Research on the detection and semi-quantification of iron in water ***using gold nanoclusters***

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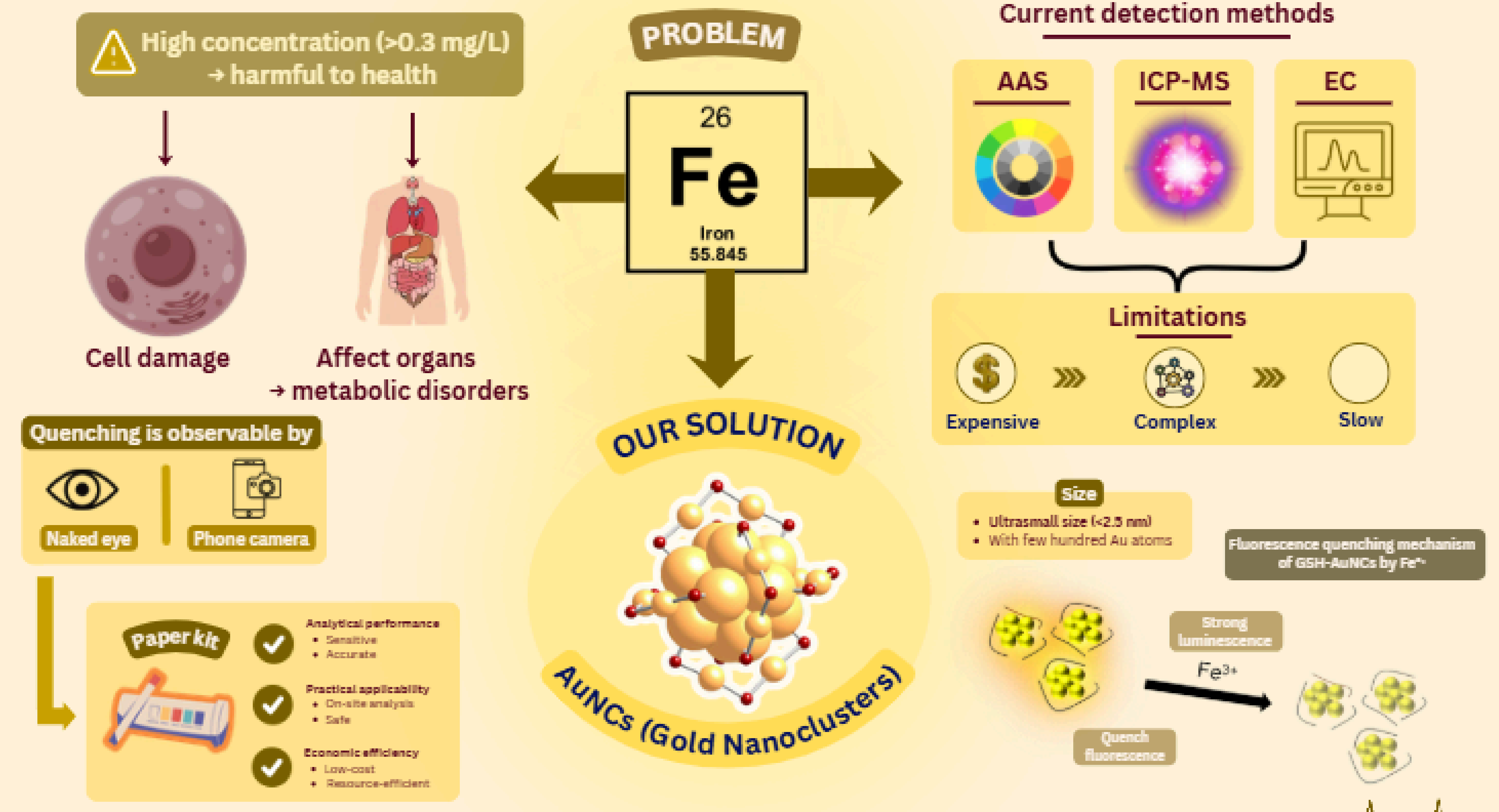
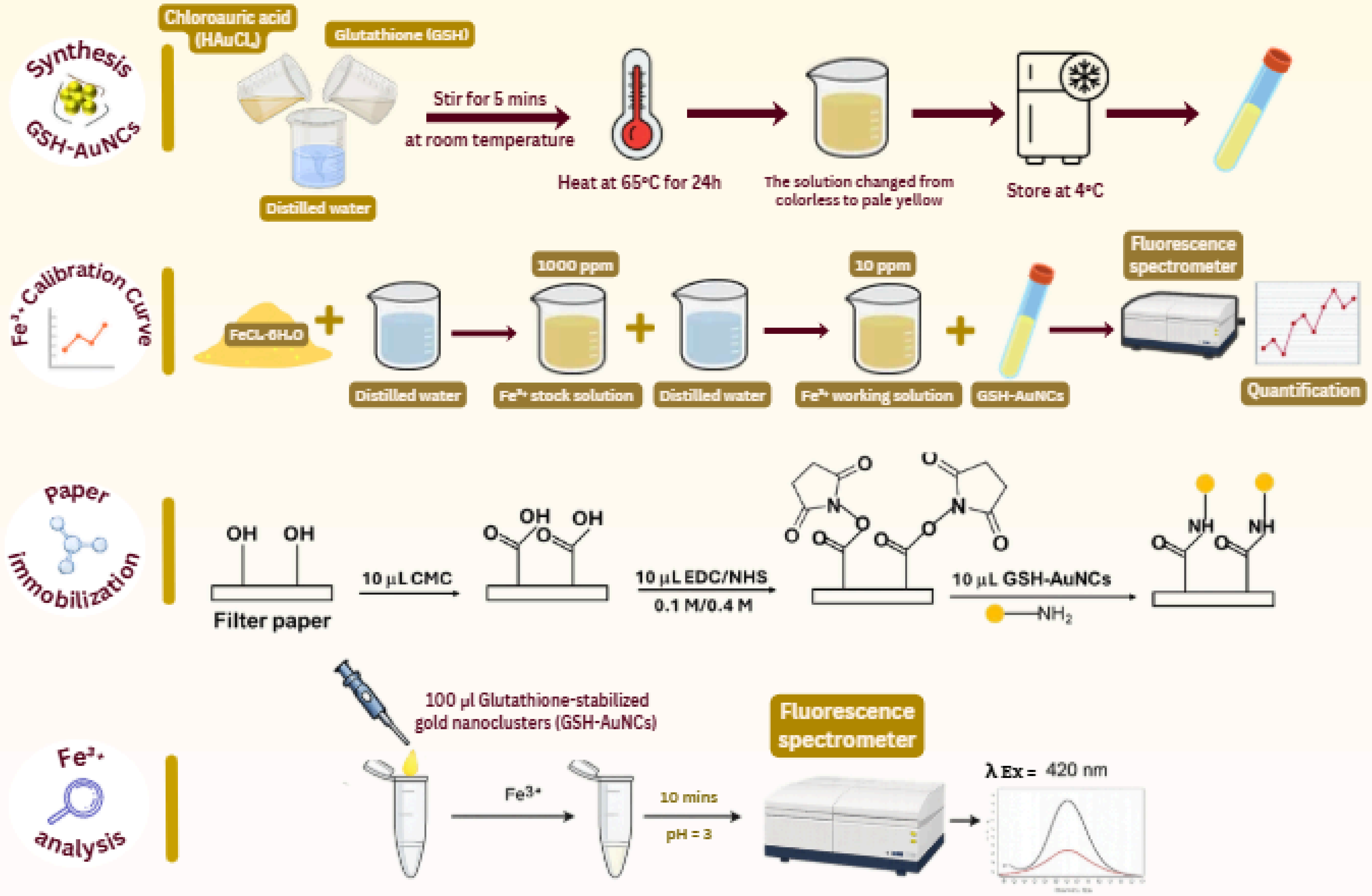
INTRODUCTION



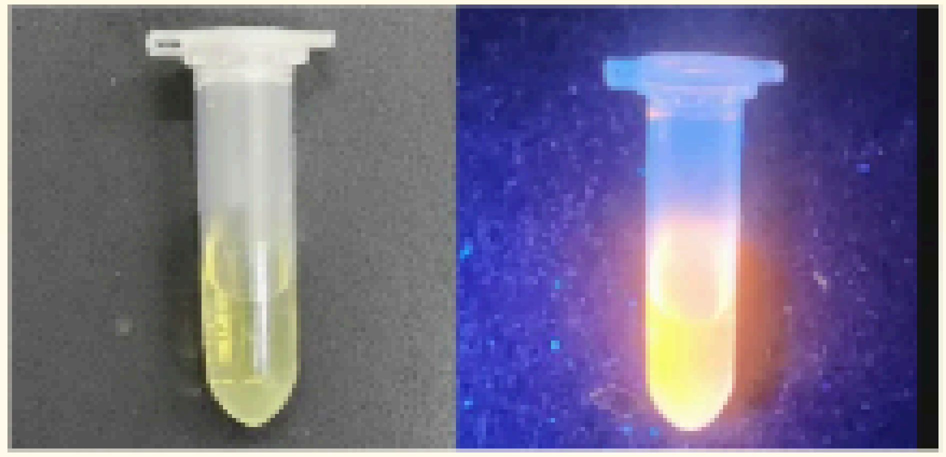
OBJECTIVES

1. Synthesize highly fluorescent GSH-stabilized gold nanoclusters.
2. Investigate the fluorescence quenching mechanism toward Fe^{3+} and establish a quantitative detection model.
3. Evaluate analytical performance and validate real water samples, establishing a basis for AuNCs-impregnated paper test kits for rapid field analysis.

METHODOLOGY



Characterization of GSH-AuNCs



Under visible light   Under UV light

Figure 1: GSH-AuNCs solutions under visible light (left) and UV light (right)

- Exhibit **bright orange fluorescence** under UV light

→ **Strong photoluminescent behavior**

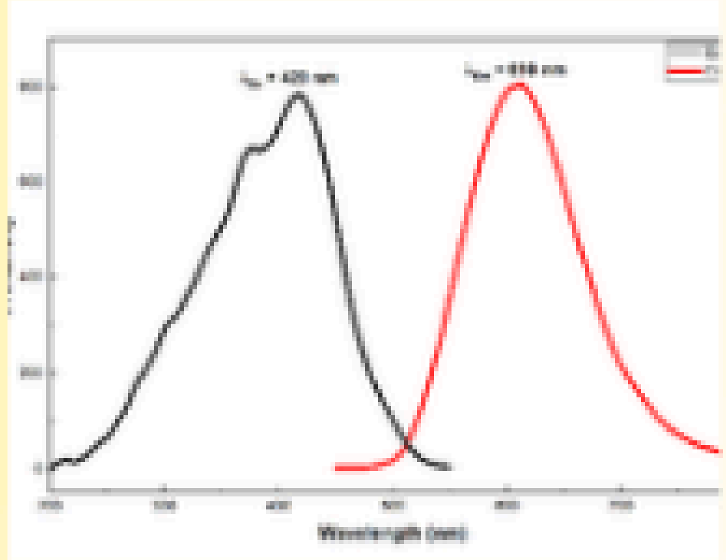


Figure 2: Excitation and emission spectra of GSH-AuNCs

- A **large Stokes shift (~190 nm)** confirms **successful AuNC formation** and ensures **clear, interference-free signals.**

- **Spectral overlap** enables **efficient energy transfer, supporting** the Fe^{3+} fluorescence quenching mechanism.

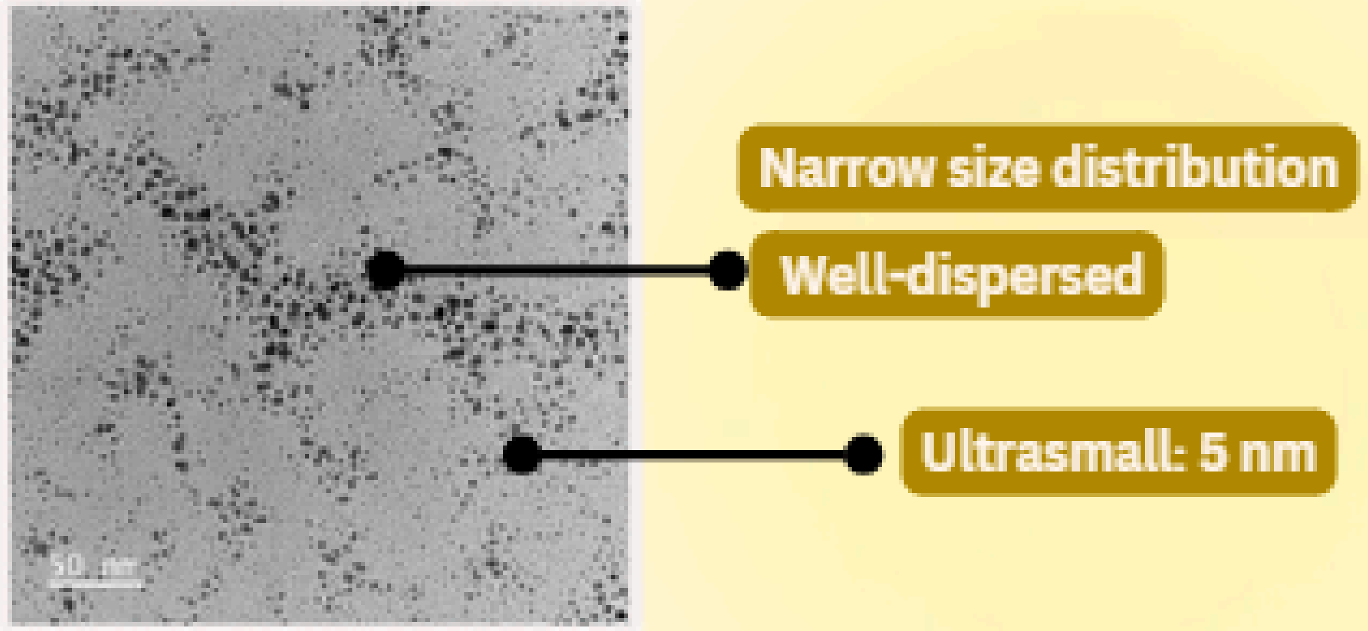


Figure 3: TEM image GSH-AuNCs

- TEM confirmed the successful formation of GSH-AuNCs.
- The nanoclusters were well dispersed with no significant aggregation.
- Particle sizes were below 5 nm, characteristic of gold nanoclusters.
- GSH acted as both a reducing and stabilizing agent.
- The ultrasmall size contributed to the strong fluorescence properties.
- The results demonstrate the successful synthesis of stable and highly luminescent GSH-AuNCs.

Optimization of Conditions

Effect of pH

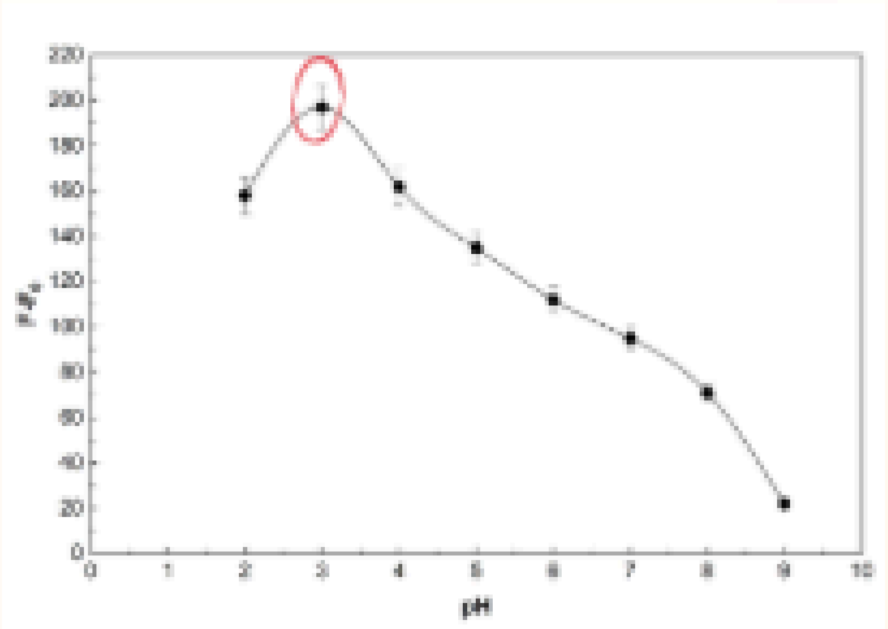


Figure 4: Effect of pH on the fluorescence quenching efficiency of AuNCs toward Fe^{3+}

Effect of incubation time

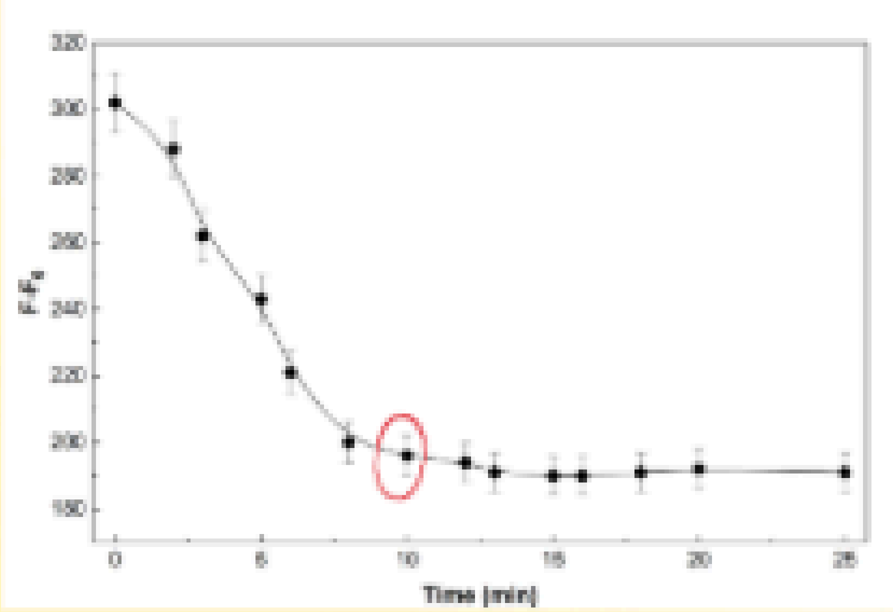


Figure 5: Effect of incubation time on the fluorescence quenching of AuNCs by Fe^{3+}

- pH 3 provides the highest fluorescence quenching response and good analytical sensitivity.
- A 10-minute incubation ensures complete reaction with fast and efficient detection.

Effect of volume GSH-AuNCs

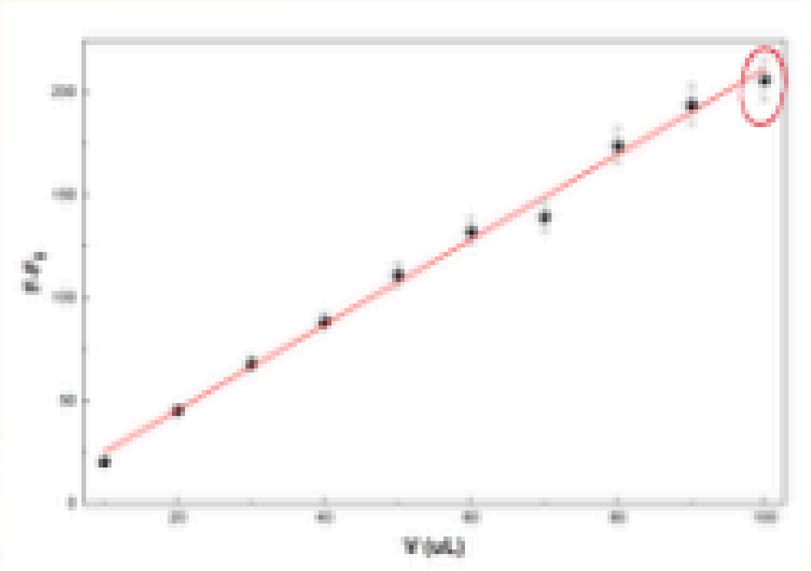


Figure 6: Effect of AuNCs volume on the fluorescence quenching response

Effect of Fe^{3+} concentration

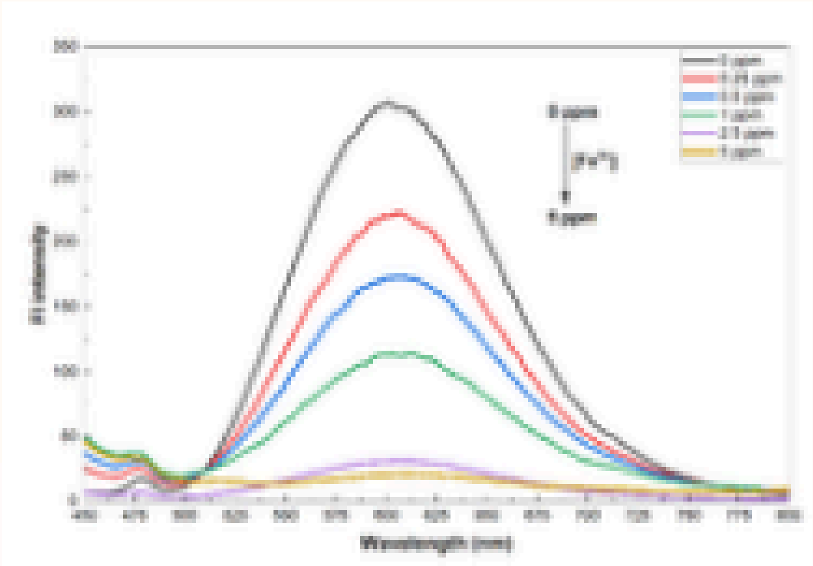


Figure 7: Effect of Fe^{3+} concentration on the fluorescence quenching efficiency of AuNCs

- Volume GSH-AuNCs = 100 uL
- Concentration-dependent fluorescence decrease → semi-quantitative visual Fe^{3+} estimation

Analytical Performance

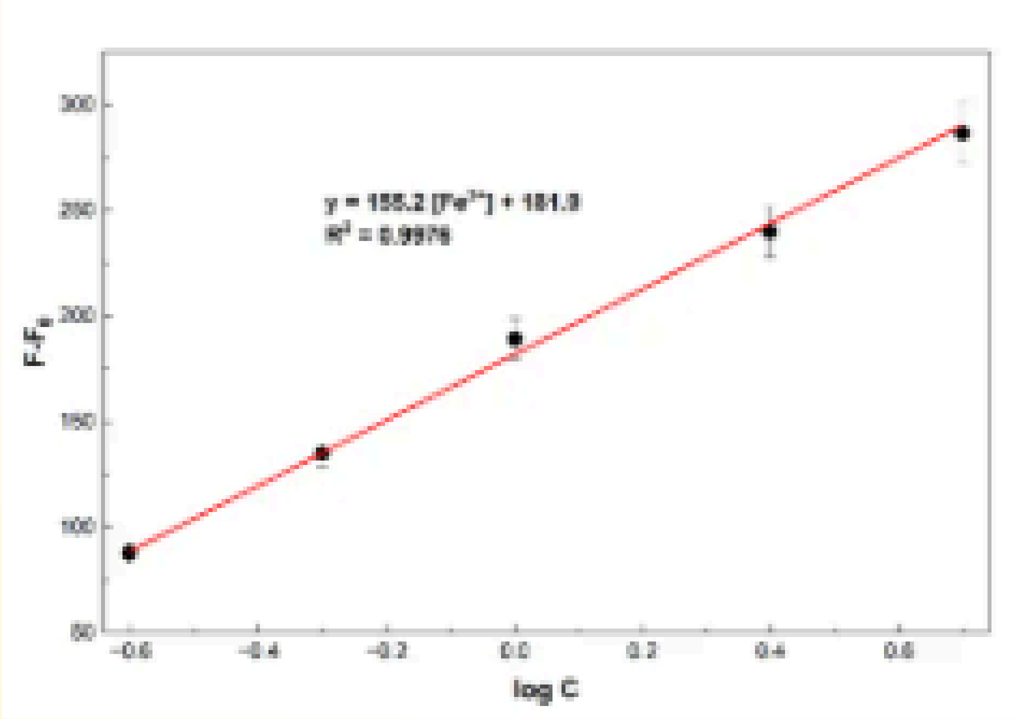


Figure 8: Calibration curve of Fe^{3+} determination

Robust linear quenching–Fe^{3+} correlation

→ ***Accurate quantification***

$[Fe^{3+}]$ (ppm)	1	2	3	4	5	C_{av} (ppm)	Error (%)	RSD (%)
0.5	0.48	0.53	0.47	0.49	0.45	0.484	**-3.2**	**6.13**
1	1.1	1.05	0.96	0.98	1.08	1.03	**3.0**	**5.95**
2	2.02	2.12	1.97	1.99	2.01	2.02	**1.0**	**2.87**

Table 1: Reproducibility of fluorescence determination of Fe3+

- **High repeatability** (RSD < 6.13%)
- **Low error** (< 3%)

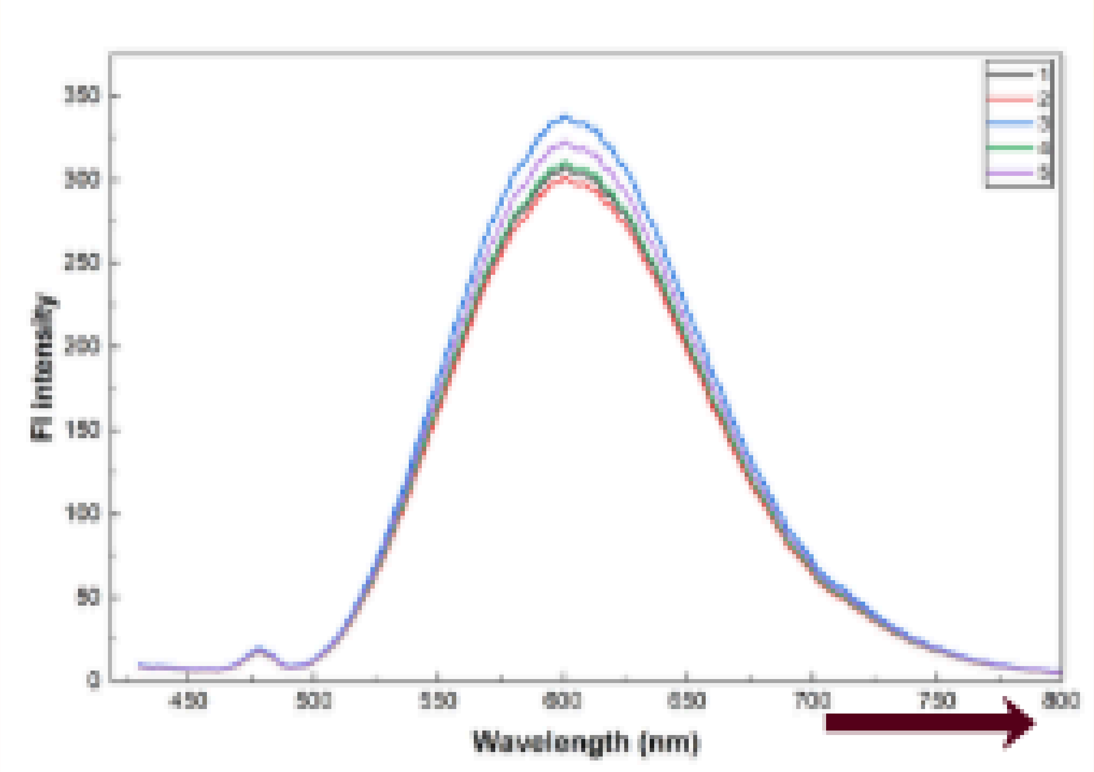
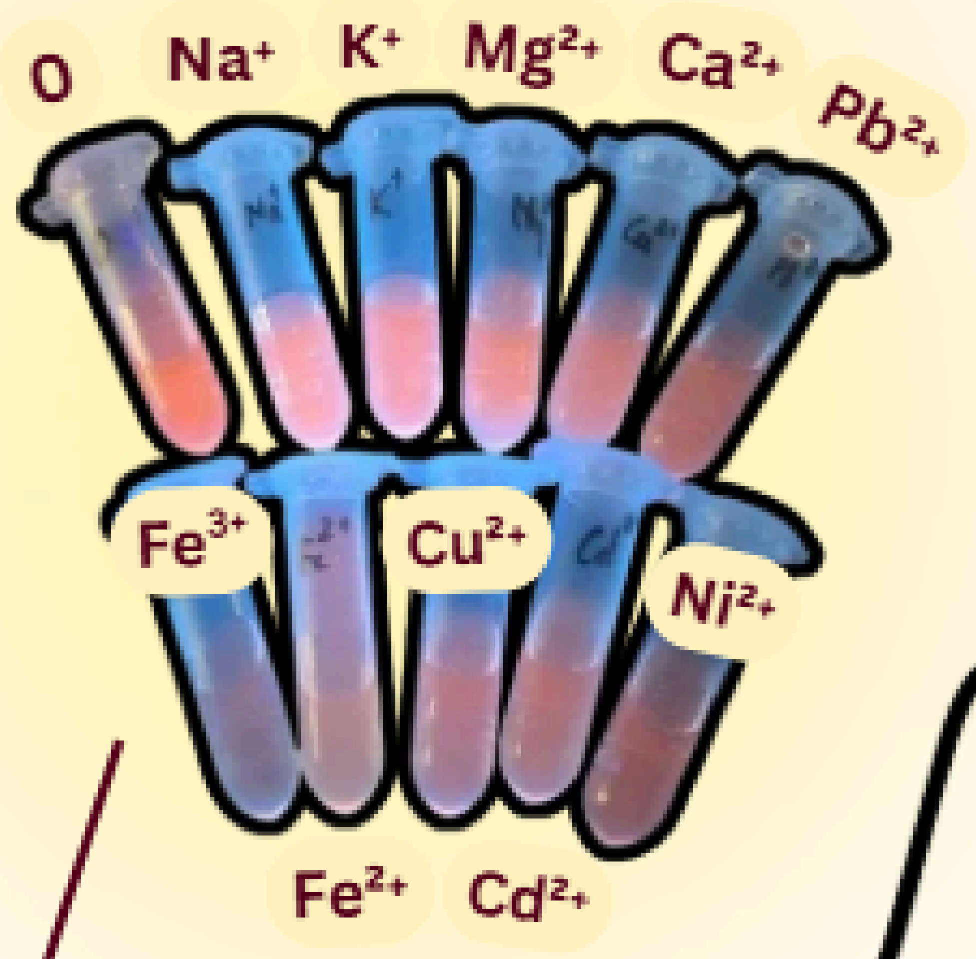


Figure 9: Repeatability of the fluorescence emission spectra of the blank sample

- Overlapping fluorescence spectra

→ Excellent blank signal stability

Selectivity



Only Fe^{3+} shows color fading

Others retain bright red/orange color

→ Direct visual discrimination

→ Naked-eye detection

Figure 10: Visual fluorescence response of GSH-AuNCs to Fe^{3+} and other metal ions

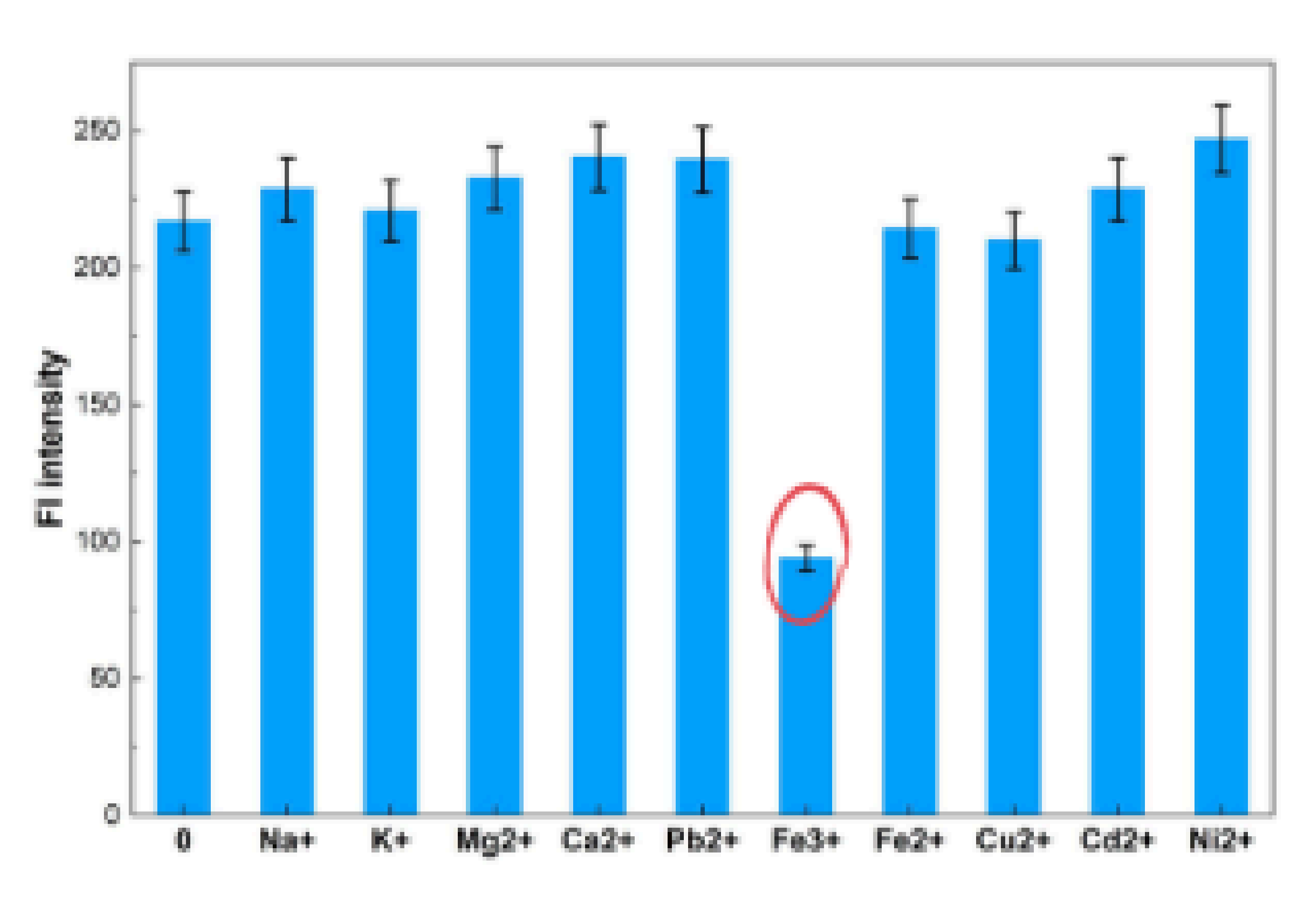


Figure 11: Fluorescence intensity of GSH-AuNCs in the presence of different metal ions

- **Negligible response** to other ions >< **Significant** Fe^{3+}-induced quenching

→ **Strong selectivity evidence**

→ **High sensor selectivity**

Real-sample Application

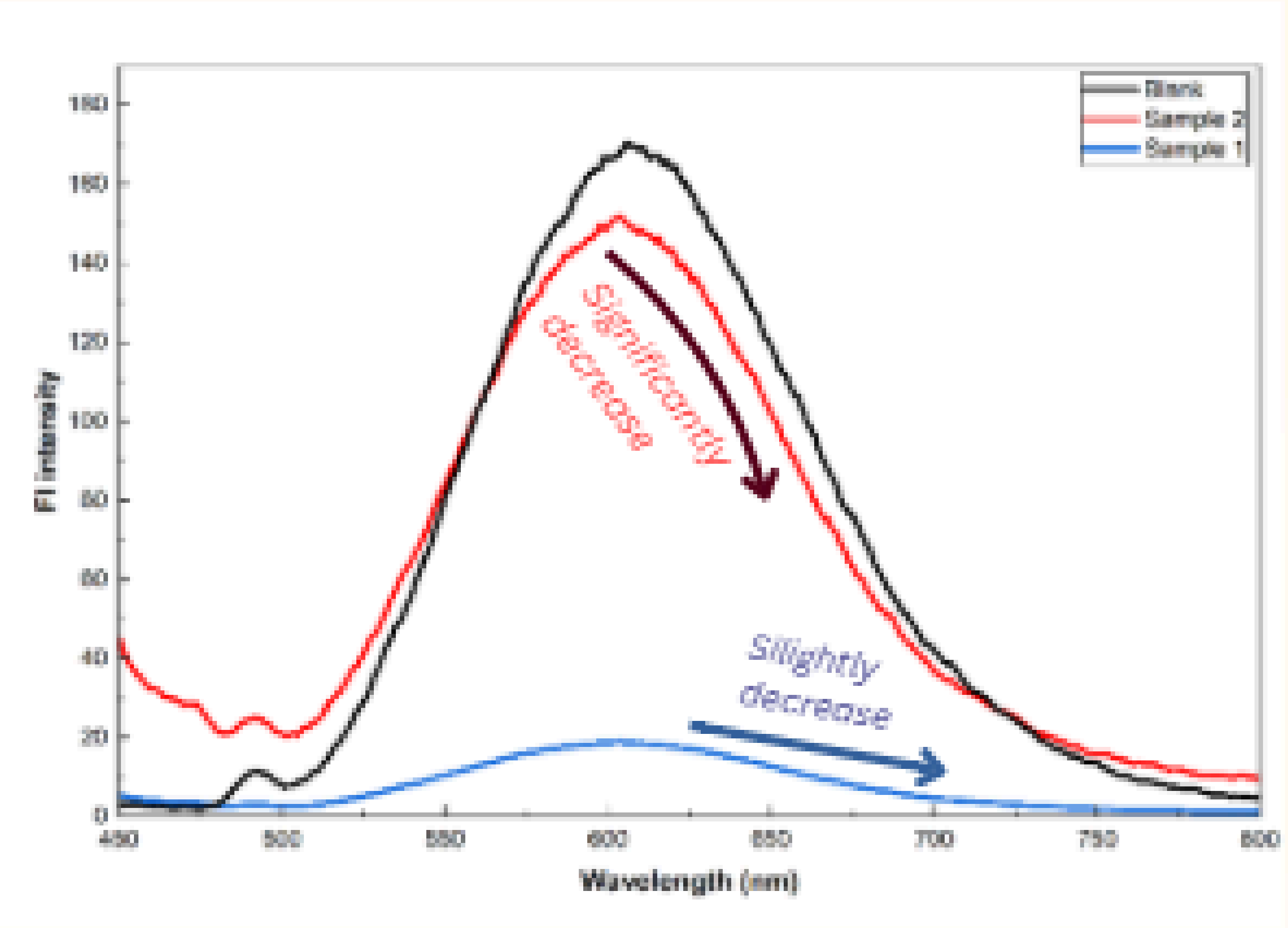


Figure 12: Fluorescence emission spectra of GSH-AuNCs for real water samples

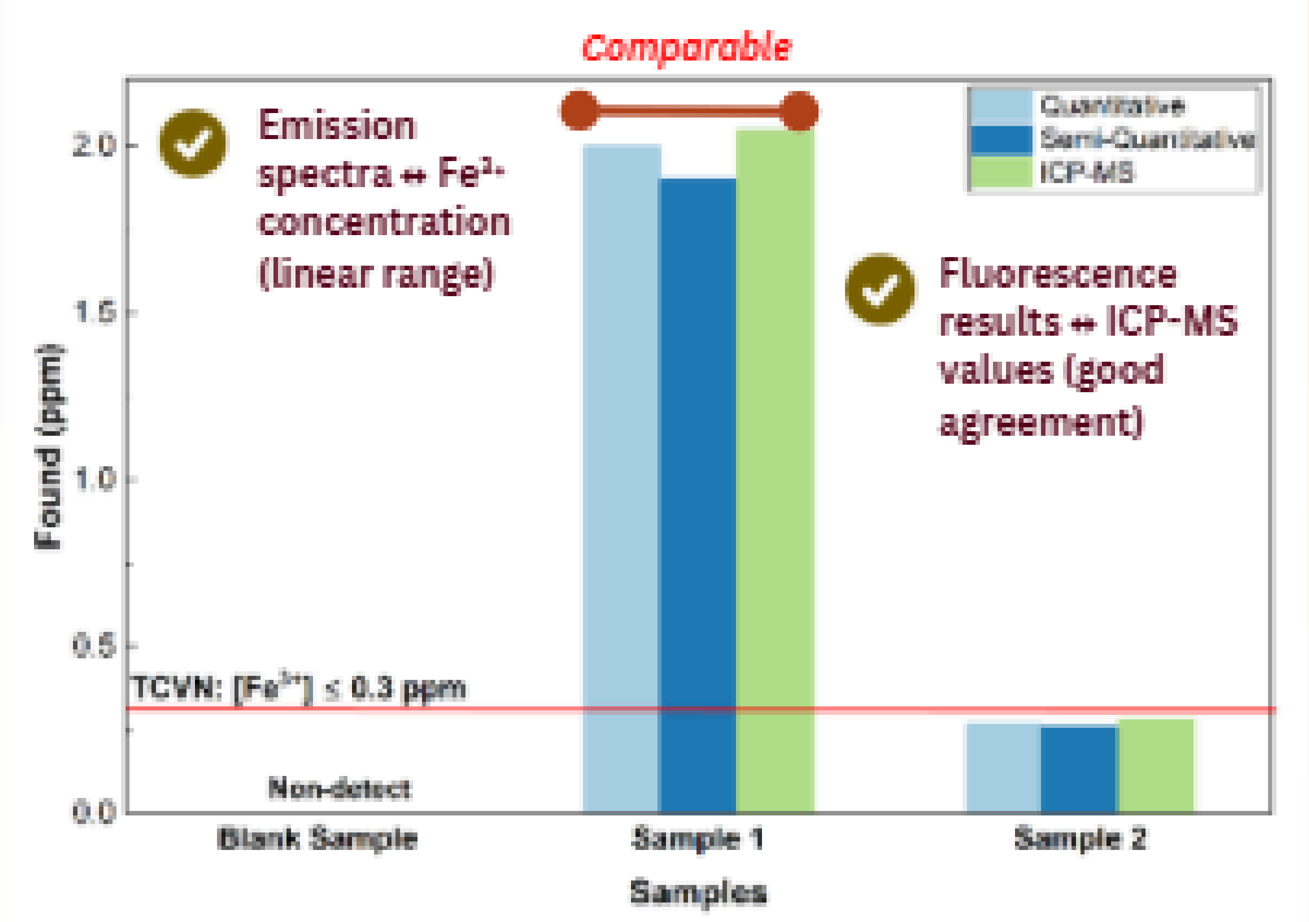


Figure 13: Comparison of fluorescence and ICP-MS results for Fe^{3+} determination

- Reliable fluorescence–concentration correlation
- Quantitative accuracy of the method
- Applicability to real sample Fe^{3+} determination

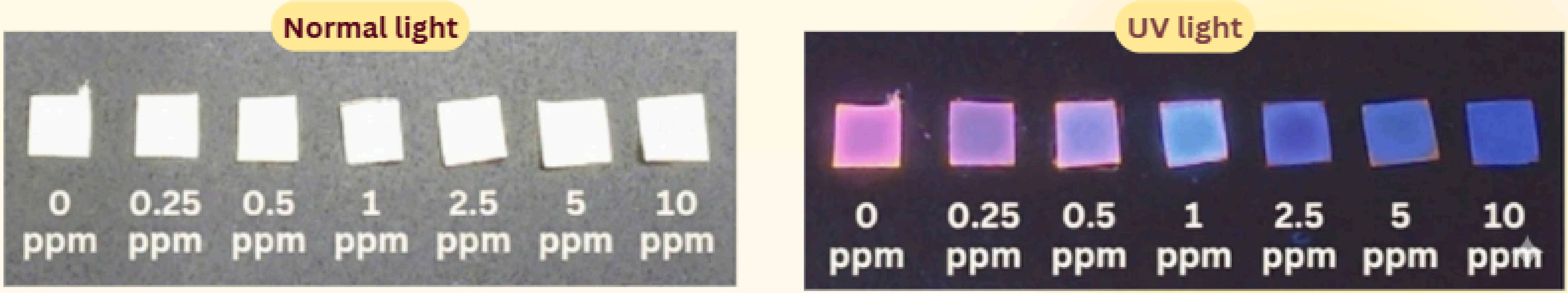


Figure 14: Visual color change of the AuNCs-based paper sensor toward increasing Fe^{3+} concentrations (0–10 ppm) under normal and UV illumination

Visible color fading & quenching

Enable rapid, naked-eye Fe^{3+} detection

Paper Kit

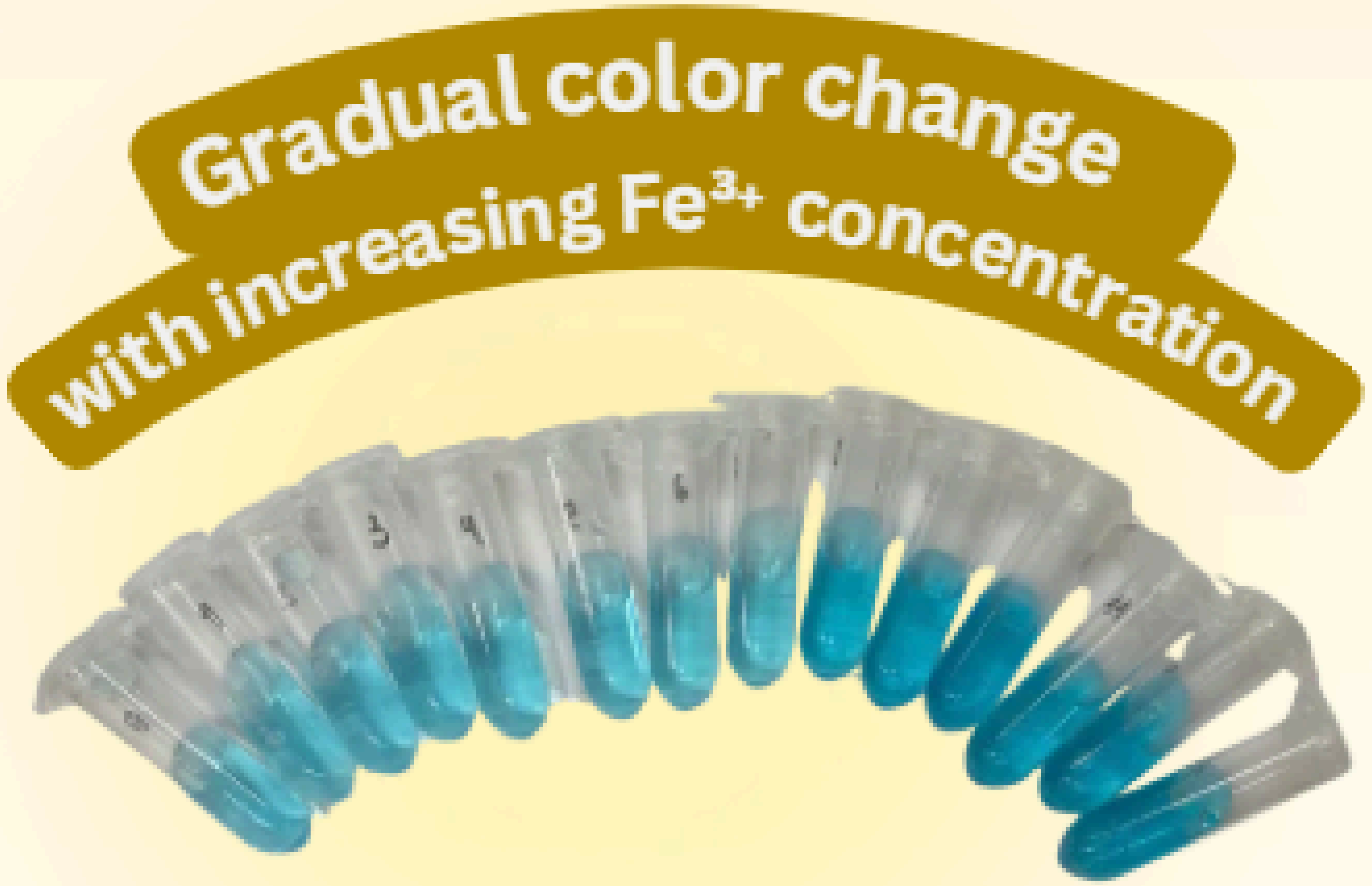
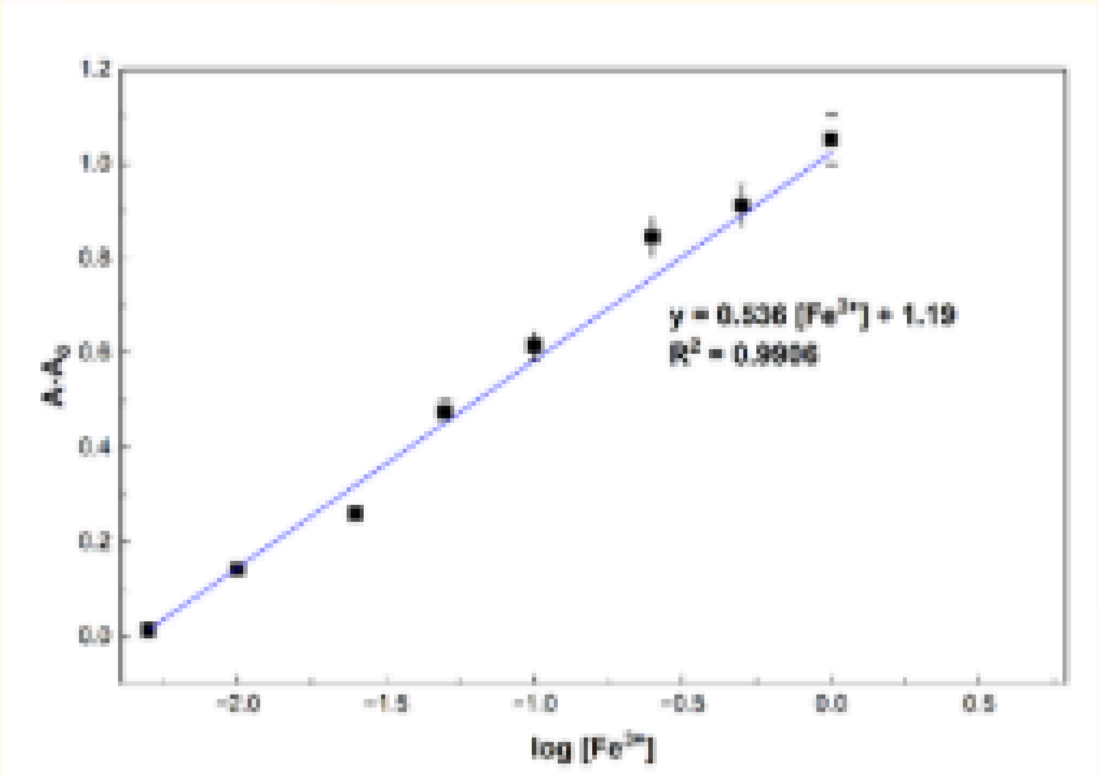


Figure 15: Peroxidase-like catalytic activity of AuNCs in the TMB–H_2O_2 system with Fe^{3+} concentrations ranging from 0.005 to 10 ppm

- ☑ Concentration-dependent catalytic response
- ☑ Fe^{3+}-enhanced peroxidase-like nanozyme activity

Figure 16: Linear relationship between absorbance ($A - A_0$) and logarithmic Fe^{3+} concentration in the AuNCs–TMB–H_2O_2 system



- ☑ Linear calibration ($R^2 \approx 0.9906$)
- ☑ Reliability of the paper–nanozyme sensing system

Paper Kit

CONCLUSION

- **Successfully synthesized** highly fluorescent GSH-AuNCs **(<5.0 nm).**
- Fe^{3+} exhibited **strong and selective fluorescence quenching.**
- Achieved **a linear detection range of 0.25 - 5 ppm (R^2 > 0.99).**
- **Successfully applied** to real water samples with **good accuracy and precision.**
- **Developed a paper-based test kit** for rapid semi-quantitative detection.
- **Tested on nanozyme activity** of GSH-AuNCs and **possibility** of using nanozyme property to colorimetrically detect Fe^{3+}

FUTURE WORK

- **Test the effects on other types of AuNCs** such as His-AuNC (Histidine AuNC) and Lys-AuNC (Lysozyme AuNC).
- **Fabricate of color sensors based on nanozyme activity** of GSH-AuNCs
- **Test on other samples** such as biological samples, food samples
- **Apply a paper-based test kit to real samples**

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Thank You

For your attention