Electronic Supplementary Information

Transforming glucose into fluorescent graphene quantum dots via microwave radiation for sensitive detection of Al^{3+} ions based on aggregation-induced enhanced emission

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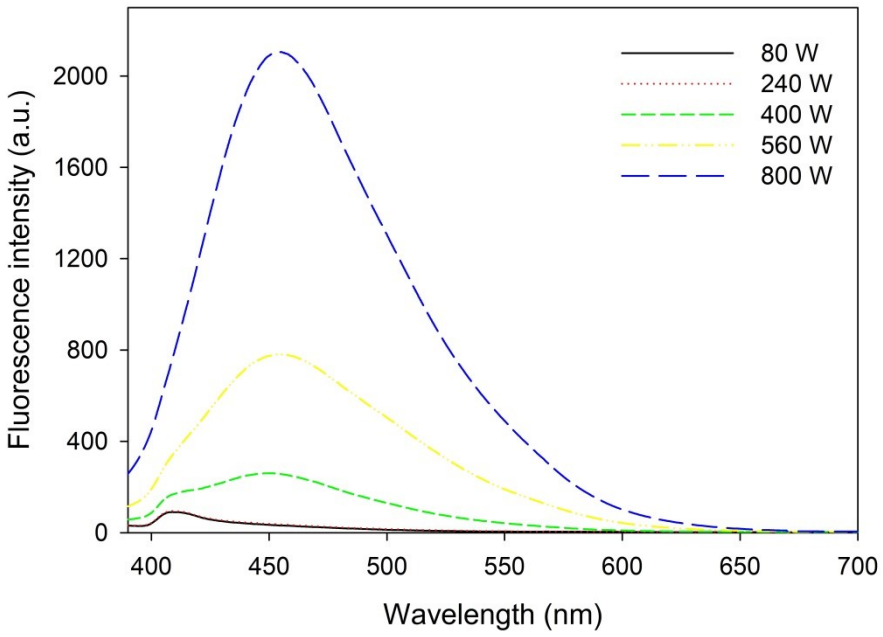

Fig. S1. Optimization of microwave power for the synthesis of graphene quantum dots (GQDs). The results indicate that the microwave power showed a big effect on the GQD synthesis, and 800 W, the highest power of the microwave oven used in this paper, should be chosen as the optimal microwave power that enabled the synthesis of GQDs showing the largest fluorescence signal.

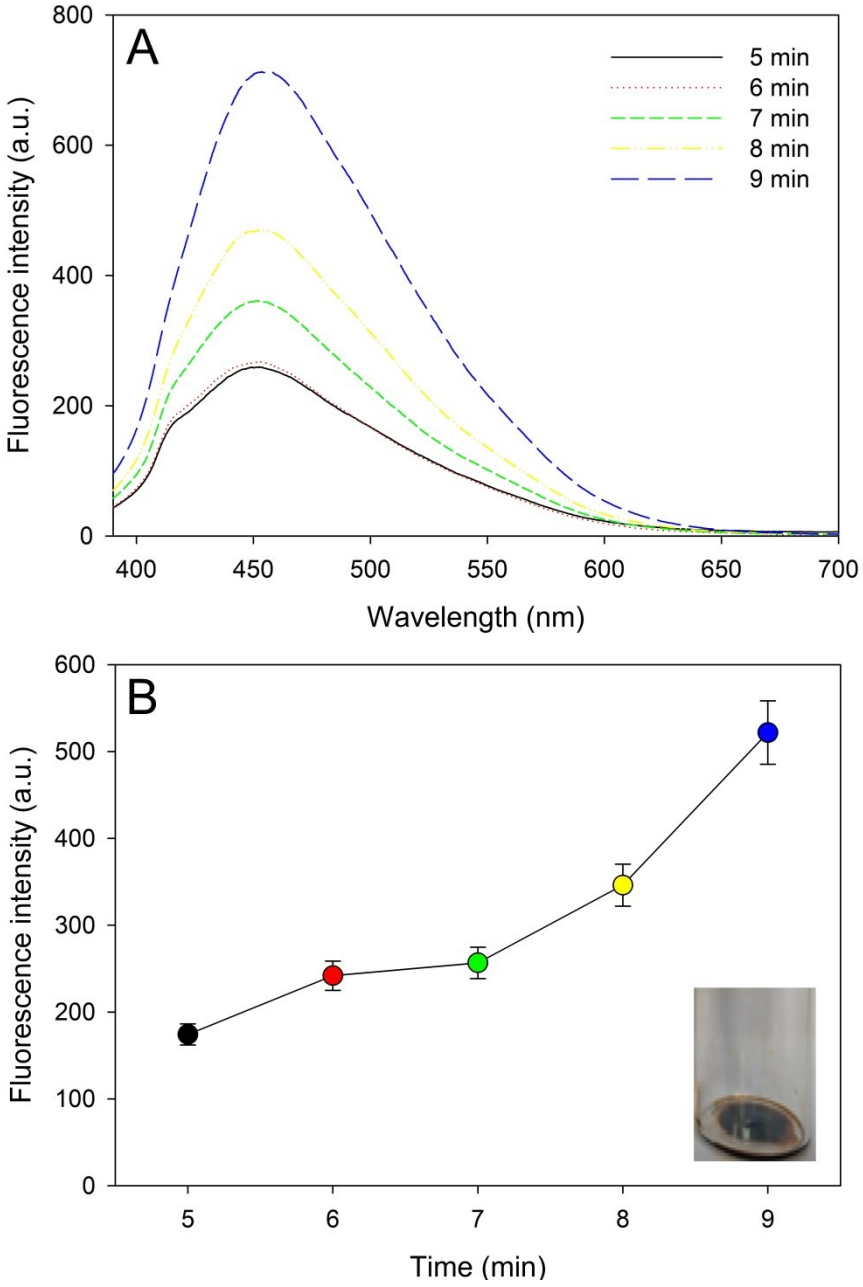

Fig. S2. Optimization of microwave radiation time for the GQD synthesis. The results indicate that the radiation time showed a big effect on the GQD synthesis because more GQD could be produced as the radiation time increased, and 9 min should be chosen as the optimal radiation time that enabled the synthesis of GQDs showing the largest fluorescence signal. However, the prolonged radiation time (i.e., 10 min) led to almost complete evaporation of the reaction solution (inset). Each error bar represents the standard deviation across three replicate experiments.

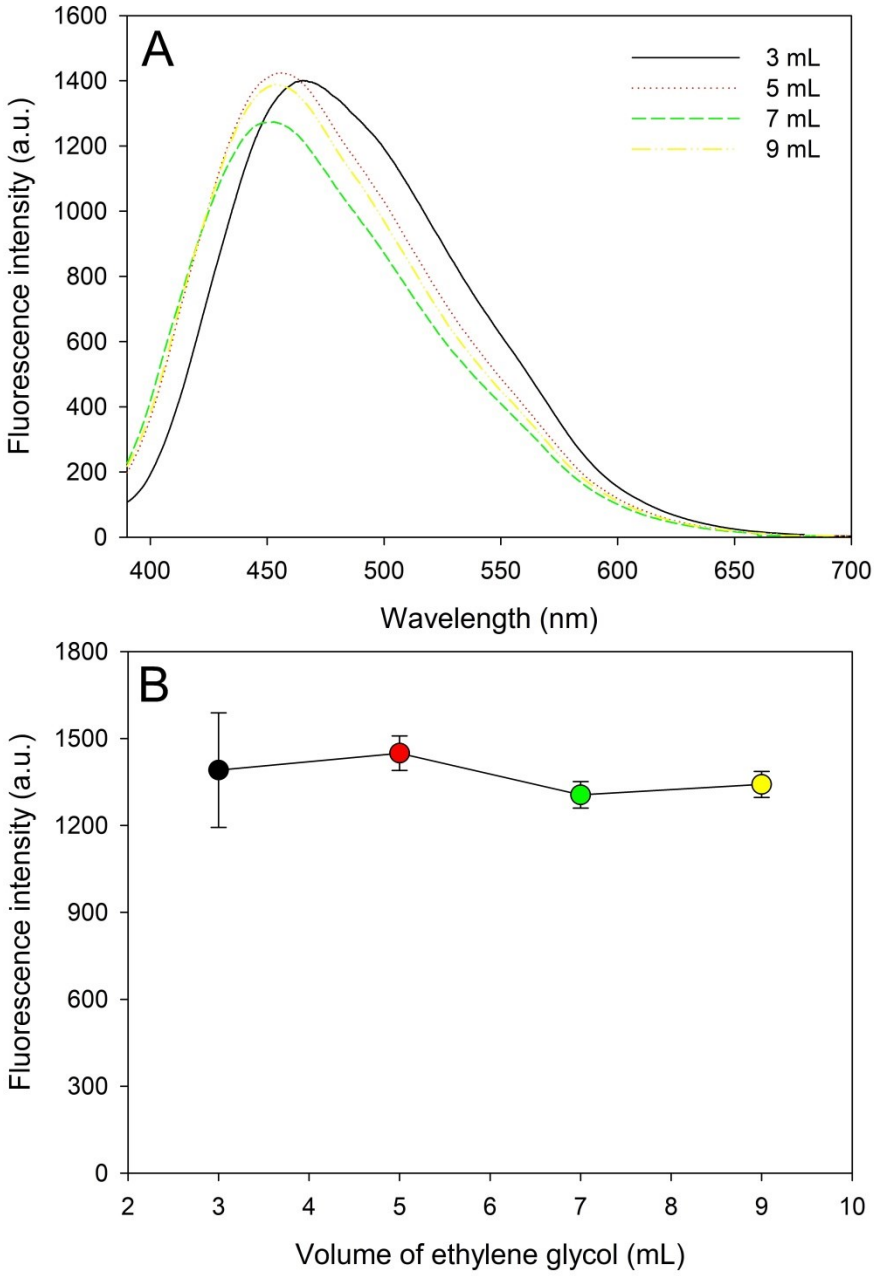

Fig. S3. Optimization of volume of ethylene glycol for the GQD synthesis. The results indicate that the volume of ethylene glycol hardly showed an obvious effect on the GQD synthesis because only the glucose served as the carbon source, and 5 mL should be chosen as the optimal volume of ethylene glycol that enabled the synthesis of GQDs showing the largest fluorescence signal. Each error bar represents the standard deviation across three replicate experiments.

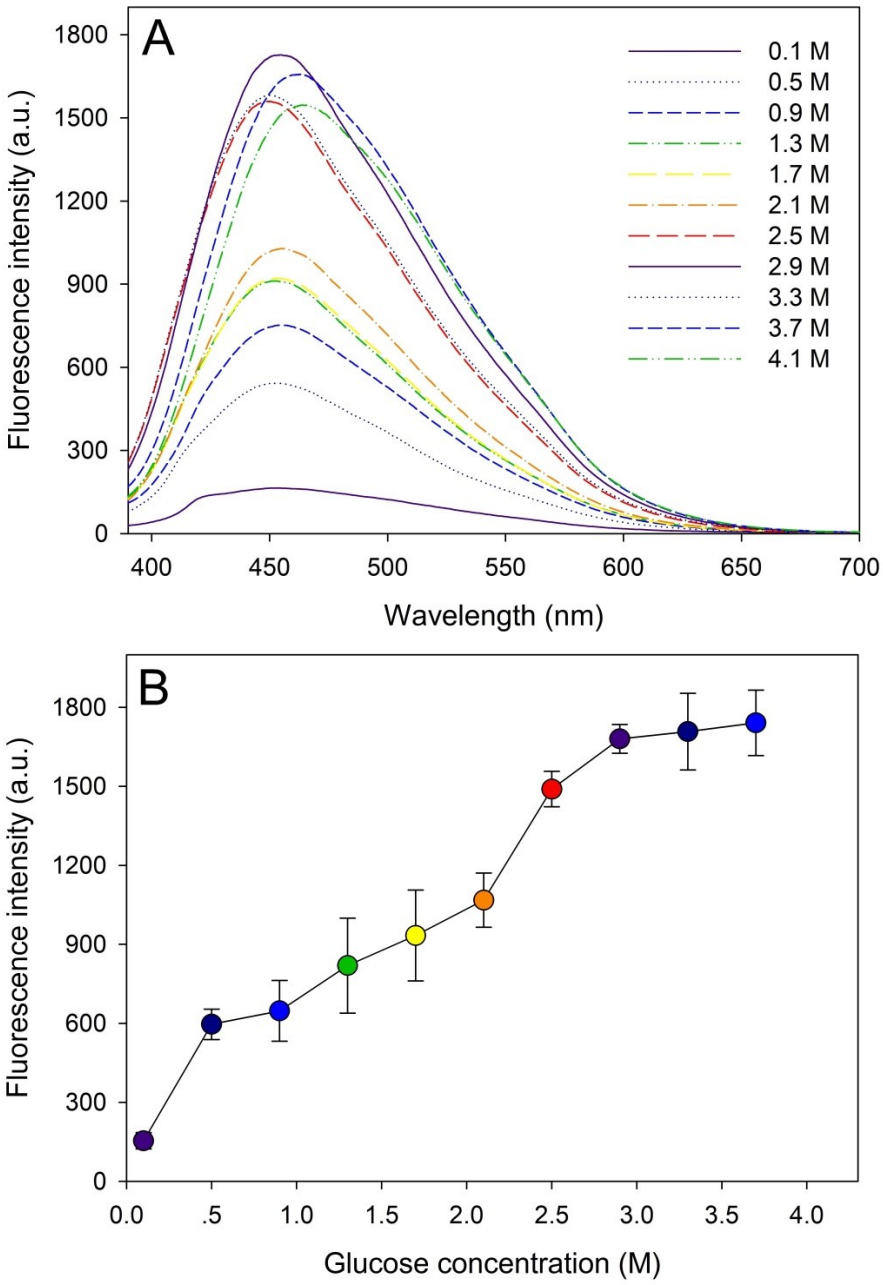

Fig. S4. Optimization of glucose concentration for the GQD synthesis. The results indicate that the glucose concentration showed a big effect on the GQD synthesis because the carbon source increased as the glucose concentration increased, and 2.9 M should be chosen as the optimal glucose concentration that enabled the synthesis of the most amounts of GQDs showing the largest fluorescence signal with the best repeatability (the smallest relative standard deviation). Each error bar represents the standard deviation across three replicate experiments.

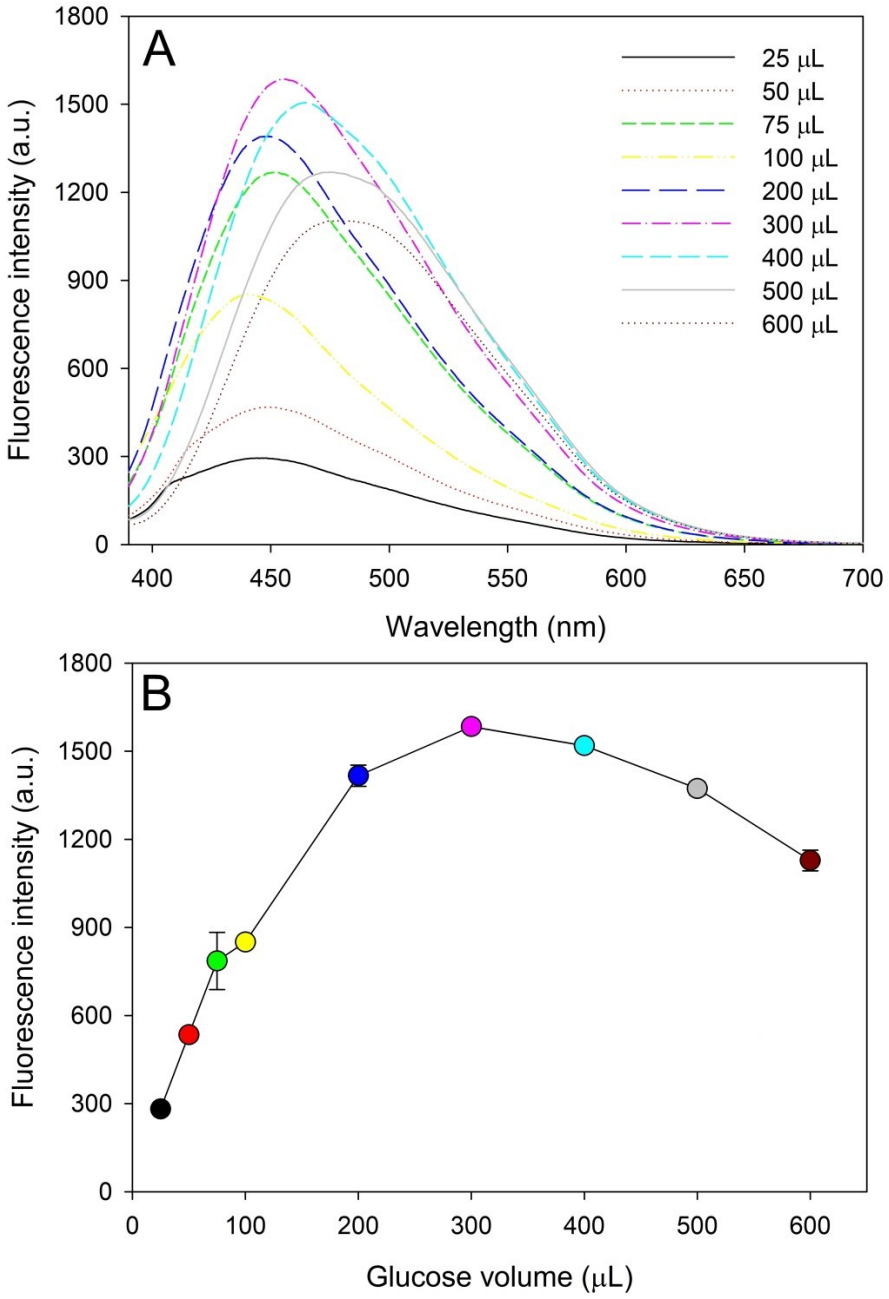

Fig. S5. Optimization of glucose volume for the GQD synthesis. The results indicate that the glucose volume showed a big effect on the GQD synthesis because the carbon source increased as the glucose volume increased. 300 μL should be chosen as the optimal glucose volume that enabled the synthesis of the most GQD amount showing the largest fluorescence signal. However, a glucose volume higher than 300 μL may result in more evaporation of reaction solution leading to less GQD production. Each error bar represents the standard deviation across three replicate experiments.

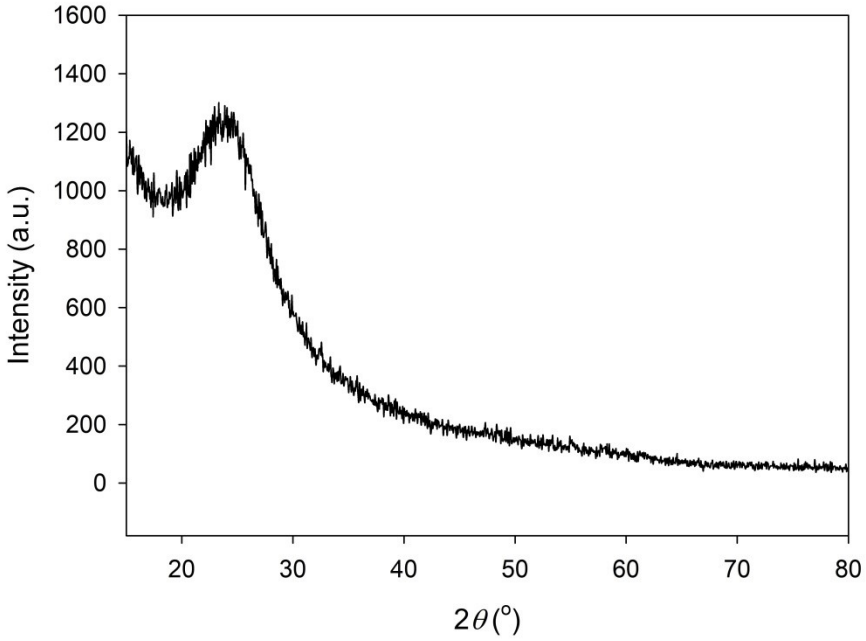

Fig. S6. X-ray diffraction pattern of the GQDs prepared.

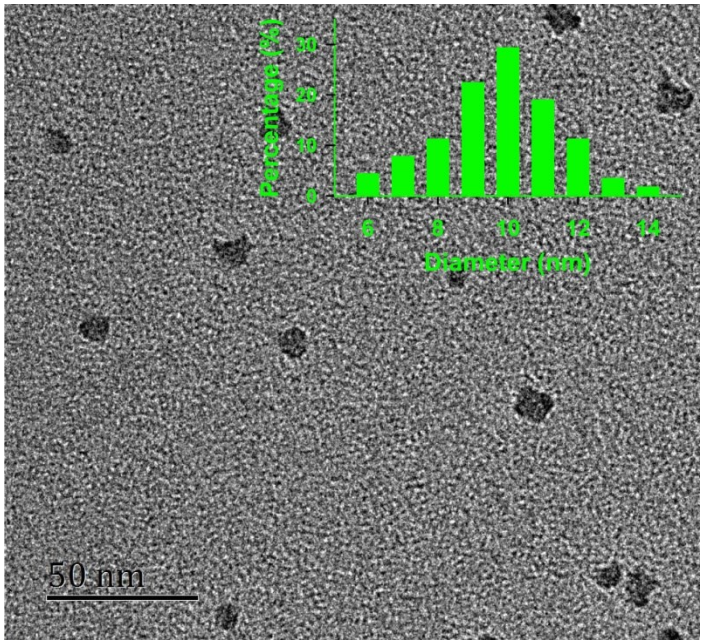

Fig. S7. SEM image of the Al^{3+}-GQD complex.

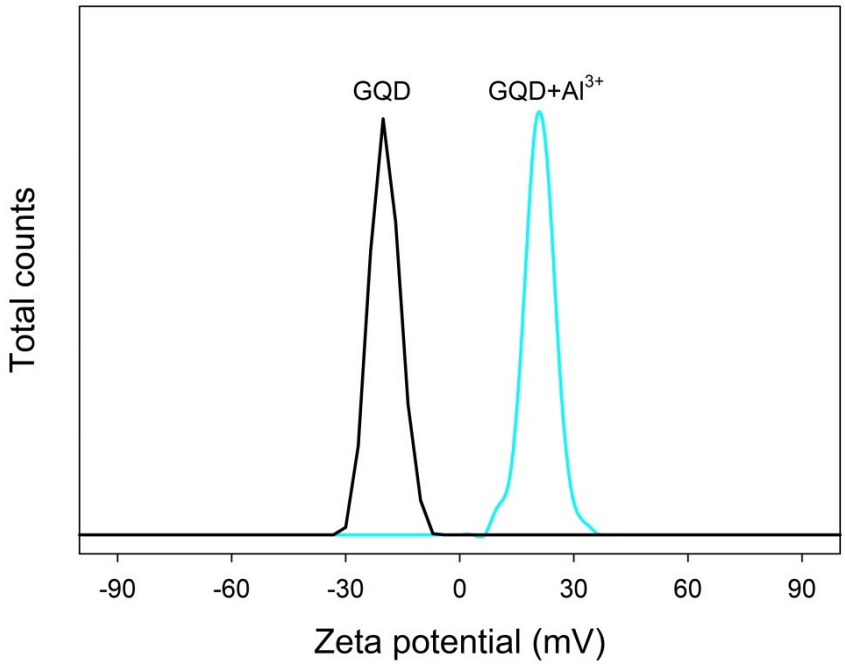

Fig. S8. Zeta potential results obtained from the GQDs and the Al^{3+}-GQD complex.

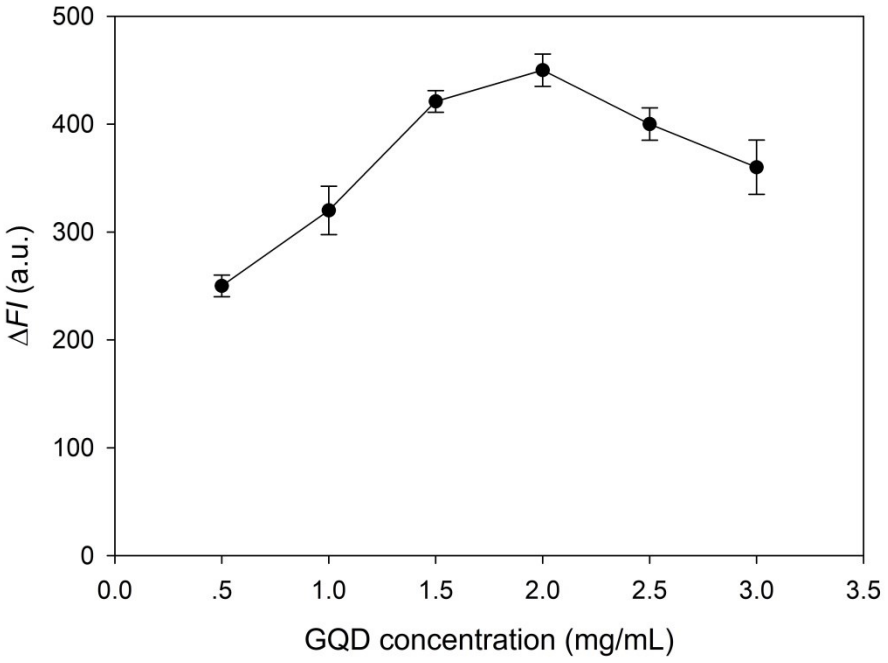

Fig. S9. Optimization of GQD concentration for the Al^{3+} detection. Different GQD solutions were used to assay the same Al^{3+} sample (100 μM) and blank sample (buffer without the analyte) separately. The buffer pH was 5.4 and the reaction time was 1 min. The change of fluorescence intensity ($\Delta FI = FL_{Al3+} - FL_{blank}$) measured was calculated for each GQD solution. The results indicate that the ΔFI value increases as the GQD concentration increases from 0.5 to 2 mg/mL. And 2 mg/mL should be chosen as the optimal GQD concentration that gave the largest ΔFI value (the highest signal-to-background value). Higher concentrations, e.g., 2.5 and 3 mg/mL, led to lower ΔFI values because of the high fluorescence intensity measured from the blank samples. Each error bar represents the standard deviation across three replicate experiments.

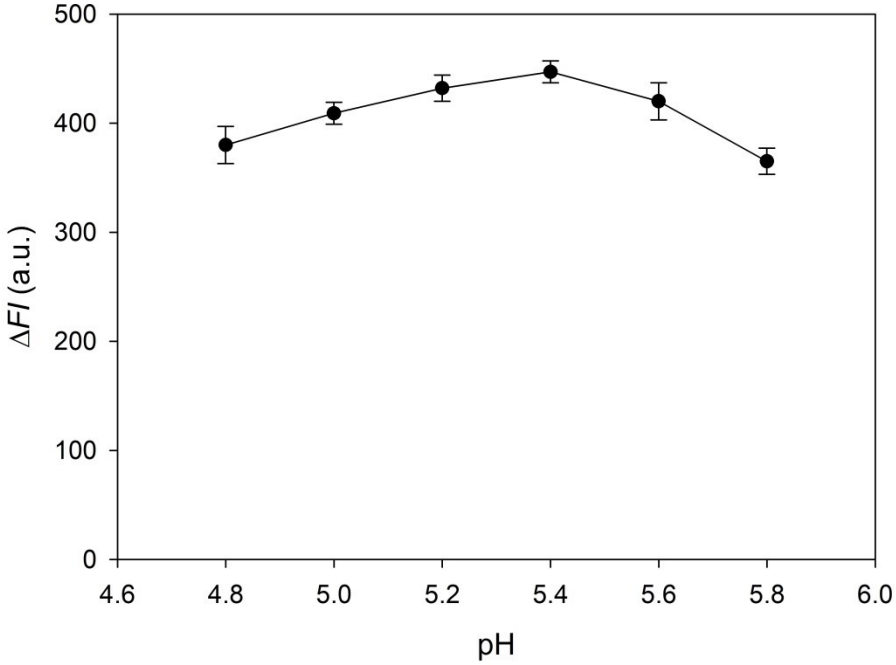

Fig. S10. Optimization of buffer pH for the Al^{3+} detection. Different buffers with various pH values were used in the analysis of the same Al^{3+} sample (100 μM) and blank sample (buffer without the analyte). The GQD concentration was 2 mg/mL and the reaction time was 1 min. The change of fluorescence intensity ($\Delta FI = FL_{Al3+} - FL_{blank}$) measured was calculated for each buffer solution. The results indicate that the buffer pH showed an obvious effect on the Al^{3+} assay. Too low or too high pH values were not beneficial to the binding reactions between the analyte ions and the nanoprobes. And 5.4 should be chosen as the optimal buffer pH that gave the largest ΔFI value (the highest signal-to-background value). Each error bar represents the standard deviation across three replicate experiments.

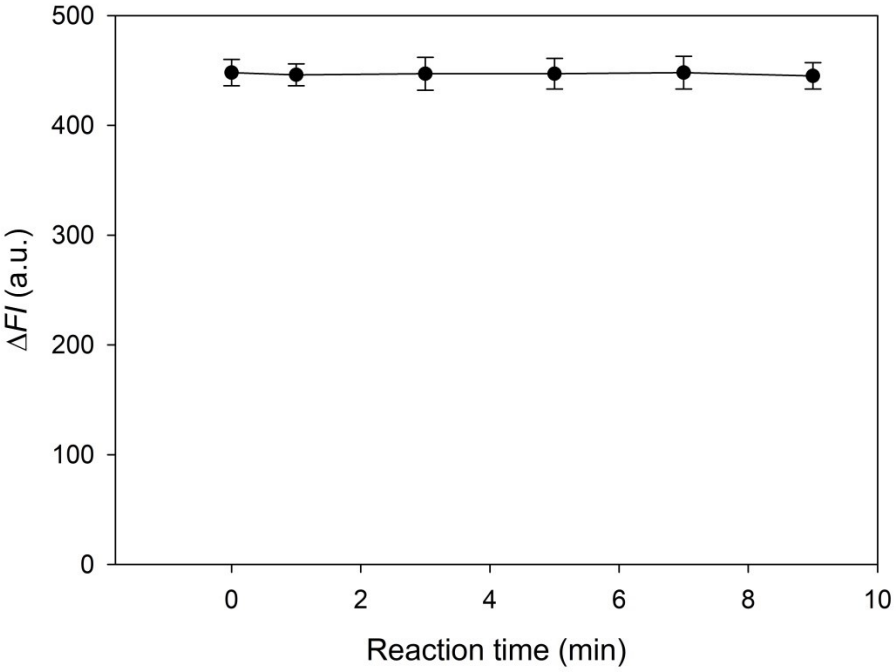

Fig. S11. Optimization of reaction time for incubating the Al^{3+} sample and the GQD solution. Different reaction time was used in the analysis of the same Al^{3+} sample (100 μM) and blank sample (buffer without the analyte). The GQD concentration was 2 mg/mL and the buffer pH was 5.4. The change of fluorescence intensity ($\Delta FI = FL_{Al3+} - FL_{blank}$) measured was calculated for each reaction time. The results indicate that the reaction time showed an ignorable effect on the Al^{3+} analysis. 1 min was thus chosen as a relatively short reaction time to give the largest ΔFI value with the best repeatability (the smallest relative standard deviation). Each error bar represents the standard deviation across three replicate experiments.

Table S1 Recovery of Al^{3+} in several real water samples

Real sample	Found[a] (μM)	Added (μM)	Calculated[b] (μM)	Recovery (%)	RSD[c] (%, n = 6)
Tap water	4.72	75.00	79.01	99.1	6.55
	7.33	200.00	227.41	109.7	4.92
	5.92	400.00	422.32	104.6	8.42
Drinking water	5.61	75.00	81.01	100.5	3.20
	5.93	200.00	202.22	98.2	4.72
	6.66	400.00	415.19	102.1	6.96
Pond water	7.46	75.00	79.82	96.8	7.95
	7.02	200.00	214.67	103.7	8.02
	5.21	400.00	422.08	109.1	7.49
River water	6.92	75.00	82.65	100.9	6.95
	4.03	200.00	209.13	102.5	5.97
	6.18	400.00	395.21	97.3	8.87

[a] The original Ag^{+} concentrations in the samples detected using atomic absorption spectroscopy.

[b] The total Ag^{+} concentrations in the samples determined using the proposed method.

[c] RSD, relative standard deviations.