Supplementary Materials

As shown in Figure S1, the horizontal axis represents temperature, while the vertical axis denotes quenching efficiency. The fluorescence spectra of the ZnO/C QDs dual-quantum-dot system containing mercury ions (Hg^{2+}) were measured at temperatures of 5°C, 10°C, 15°C, 20°C, and 25°C. The results indicate that the quenching efficiency gradually increases with rising temperature, a characteristic feature of dynamic quenching. These data further rule out the possibility of simultaneous static and dynamic quenching.

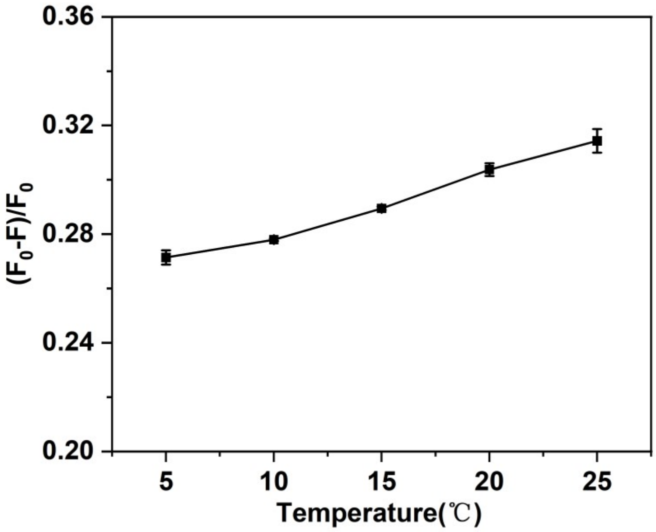

Figure S1: Effect of Temperature on Quenching Efficiency

Effect of pH (Figure S2): The sensor's fluorescence intensity was measured across a pH range of 6.0 to 9.0. Optimal fluorescence response and stability were observed at pH 7.5, which was therefore selected for all subsequent experiments.

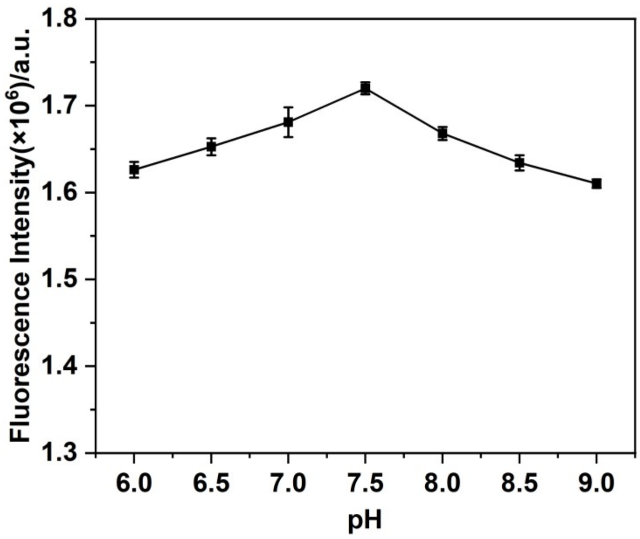

Figure S2: Effect of pH on Sensor Fluorescence Intensity

Effect of Storage Duration (Figure S3): Sensors were stored at 4°C, with fluorescence intensity measured every 5 days. Even after 25 days of storage, no significant change in fluorescence intensity was observed, indicating excellent stability.

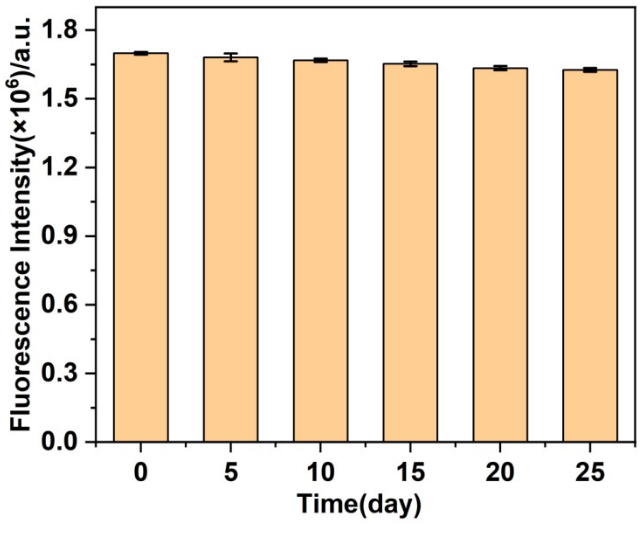

Figure S3: Effect of Storage Time on Sensor Fluorescence Intensity

Effect of Temperature (Figure S4): The fluorescence intensity of the sensor was tested at different temperatures (10–40°C). The sensor exhibited relatively stable fluorescence within the 25–30°C range. All detection experiments were conducted at a controlled room temperature of 25°C.

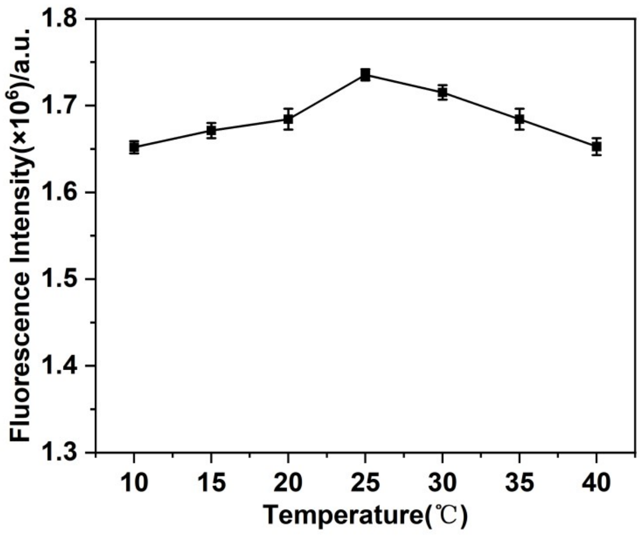

Figure S4: Effect of Temperature on Sensor Fluorescence Intensity

In Figure S5, F represents the difference between F_0 and F_1, where F_0 denotes the fluorescence intensity of ZnO/C QDs, and F_1 denotes the fluorescence intensity of ZnO/C QDs + interfering substances. Common metal ions at a concentration of 100 μmol/L (e.g., sodium ions, potassium ions, calcium ions) to the sensor system and measured the changes in fluorescence intensity. Except for Hg^{2+}, other ionic substances showed negligible quenching effects on the sensor, indicating that the ZnO/C QDs fluorescence sensor exhibits excellent selectivity toward Hg^{2+}. In Figure S6, F equals F3 minus F2, where F2 represents the fluorescence intensity of ZnO/C QDs + Hg^{2+}, and F3 denotes the fluorescence intensity of ZnO/C QDs + Hg^{2+} in the presence of different interfering substances. The figure shows that OA, TA, Cl^-, NO_3^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}, K^+, Na^+, and Ca^{2+} do not interfere with the detection of Hg^{2+} by ZnO/C QDs, confirming the sensor's excellent anti-interference capability.

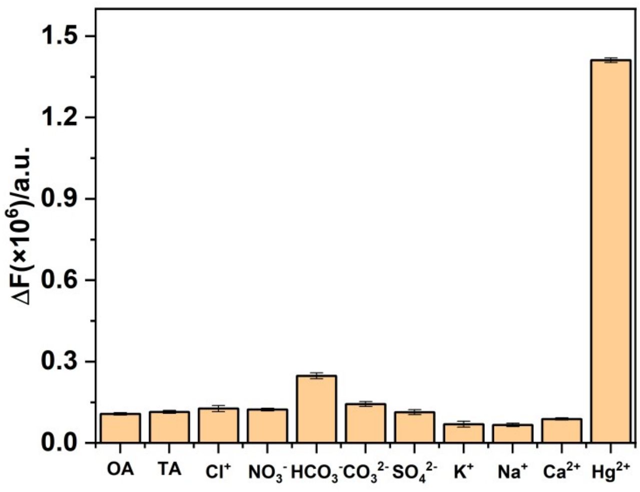

Figure S5: Selectivity of ZnO/C QDs (Hg^{2+} concentration: 10 μmol/L; interference substance concentration: 100 μmol/L)

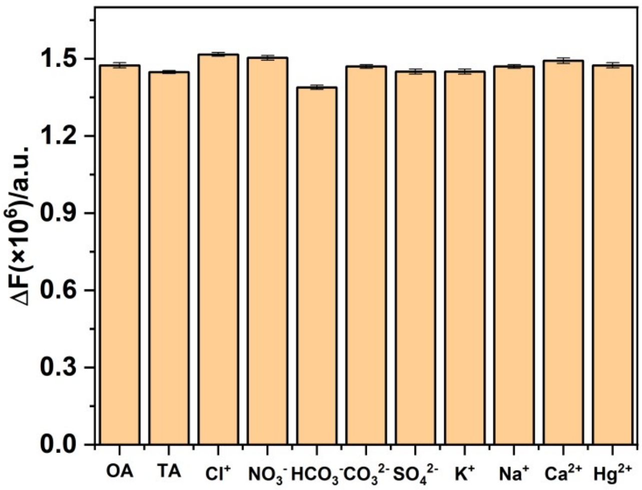

Figure S6: Interference resistance of ZnO/C QDs (Hg^{2+} concentration: 10 μmol/L; interference substance concentration: 100 μmol/L)

We measured the fluorescence spectra of ZnO QDs (without C QDs) and ZnO/C QDs in the presence of Hg^{2+} at different concentrations (4–12 μmol/L). The results indicate that standalone ZnO QDs exhibit a certain degree of fluorescence response to Hg^{2+}, but their quenching efficiency is significantly lower than that of the ZnO/C QDs dual-quantum-dot system. This demonstrates that the combination of ZnO QDs and C QDs substantially enhances the sensitivity of Hg^{2+} detection.

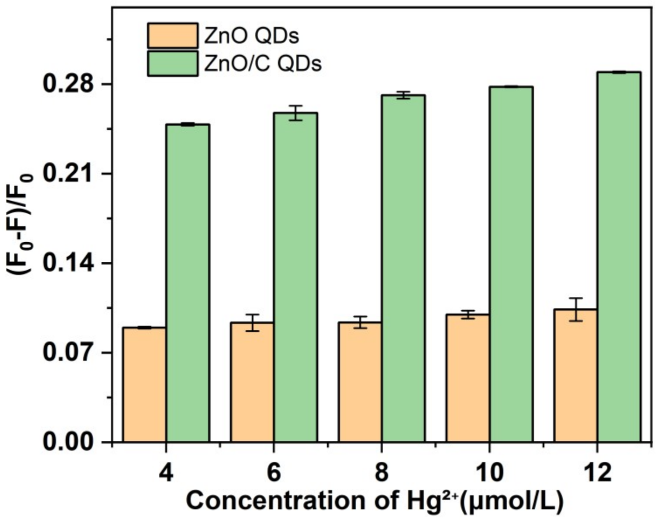

Figure S7: Effect of Different Hg^{2+} Concentrations on the Quenching Efficiency of ZnO QDs and ZnO/C QDs