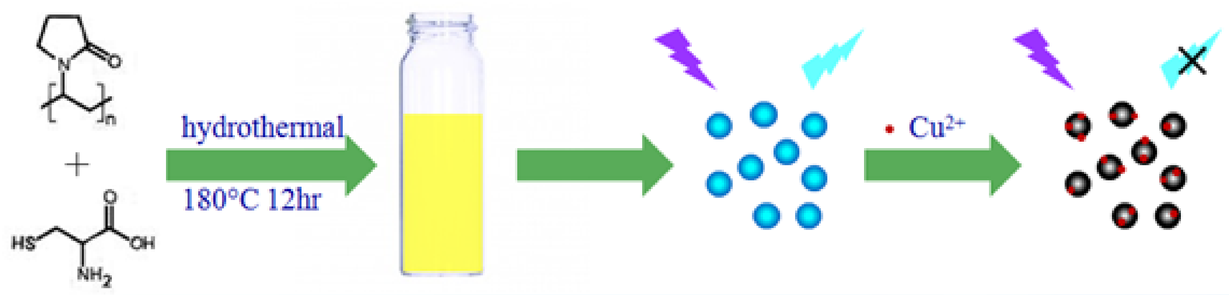
One-pot synthesis of fluorescent carbon nanodots as the sensitive and selective probes for copper ions

Abstract :

A novel sensing system has been designed for copper ions (Cu^{2+}) detection based on the quenched fluorescence signal of polyvinylpyrrolidone (PVP) and cysteine (Cys)-functionalized carbon nanodots (CNDs). Cu^{2+} ions can be captured by the nitrogen groups of the CNDs at the surface of CNDs, resulting in a strong quenching of the fluorescence of CNDs. The resulting water-soluble CNDs also showed a quantum yield of 4.1% with favorable photoluminescent properties, and good photostability. Importantly, the fluorescence intensities of the CNDs were quite stable in high-salt conditions (up to 1.0 M) and over a broad pH range (2.0–12.0). Herein, this facile methodology can offer a rapid, reliable, and selective detection of Cu^{2+} with a detection limit as low as 0.23 μM and a dynamic range from 0.7 μM to 10.0 μM. Furthermore, this sensing system has successfully applied to determine Cu^{2+} ions in lake water samples with satisfied recoveries.



Scheme 1. Schematic representation of the synthesis procedures for the CNDs and used for Copper ions detection base on fluorescence turn-off mechanism.

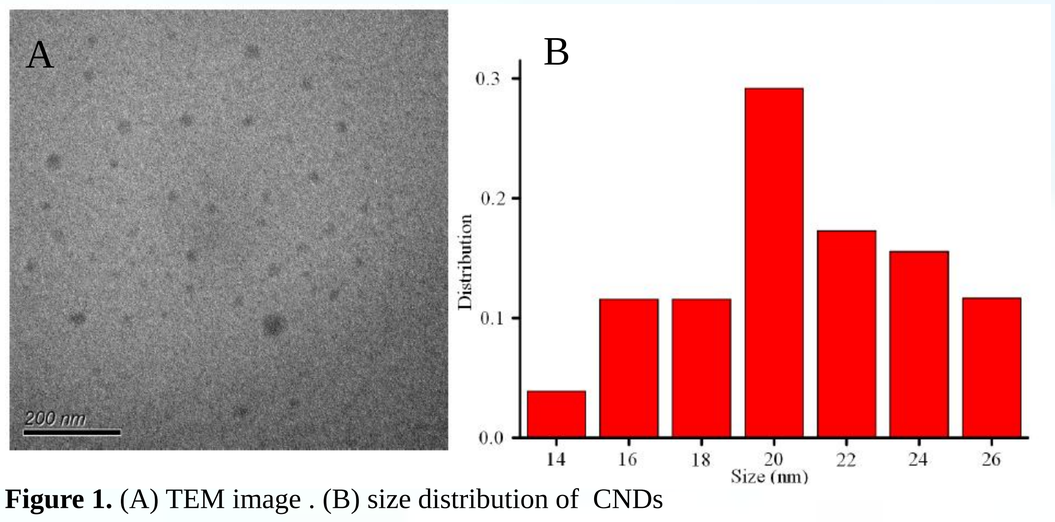


Figure 1. (A) TEM image . (B) size distribution of CNDs

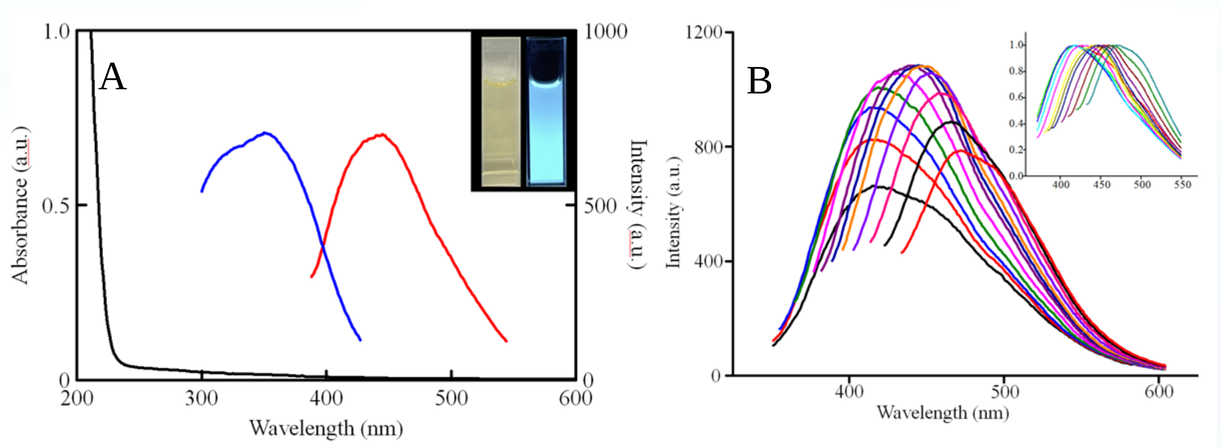


Figure 2. (A) UV-vis absorption and FL spectra of CNDs (Inset : photograph of the CNDs excited by normal light and a λ 365 UV lamp) .(B) FL spectra of CNDs excited at different wavelengths in the range of 300 – 400 nm (Inset : shows normalize FL spectra).

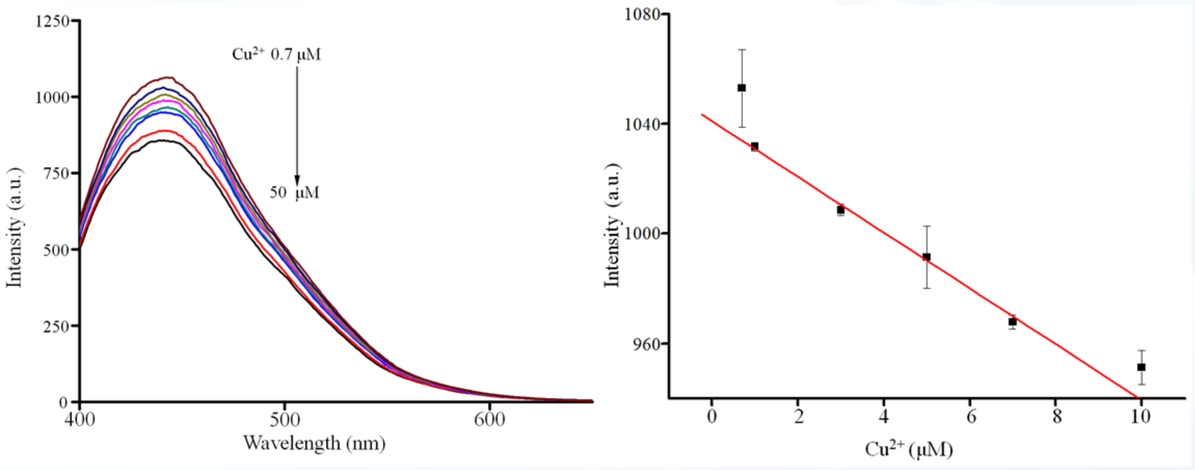


Figure 3. FL spectra of CNDs in the presence of different concentration of Cu^{2+} (0.7μM to 50μM , top to bottom) . Plot of quench of FL intensity , Linear dependence of intensity on Cu^{2+} concentration .

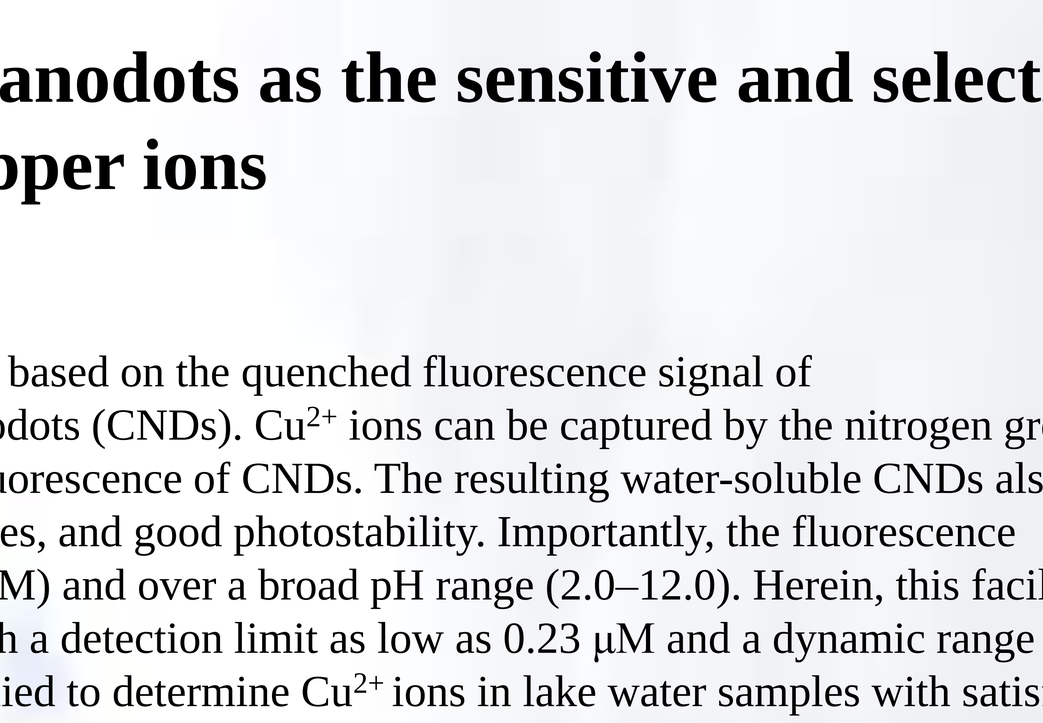


Figure 4. Effect of different metal ions on the FL properties of CNDs ..

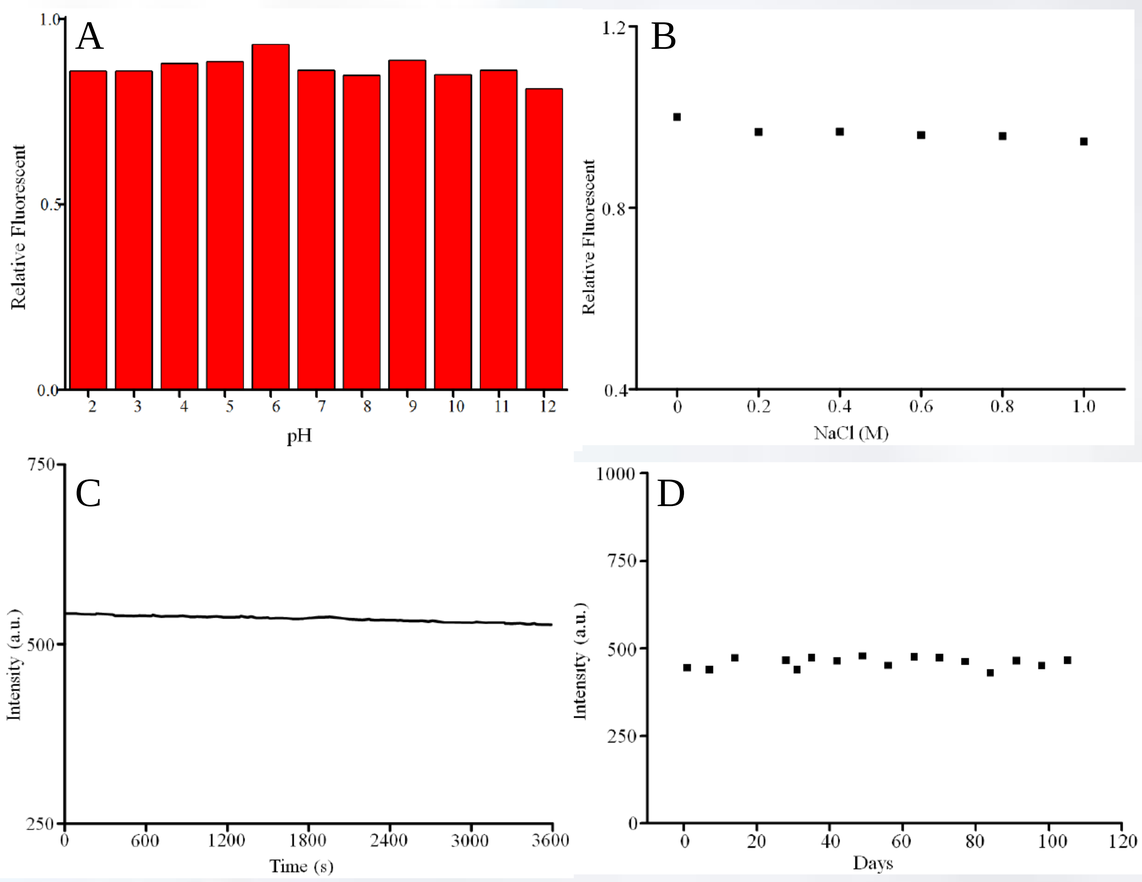


Figure 5 : The factors impact on CNDs FL intensity. (A) FL intensity of CNDs in pH 2 – 12 environment. (B) FL intensity of CNDs in different NaCl environment. (C) Effect of irradiation time at 355 nm. . (D) FL intensity long-term photostability of CNDs .

Table 1. Determination of copper ions in real samples using CNDs

Sample	Added (μM)	Found (μM)	Recovery (%)	RSD (%)
Lake water	5.0	4.57	91.3	3.1
	10.0	10.2	101.7	6.2

Conclusions:

In summary, a facile synthetic method has been established to fabricate CNDs by carbonization of PVP and CYS. The as-prepared CNDs exhibit good water solubility, strong and stable photoluminescence, and excitation-dependent emission behavior. More interestingly, the CNDs display pH stable and have the resist high ion strength environments. Furthermore, the obtained CNDs show selective fluorescence quenching to Cu^{2+} with a wide linear range and low detection limit of 0.23 μM, and it can be applied to the detection of Cu^{2+} in the lake samples with satisfactory recovery. Owing to the advantages of simple synthesis, high aqueous stability and good luminescence, the CNDs prepared show promising potential application in analysis and detection.