

**Stable metal-organic frameworks modulated by doping Tb³⁺ for multi-hazard
detection and capture**

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Experimental Procedures

Photophysical Measurements

Samples were prepared for photophysical measurements by grinding the powder products to uniform particle size. Each sample of Tb@UiO-66-(COOH)₂ (1 mg) was suspended in aqueous solutions (2 mL, 10⁻³ M~10⁻⁷ M) of M(NO₃)_z (M^{z+} = Ag⁺, Co²⁺, Ni²⁺, Cu²⁺, Fe³⁺, Sn⁴⁺, UO₂²⁺), and then sonicated for 10 min to obtain the uniform metal ion-incorporated suspensions for luminescent measurements.

UO₂²⁺ ion adsorption test

Note that the UO₂²⁺ is present in the form of a complex with a positive charge in solution. Uranyl carbonate becomes predominant species at pH higher than 6.5 and the negative charge of uranyl

carbonate will compromise the adsorption on the MOF's surface. Therefore, we decided to perform the batch experiments in the pH range from 2 to 6. In a typical experiment, 5 mg adsorbent and 30 mL UO_2^{2+} ($50 \text{ mg}\cdot\text{L}^{-1}$) solution with appropriate concentration and pH value were added to a 250 mL flask placed in an air bath oscillator (180 rpm) at 308 K. The pH was adjusted with 0.1 M negligible volume of HCl and Na_2CO_3 . After adsorption of UO_2^{2+} , the residual concentration of UO_2^{2+} in the solution was analyzed by UV-Vis and monitoring the absorption at $\lambda_{\text{max}} = 650 \text{ nm}$ (1 mL Arsenazo (III) as chromogenic agent). The equilibrium adsorption capacity of UO_2^{2+} (q_e) and the removal efficiency (%) was calculated as follows:

$$q_e = \frac{(C_o - C_e)V}{m} \quad (1)$$

$$(\%) = \frac{(C_o - C_e)}{C_o} \times 100\% \quad (2)$$

where C_o and C_e are the initial and equilibrium concentrations of UO_2^{2+} (mg/L), respectively, V is the liquid phase volume (L), and m is the amount of adsorbent (g). All the flasks were closed to avoid evaporation.

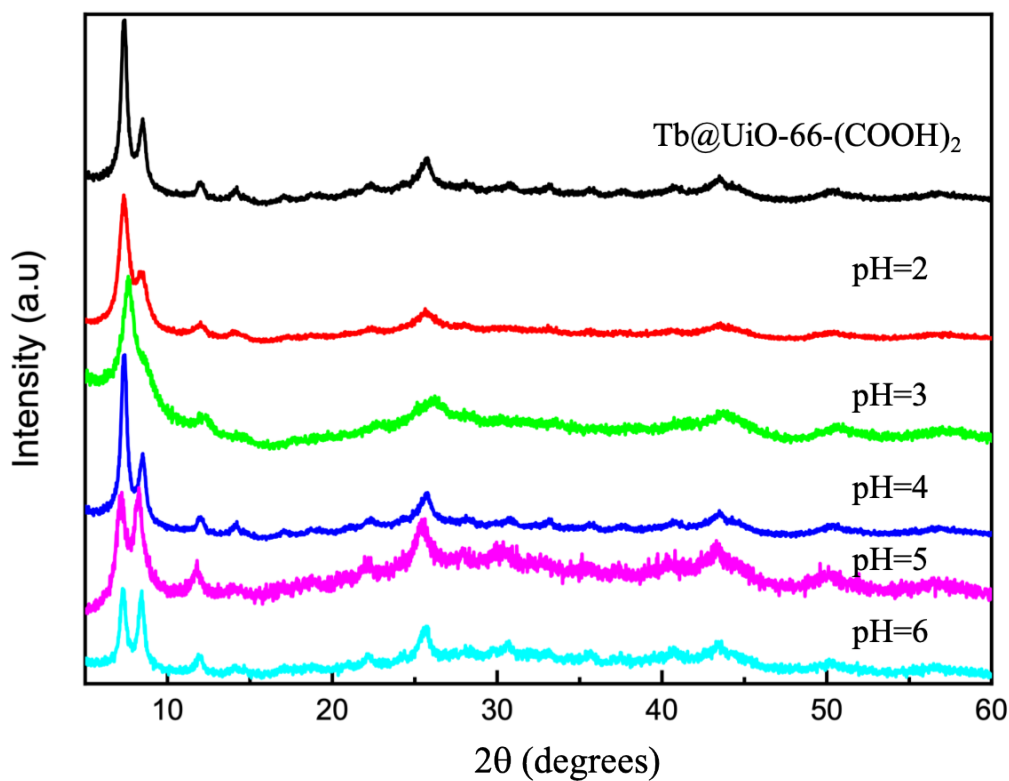


Fig. S1 PXRD patterns of $\text{Tb@UiO-66-(COOH)}_2$ after immersion in aqueous solutions at pH values ranging from 2 to 6.

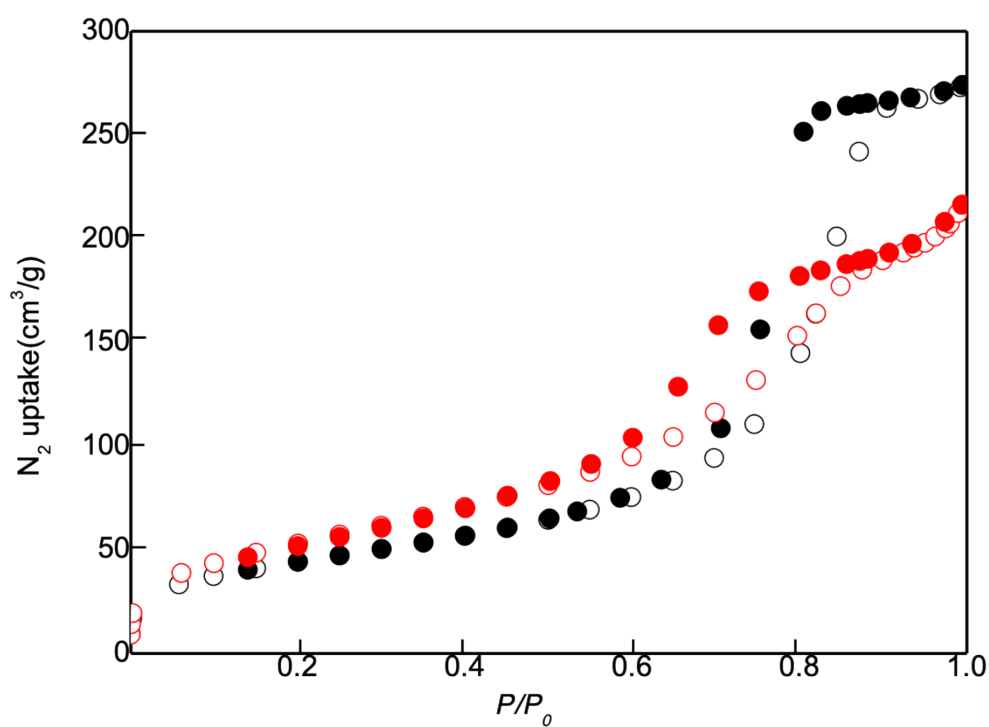


Fig. S2 N_2 adsorption of UiO-66-(COOH) $_2$ (black) and Tb@UiO-66-(COOH) $_2$ (red).

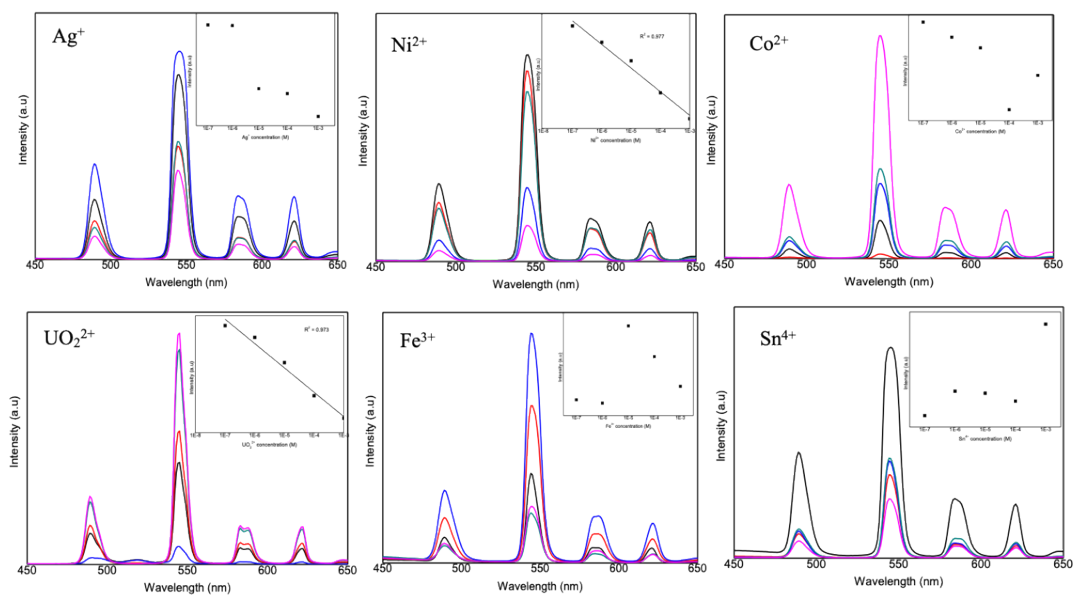


Fig. S3 Photoluminescent spectra of Tb@UiO-66-(COOH) $_2$ under different concentrations of M^{z+} aqueous solution ($M^{z+} = Ag^+, Co^{2+}, Ni^{2+}, Fe^{3+}, Sn^{4+}$ and UO_2^{2+}). The inset is the relationship between the luminescence intensity and corresponding ion concentration at 545 nm.

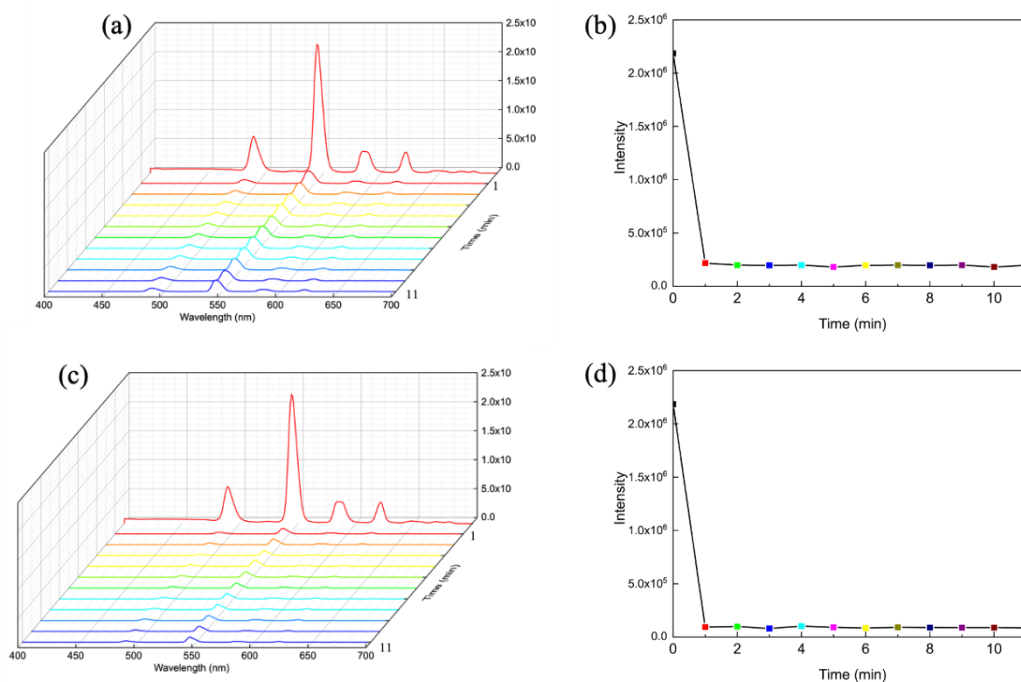


Fig. S4 Emission spectra of Tb@UiO-66-(COOH)₂ suspensions after addition of 10⁻⁹ M Ni²⁺ (a) and UO₂²⁺ (c) at various time intervals and the emission intensity at 544 nm as a function of contact time to Ni²⁺ (b) and UO₂²⁺ (d).

Table S1 K_{sv} value of uranium adsorption by reported Ln-MOFs

MOFs	$K_{sv} (M^{-1})$	Ref.
[Tb(BPDC) ₂](CH ₃) ₂ NH ₂	1.03×10^4	1
[Eu ₂ (MTBC)(OH) ₂ (DMF) ₃ (H ₂ O) ₄].2DMF.7H ₂ O	3631.5	2
[Ln(ox)(L)] _n (ox = oxalate, HL = <i>N,N'</i> -dipropionic acid imidazolium, Ln = Eu ³⁺)	6.19×10^4	3
(CH ₃) ₂ NH ₂ [Ln ₂ (BTC)(AC) ₃ (FM)] (H ₃ BTC=1,3,5-benzenetricarboxylic acid)	8.56×10^3	4
Tb@UiO-66-(COOH) ₂	5.994×10^7	This work

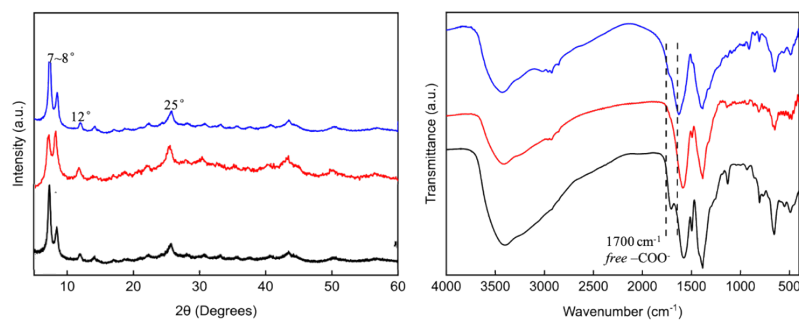


Fig. S5 The PXRD patterns and FTIR spectra of the Tb@UiO-66-(COOH)₂ (black), Tb@UiO-66-(COOH)₂ treated with Ni²⁺ (red) and UO₂²⁺ (blue).

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