Supplementary Information (SI) for New Journal of Chemistry.

Supplementary Material

for

Green Synthesis of Garlic peel-based Carbon Dots for Detection of Metal Ions and Printable Anti-counterfeiting Applications

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Experimental section

Construction of ratio-type probes and smartphone-assisted visual detection

After mixing rhodamine B with G-CDs in different proportions, a series of solutions with different fluorescence colors can be obtained (volume ratios of rhodamine B to CDs are 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, and 1:10). A specific ratio was selected as the probe solution. To make the fluorescence color change more significant after adding Cr^{3+} to the probe solution, a 1: 3 ratio was selected for subsequent detection experiments. Mix the prepared probe solution with the Cr^{3+} solution and observe under 365 nm ultraviolet light. With the addition of Cr^{3+}, the fluorescence color of the probe solution will change. At the same time, take photos and record them with a smartphone. Import the captured photos into the "Color Selector" App to obtain RGB values, and construct the relationship between the change in solution color (RGB values) and ion concentration.

Testing of Fluorescent Ink Performance and Printing Compatibility

Drying time test: The dryness of ink was tested by the friction test. By observing the transfer of ink on the pattern surface printed through friction, the degree of ink drying can be determined. First, prepare the printed samples and record the moment when they were printed on non-fluorescent paper. Then, conduct the drying test at different time points after printing (such as 30 seconds, 60 seconds, 120 seconds). Place the printed sample on a glass plate, then cover the printed surface with non-fluorescent paper. Apply a fixed pressure and perform back-and-forth friction. Observe whether any ink adheres to the non-fluorescent paper and record the result. To keep the experimental results accurate, repeat the above experiments and take the average value as the experimental results.

Test of ink viscosity performance: Test by rotary viscometer. First, assemble the instrument and prepare the sample ink to be tested. Select the 28th rotor, then introduce the sample ink into the sample cylinder and immerse the test rotor in the ink. Data needs to be measured and recorded multiple times.

Test of ink transfer rate: Prepare non-fluorescent paper (filter paper and weighing paper), and calculate the ink transfer rate by measuring the weight difference of the substrate before and after printing. The ink transfer rate refers to the ratio of the amount of ink transferred to the surface of the substrate and the amount of ink applied to the plate. It can be expressed by the formula: $F = y/x * 100\%$ (where F represents the ink transfer rate, y represents the ink amount transferred onto the substrate surface, and x represents the ink amount applied to the printing plate).

Test of print gloss: The glossiness of the printed materials is tested using a gloss meter. Specular reflection and diffuse reflection will occur when the light hits the surface at a specific angle. Glossiness is the ratio of specular reflection light intensity to incident light intensity. The higher the ratio, the higher the glossiness. Turn on the gloss meter and wait for the instrument to complete the self-check. Then, select the test angle of 75° for the test. The square pattern (4 cm × 4cm) printed by a 200 mesh screen printing plate was selected for sample measurement. At the same time, the surface glossiness of the paper without printed ink was measured as a blank control.

Test of rub resistance: The printed materials were tested using a friction resistance testing machine. The friction head moves back and forth in a straight line on the surface of the sample, which is judged by observing the fluorescent effect of the printed matter under UV light. After assembling the wear resistance test unit, fix the sample on the friction head. Then, attach weights (a 500 g weight and two 250 g weights) to the friction head (the friction head weighs 1000 g). Set the number of reciprocating cycles of the testing machine (43 times, 60 times, 250 times) and then start the machine to conduct the test. After each experiment, take photos and record the number of trips, and observe the wear of the sample surface.

Test of fluorescent anti-counterfeiting: The fluorescent ink was printed on non-fluorescent paper using screen printing (at 80 mesh and 100 mesh), and the fluorescent anti-counterfeiting effect was observed under natural light and 365 nm ultraviolet light, and photos were taken for preservation.

Results and Discussion

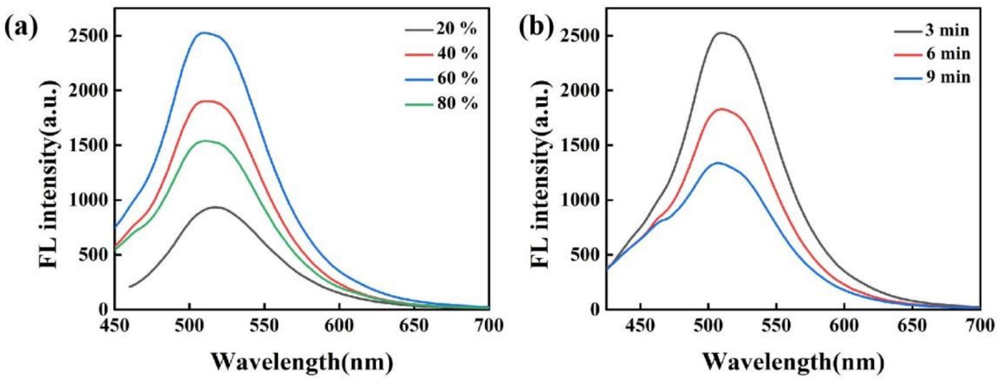

Figure S1. Fluorescence emission spectrum of G-CDs under different reaction conditions: (a) microwave reaction time; (b) microwave reaction power

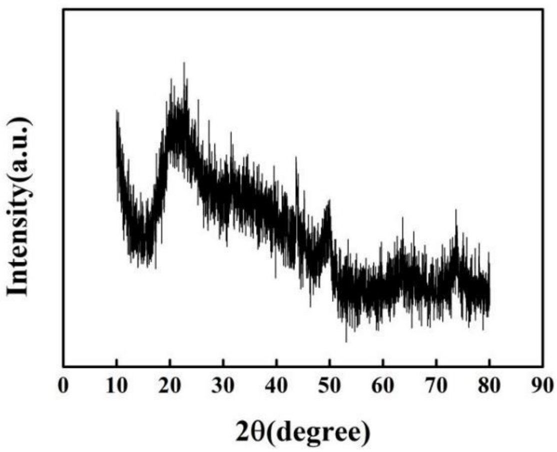

Figure S2. XRD spectrum of G-CDs

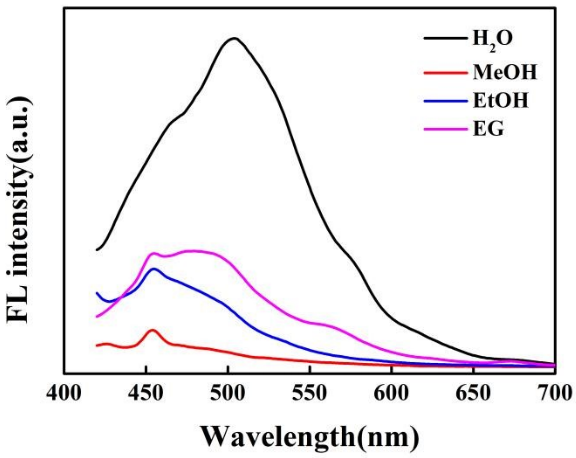

Figure S3. Emission spectra of G-CDs in different Organic solvents

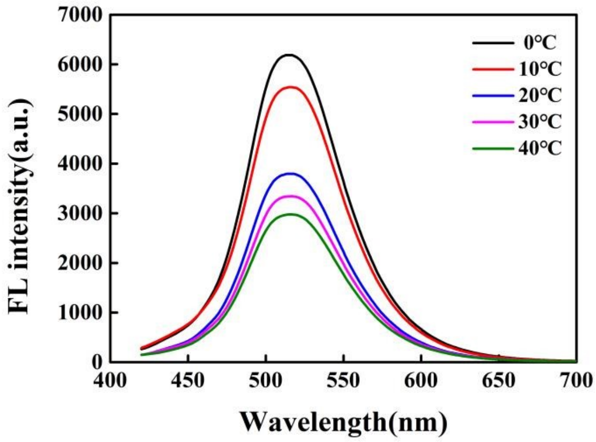

Figure S4. Emission spectra of G-CD in water at different temperatures

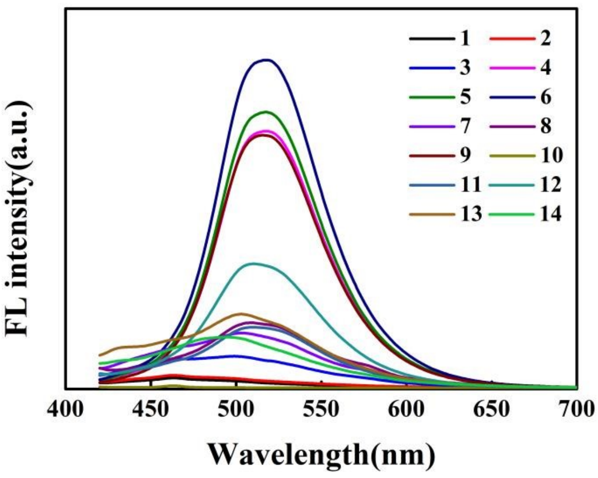

Figure S5. Emission spectra of G-CD in different pH solutions

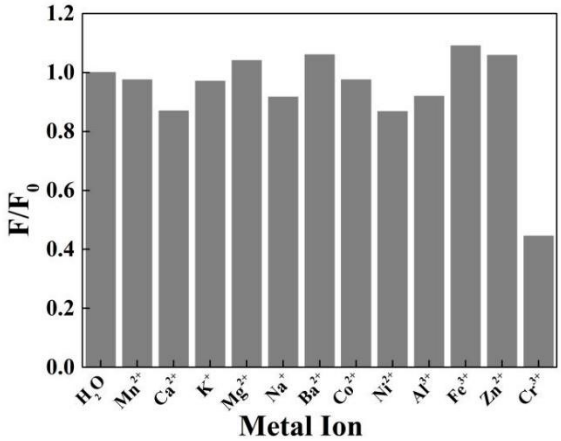

Figure S6. Ion selectivity studies of the G-CDs

Table S1: Comparison of different CDs sensors for the determination of Cr^{3+}

Precursor	synthetic method	emission	QY	LOD	Detection range	Ref.
natural kelp	hydrothermal	446 nm	20.5%	0.52 μM	0.01 - 50 μM	[1]
citric acid; Houttuynia cordata	pyrolysis	450 nm	15%	52.2 nM	5-100 nM	[2]
Thiourea; TA; MPD	Solvothermal	418 nm	-	0.08 μM	0-14 μM	[3]
spinach juice	hydrothermal	-	8.746%	1.38 μM	-	[4]
sucrose	acid carbonization	560 nm	0.18 %	24.6 μM	0-200 μM	[5]
succinic acid; sodium thiosulfate	microwave irradiation	407 nm	36.40%	0.17 μM	0-45 μM	[6]
wine lees	heat	-	-	-	0.1-80 μM	[7]
citric acid ; ethylenediamine	hydrothermal	440 nm	-	27 nM	0.1-6.0 μM	[8]
Garlic peel	microwave irradiation	520 nm	-	1.69 μM	20-150 μM	This work

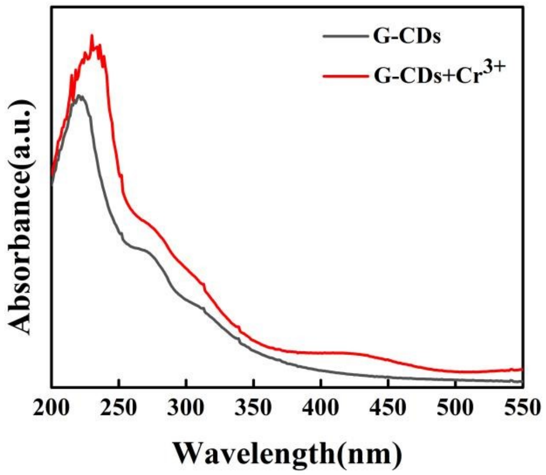

Figure S7. Ultraviolet-visible absorption spectra with and without Cr^{3+}

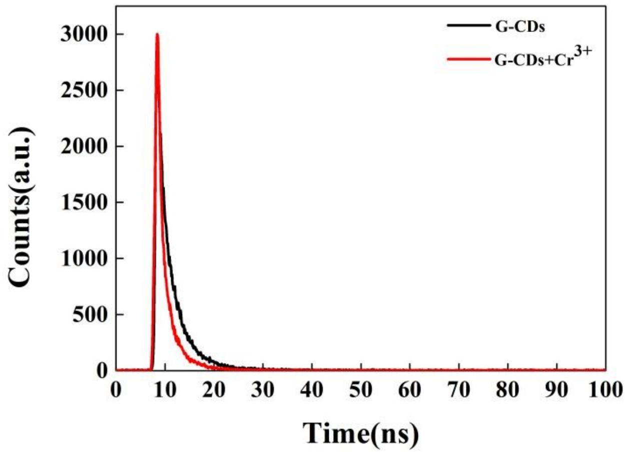

Figure S8. Fluorescence decay of G-CDs in the absence and presence of Cr^{3+}

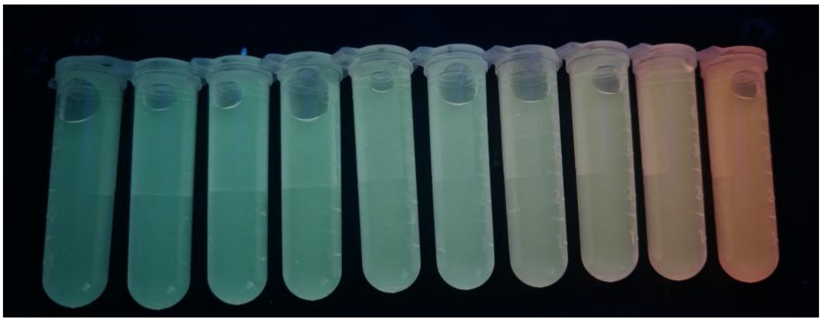

Figure S9. Fluorescence photos of mixed solutions of Rhodamine B/G-CDs with different ratios under ultraviolet light

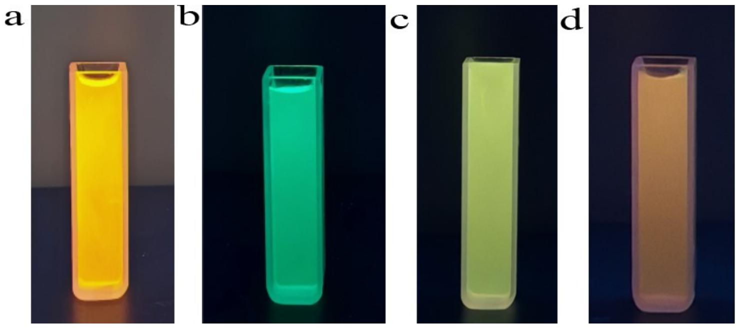

Figure S10. Fluorescent photos of samples: (a) Rhodamine B solution; (b) G-CDs solution; (c) The mixture solution of rhodamine B and G-CDs; (d) Rhodamine B/G-CDs and Cr^{3+} mixed solution

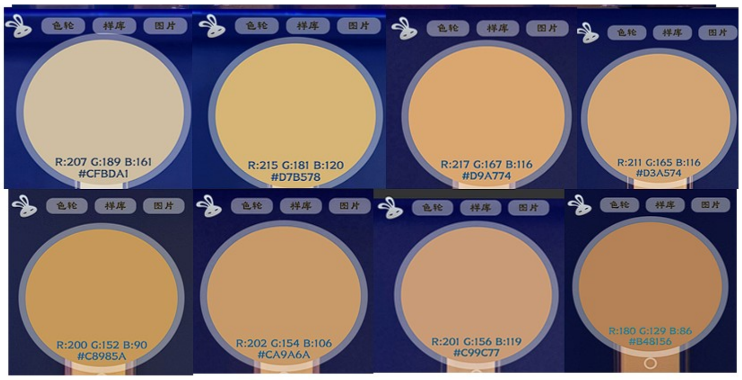

Figure S11. The RGB values of the photos of the sample being tested by the probe solution recognized by the mobile phone software under the ultraviolet light

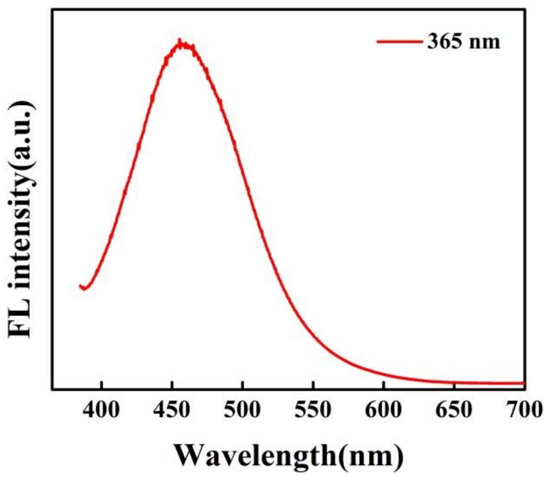

Figure S12. Emission spectra of G-CDs fluorescent powder under 365 nm excitation light

Table S2. Drying time of fluorescent ink on non-fluorescent paper

The drying time of fluorescent ink on non-fluorescent paper							Average value
Filter	Drying time	636	658	639	616	618	633.4

Paper	(s)						
Weighing paper	Drying time (s)	153	138	135	160	143	145.8

Table S3. The ink transfer rate of fluorescent ink on non-fluorescent paper

The ink transfer rate of fluorescent ink on non-fluorescent paper							Average value
Filter Paper	Amount of ink on the printing plate（x）	0.241 g	0.230 g	0.253 g	0.246 g	0.232 g	0.2404 g
	Amount of ink transferred（y）	0.032 g	0.031 g	0.033 g	0.034 g	0.033 g	0.0326 g
	Transfer rate（F）	13.3%	13.5%	13.1%	13.8%	14.2%	13.58%
Weigh-ing paper	Amount of ink on the printing plate（x）	0.243 g	0.229 g	0.252 g	0.248 g	0.222 g	0.193 g
	Amount of ink transferred（y）	0.031 g	0.029 g	0.031 g	0.032 g	0.030 g	0.0306 g
	Transfer rate（F）	12.7%	12.6%	12.3%	12.9%	13.5%	12.8%

Table S4. The glossiness of fluorescent ink on non-fluorescent paper

non-fluorescent paper (GU)							Average value
Weighing paper	Crosswise	28.9	28.7	28.6	30.6	29.1	29.18
	Lengthways	30.6	31.1	30.9	31.5	30.4	30.9
Filter Paper	Crosswise	3.6	3.8	3.7	3.5	3.6	3.64
	Lengthways	4.4	4.3	4.3	4.3	4.4	4.34
printed matter (GU)							
Weighing paper	Crosswise	8.3	8.2	8.1	8.5	8.6	8.34
	Lengthways	9.1	9.2	9.0	9.3	9.3	9.18
Filter Paper	Crosswise	4.3	4.2	4.1	4.3	4.4	4.26
	Lengthways	5.5	5.6	5.7	5.9	5.4	5.62

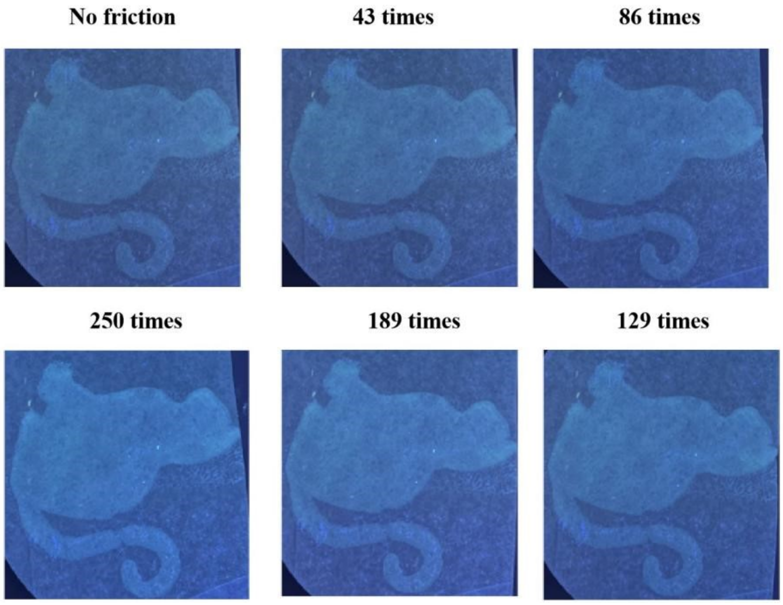

Figure S13. Photos of the friction resistance test samples

References

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