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RESEARCH ARTICLE

AN Al³+-SELECTIVE FLUORESCENT PROBE BASED ON NAPHTHALIMIDEDERIVATIVE

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ABSTRACT

An Al^{3+}-selective fluorescent probe P3 derived from naphthalimide was designed and characterized. Study showed that -OH groups in the structure of compound play important role in the selectivity and binding ability of compound to Al^{3+}. The linear range of probe P3 to Al^{3+} was 4.0×10^{-5} to 1.0×10^{-4} M in ethanol, and 1:1 binding mode of P3–$Al^{3+}$was obtained by Job's plot experiment.

INTRODUCTION

Aluminum (Al) has a wideused in daily life because of its good metallic properties. Though it is the most abundant metal on Earth (Weidenhamer, 2017), it it not the necessary element to human body. Moreover, the accumulation of it in organism can cause severe disease, such as osteomalacia, Alzheimer's disease, *et al* (Weidenhamer, 2017; Yang, 2025). So the detection of Al^{3+}in vivo and/or in vitro becomes an interesting study fields. Among the detection methods for Al^{3+}, fluorescent probe method is outstanding because of it's small or no hurt to body. Many fluorescent probes for different ions had been reported (Zheng, 2020; Gao, 2024; Ma, 2024; Zhang, 2023). Naphthalimide compounds have excellent photo, thermal, and chemical stability, which allows them to maintain their properties in various environments (Sun, 2012; Liu, 2020; Zhang *et al*., 2023; Roy *et al*., 2025; Yu, 2011). Kept this in mind, three naphthalimidederivatives were designed and characterized.

EXPERIMENTAL SECTION

MATERIALS

All reagents are commercially available and used directly. Except for $AgNO_3$, all other metal compounds are hydrochloride salts.

Synthesis of Compounds P1-P3: Compounds 1 and 2 were synthesized as reported method (Yu, 2011). 0.2 mmol 1 or 2 and 0.2 mmol 3 or 4 were mixed in 40 mL ethanol and stirred. The mixture was heated to reflux and react for 4 h, and then cooled to room temperature, the solid was filter and recrystallized with ethanol to obtained pure P1-3. P1: MS (ESI) m/z: 416.25 $(M+H^+)^+$; P2: MS (ESI) m/z: 417.30 $(M+H^+)^+$; P3: MS (ESI) m/z: 433.33 $(M+H^+)^+$.

Basic spectroscopic procedures: 1.0 mM stock solutions of were prepare by dissolving in P1-3 DMSO; Metal ions were dissolved in deionized water. The widths of excitation and emission slit were 10 nm, with an excitation wavelength established at 350 nm.

RESULT AND DISCUSSION

Selectivity measurements of compounds P1-3:A good fluorescent probe for the detection of targets in real sample mast had excellent selectivity. So, the selectivity tests of compounds P1-3 experiment were firstly carried out. The testing metal ions were Na^+, K^+, Zn^{2+}, $A1^{3+}$, Hg^{2+}, Cu^{2+}, Cr^{3+}, Cd^{2+}, Fe^{3+}, Mg^{2+},Ag^+, Ca^{2+}. After the addition of Al^{3+} (100 μM) to the solution of P1-3 (50 μM), P1-2 gave no selectivity, but P3 showed good selectivity with and obvious fluorescent enhancement at 430 nm in ethanol(Figure 2). The results showed that groups -OH in P3 participated in the formation of complex P3-Al^{3+}. Thus, P3 was characterized as an Al^{3+}-selective fluorescent probe.

Fluorescent titration experiment of P3 to Al^{3+}: Fluorescent titration experiment was carried out to study the sensitivity of P3 to Al^{3+}. With the concentration of Al^{3+}(0-50 μM) increasing,

fluorescent intensity of P3 (50 μM) in ethanol enhanced to Al^{3+} was produced in ethanol (Figure 3). With the increase of Al^{3+} concentration correspondingly, linear range of 4.0×10^{-5}-1.0×10^{-4} Mwas obtained.

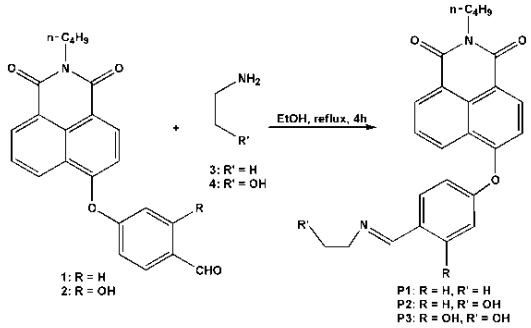

Figure 1. Synthetic route of probe P1-3

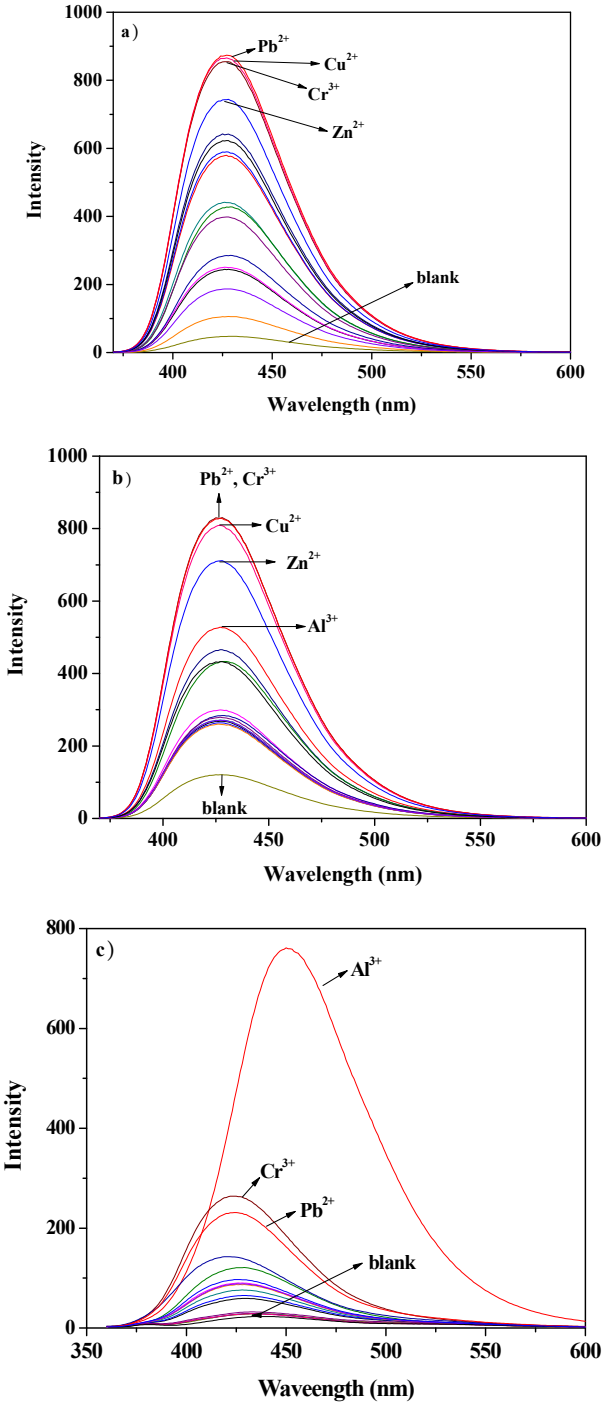

Figure 2. Selectivity measurement of compounds (50μM) withtested metal ions (100 μM)in ethanol.P1 (a), P2 (b), P3 (c).

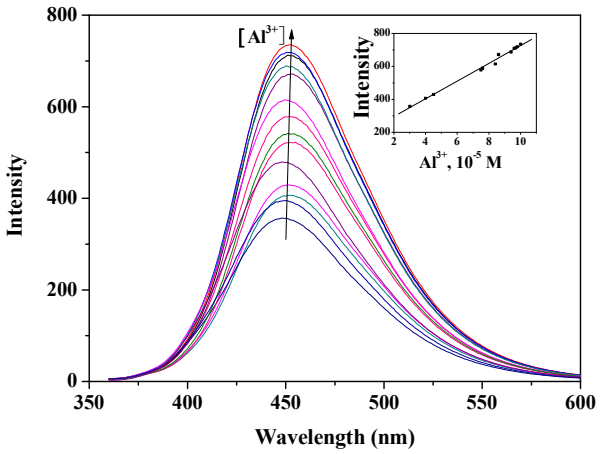

Figure 3. Fluorescence titration experiment of probe P3 (50μM) withAl^{3+}(0-50 μM) in ethanol

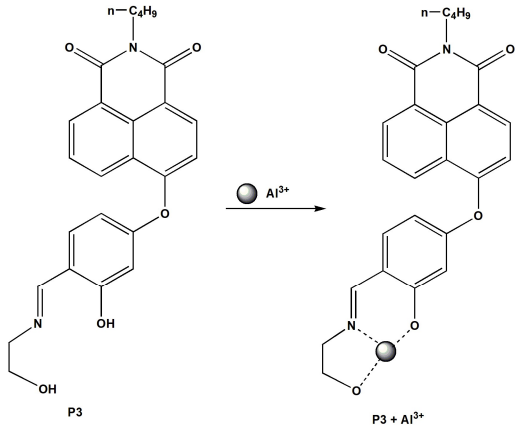

Figure 4. Proposed binding mode ofP3 with Al^{3+}

Reaction mechanism of P3 with Al^{3+}:A 1:1 binding ratio of P3 with Al^{3+} was obtained by Job's plot experiment. According to the obtained experiment results, the reaction mechanism was shown in Figure 4.

CONCLUSION

A naphthalimidederivative P3 was synthesized and characterized as Al^{3+}-selective fluorescent probe in ethanol. Hydroxyl groups in the structure of P3had big influence on the selectivity of compounds to Al^{3+}.

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