A recyclable, fluorescent, and colorimetric sensor for fluoride anion in water using a crosslinked polymer functionalized with hydroxyl quinolinium

1. The optimization of the molar ratio of AHPEQB/TRIM

![Graph showing fluorescent intensity vs fluoride concentration for different molar ratios](image)

S. Fig. 1 The change in fluorescent intensity at 540 nm versus fluoride concentration for CpA1T1 (black curve), CpA1T3 (red curve), CpA1T5 (blue curve), and CpA1T7 (indigo blue).

2. Morphology studies for CpA1T5

![SEM image of CpA1T5](image)

S. Fig. 2 SEM images of CpA1T5.
3. Thermal stability of CpA1T5

The thermal stability of the polymer CpA1T5 was characterized by TGA (S. Fig. 3). The 5% weight loss temperature below 100 °C could be ascribed to the removal of adsorbed water. The weight loss of the organic skeleton occurred in the temperature range from 305 to 500 °C, demonstrating CpA1T5 is thermal stable.

![Thermogravimetric curves of CpA1T5](image)

S. Fig. 3 Thermogravimetric curves of CpA1T5.


The Brunauer–Emmett–Teller (BET) equation was used to measure the surface area (m²/g) of the sensor. The pore volume (cm³/g) and pore diameter (Å) were analyzed by the Barrett–Joyer–Halendal (BJH) model. It was found that the CpA₁T₅ has
microporous and mesoporous structure (S. Fig. 4). The pore size distributes mainly in 1.0-4.5 nm and 4.5-10 nm. Surface area of 216.0 m$^2$/g, Pore diameter of 5.938 Å, pore volume 0.2783 cc/g.

5. Anion response of AHPEQB

S. Fig. 5 Color of AHPEQB in DI water (1.0 × 10$^{-5}$ mol/L) in the presence of various anions (1.0 × 10$^{-4}$ mol/L) (a). Absorbance (b) and fluorescence (c) spectra of AHPEQB in DI water (1.0 × 10$^{-5}$ mol/L) in the presence of various anions (1.0 × 10$^{-4}$ mol/L).

6. UV-Vis spectra of CpA1T5 in DI water in the presence of various anions
S. Fig. 6 UV-Vis spectra of CpA1T5 (0.6 mg/mL) in DI water in the presence of various anions (1.0 × 10⁻⁴ mol/L).

7. Fluorescence spectra of CpA1T5 in HEPES buffer in the presence of various anions

The anionic response of CpA1T5 in 2-[4-(2-hydroxyethyl)-1-piperazinyl]ethane sulfonic acid (HEPES) buffer at pH 7.0 (S. Fig. 7) was also investigated, similar phenomena as that in DI was was observed.

S.Fig. 7 Fluorescence spectra of CpA1T5 in HEPES buffer (1.0 × 10⁻⁵ mol/L) in the presence of various anions (1.0 × 10⁻⁴ mol/L).
8. Influence of CpA1T5 concentration

We investigated fluoride sensing at a lower CpA1T5 concentration (0.12 mg/mL) (S. Fig. 8), similar result was observed, but the fluorescence enhancement upon the addition of F\(^-\) was not as great as that at 0.6 mg/mL.

S. Fig. 8 Fluorescence spectra of CpA1T5 in DI water (0.12 mg/mL) in the presence of F\(^-\) (1.0×10\(^{-4}\) mol/L).

9. Investigation of anti-jamming ability of CpA1T5

S. Fig. 9 Selectivity of CpA1T5 for F\(^-\) in the presence of other anions in DI water at pH 7. Black bars represent the addition of an excess of the appropriate anion (1.0 × 10\(^{-4}\) mol/L) to a suspension of CpA1T5 (0.6 mg/mL) in DI water and red bars represent the subsequent addition of F\(^-\) (1.0 × 10\(^{-4}\) mol/L) to the suspension (\(\lambda_{\text{ex}} = 420\) nm, \(\lambda_{\text{em}} = 540\)nm).

10. Determination of fluoride anion concentration in mouthwash samples
S. Fig. 10 The fluorescence emission spectra (ex = 420nm) of CpA1T5 (0.6 mg/mL) toward different volumes of mouthwash sample 1 (a) and 2 (b).