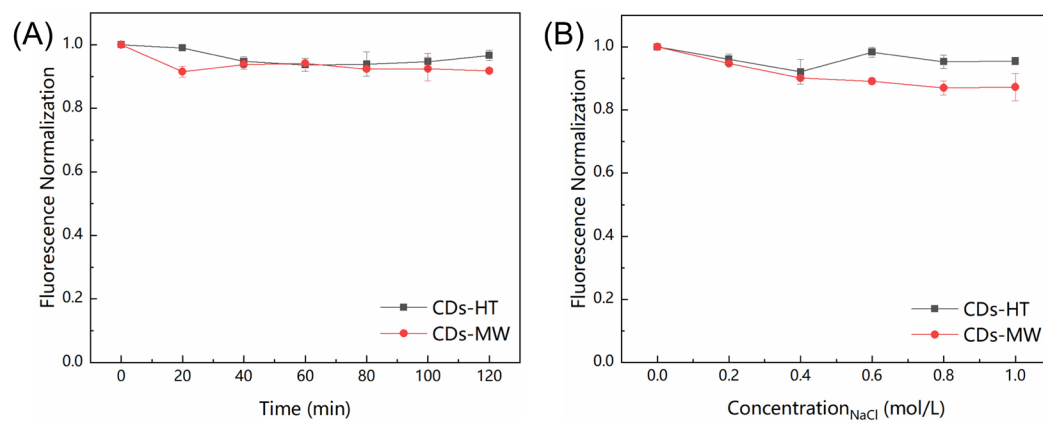


Figure S5. Effects of xeno-lamp irradiation (A) and ion intensity (B) on the fluorescence intensity of CDs

4. Characterization of Surface Properties of CDs

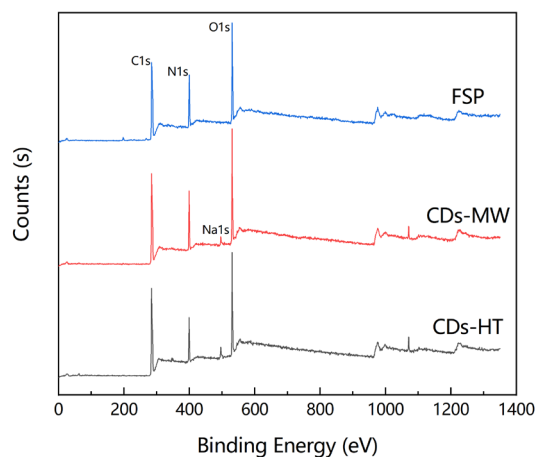


Figure S6. XPS full-scan survey spectra of CDs-HT, CDs-MW and FSP

Table S4. Peak parameters obtained by deconvolution of the XPS spectra

Sample	Peak	Position (eV)	Area	FWHM (eV)	Area (%)	Sample	Peak	Position (eV)	Area	FWHM (eV)	Area (%)
CDs-HT	1	284.8	158657.1	1.8	58.7	CDs-MW	1	284.8	150530.5	1.8	51.9
	2	285.9	28665.5	1.0	10.6		2	285.9	45372.3	1.0	15.6
	3	286.5	11504.6	1.0	4.3		3	286.5	13148.5	1.0	4.5
	4	287.7	71619.8	1.8	26.5		4	287.7	81014.5	1.7	27.9
	5	398.5	6559.8	1.3	7.4		5	398.5	9732.1	1.5	7.8
	6	399.6	48648.8	1.3	54.6		6	399.6	76048.4	1.3	60.6
	7	400.2	25676.2	1.3	28.8		7	400.2	26168.2	1.3	20.8
	8	401.3	8181.3	2.0	9.2		8	401.3	13626.1	2.0	10.9
	9	531.1	188352.7	1.8	85.4		9	531.1	199174.1	1.8	83.7
	10	532.5	32207.3	1.8	14.6		10	532.4	38673.3	1.8	16.3

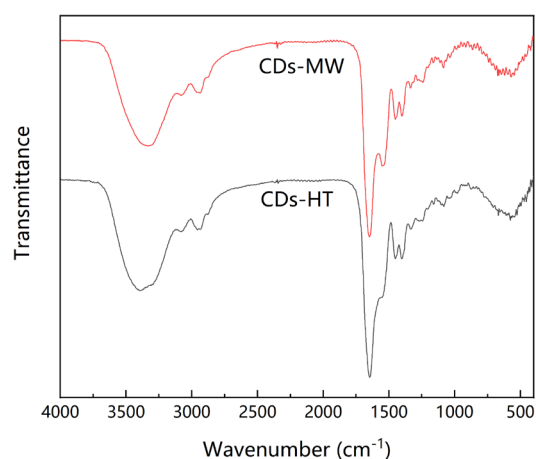


Figure S7. FTIR spectra of CDs-HT and CDs-MW

Table S5. Peak parameters obtained by deconvolution of the FTIR spectra (3800~2800cm⁻¹)

Sample	Center	Area	Amplitude	Center	Width	Sample	Center	Area	Amplitude	Center	Width
CDs-HT	1652.1	83.8	0.918	1652.1	85.8	CDs-MW	1654.7	75.6	0.917	1654.7	77.5
	1563.4	36.6	0.441	1563.4	77.9		1566.4	40.4	0.436	1566.4	87.2
	1524.0	6.9	0.150	1524.0	43.6		1525.3	13.4	0.238	1525.3	52.7
	1451.9	10.7	0.241	1451.9	41.8		1450.0	11.3	0.251	1450.0	42.2
	1402.2	8.5	0.202	1402.2	39.5		1400.8	7.6	0.197	1400.8	36.5
	1381.8	0.7	0.039	1381.8	16.0		1382.7	0.3	0.024	1382.7	11.4

Table S6. Peak parameters obtained by deconvolution of the FTIR spectra (1800~1300cm⁻¹)

Sample	Center	Area	Amplitude	Center	Width	Sample	Center	Area	Amplitude	Center	Width
CDs-HT	3544.8	30.1	0.201	3544.8	141.1	CDs-MW	3550.5	13.1	0.096	3550.5	128.1
	3442.9	41.1	0.248	3442.9	155.8		3457.1	33.4	0.169	3457.1	185.4
	3298.2	126.1	0.448	3298.2	264.5		3305.4	135.9	0.438	3305.4	291.6
	3066.8	14.0	0.129	3066.8	102.5		3063.6	13.5	0.120	3063.6	105.3
	2947.4	18.0	0.170	2947.4	99.4		2946.6	17.5	0.168	2946.6	97.9
	2864.6	2.6	0.049	2864.6	50.5		2865.2	2.7	0.049	2865.2	50.5