ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 15, Issue, 06, pp.25038-25040, June, 2023
DOI: https://doi.org/10.24941/ijcr.45405.06.2023

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

AN Al^{3+}-SELECTIVE FLUORESCENT PROBE DERIVED FROM OF NAPHTHALENE

Fu Zhihan, Zhang Jun and Yu Chunwei*

Key Laboratory of Tropical Translational Medicine of Ministry of Education, NHC Key Laboratory of Control of Tropical Diseases, School of Tropical Medicine, Hainan Medical University, Haikou, Hainan, 571199, China

ARTICLE INFO

Article History:
Received 24th March, 2023
Received in revised form
14th April, 2023
Accepted 20th May, 2023
Published online 30th June, 2023

Key words:
Naphthalene; Al^{3+}; F
luorescence; Probe

Corresponding Author:
Yu Chunwei

ABSTRACT

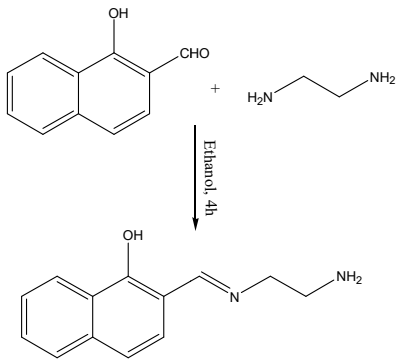
A novel Al^{3+}selective probe was rationally constructed based on naphthalene derivative. Compared to other tested metal ions, the probe displayed the selective recognition for Al^{3+}which could be detected by a significant turnon fluorescent response at 442 nm with a detection limit of 1.33 μM Al^{3+}. Besides, a 1:1 metal-ligand complex was confirmed by Job's plot experiment.

Citation: ***Fu Zhihan, Zhang Jun and Yu Chunwei.*** **2023.** "An Al^{3+}selective fluorescent probe derived from of naphthalene*". International Journal of Current Research*, 15, (06), 25038-25040

INTRODUCTION

Due to the large number of aluminum ions used in daily life, aluminum ions will enter the human body through the food chain, which can increase people's risk of aluminum poisoning, resulting in calcium metabolism disorders, interference with iron concentration in the blood[1-4]. Under overload conditions, Al^{3+} may be involved in the production of reactive oxygen species, contributing to neurodegenerative diseases such as Alzheimer's disease, Wilson's disease and Parkinson's disease [5-7]. The World Health Organization has reported that humans can consume the maximum amount of aluminum per day is about 3 mg, and the highest concentration of aluminum in drinking water is 7.41 μ M. Therefore, it is particularly important to establish an efficient and accurate method for detecting Al^{3+} in the environment. As a method to overcome alumina defects, fluorescent probe technology has been widely used in the study of sensitive and rapid detection of alumina[8-10]. This technique allows real-time detection of target ions at very low ion concentrations without any special treatment of the sample. They are highly selective, sensitive and suitable for biological imaging and medical diagnosis[11-22].Naphthalene derivatives are excellent fluorophores because of their large two-photon absorption cross section. Naphthalene derivatives are combined with compounds or materials to construct a novel efficient fluorescence probe which may selectively respond to small molecules. It is of great significance for the analysis and detection of small molecules. Based on the above considerations, naphthalene was selected as fluorescent group and ethylenediamine functional unit was introduced in this study.

The probe showed excellent selectivity for aluminum ions in ethanol, and the interference of other ions was very small. It was preliminarily proved that the binding ratio between the probe and aluminum ions was 1:1 by equimolar continuous change method. When Al^{3+} was present, the fluorescence intensity of the system at 442 nm was positively correlated with the concentration of Al^{3+}.



Scheme 1 Synthetic route of P

EXPERIMENTAL SECTION

Reagents and Instruments: The metal ions used in the experiment are mainly chloride.They were from NaCl, $MgCl_2·6H_2O$, $CdCl_2$, $HgCl_2$, $CaCl_2·2H_2O$, $FeCl_3·6H_2O$, $CrCl_3·6H_2O$, $Zn(NO_3)_2·6H_2O$, $AgNO_3$,

$AlCl_3·6H_2O$,$CoCl_2·6H_2O$, $MnCl_2·4H_2O$, $CuCl_2·2H_2O$, $NiCl_2·6H_2O$, and $PbCl_2$, respectively. Fluorescence emission spectra were conducted on a Hitachi4600 spectrofluorometer.

Synthesis of P: 2-hydroxy-1-naphthalene formaldehyde (0.01017 g) was added in ethanol (30 mL), and then 100 μL ethylenediamine was added drop by drop in the stirring state. Yellow solids were precipitated at the beginning of the reaction. After reflux reaction for 6 h, the mixture was cooled to room temperature, then filtered and washed with ethanol to get dark brown solid P.

General spectroscopic methods: Metal ions were dissolved in deionized water to obtain stock solution (10 mM); the probe was dissolved in DMSO to obtain stock solution (1 mM). All of the fluorescence spectra were recorded at room temperature (25 °C). Test solutions were prepared by placing 50 μL of the probe stock solution (1 mM) and an appropriate aliquot of individual ion stock solution into a test tube, and then diluting the solution with ethanol to 5 mL, the resulting solution was shaken well before recording the spectra. Excitation and emission slit widths were 10/10 nm, respectively. The excitation wavelength was 350 nm.

RESULTS AND DISCUSSION

Selectivity Measurement of P: Selectivity was the most important property of probes, which decided the further use of probe. Thus, the selectivity of P (10μM) to different metal ions (100 μM) (Ag^+, Ca^{2+}, Mg^{2+}, Zn^{2+}, Pb^{2+}, Cu^{2+}, Hg^{2+}, Cd^{2+}, Cr^{3+}, Fe^{3+} and Al^{3+}) was detected in ethanol firstly (Figure 1). Among the tested ions, only the addition of Al^{3+} caused an obvious enhancement of fluorescence of P at 442 nm, which proved that P was a good Al^{3+}-selective probe.

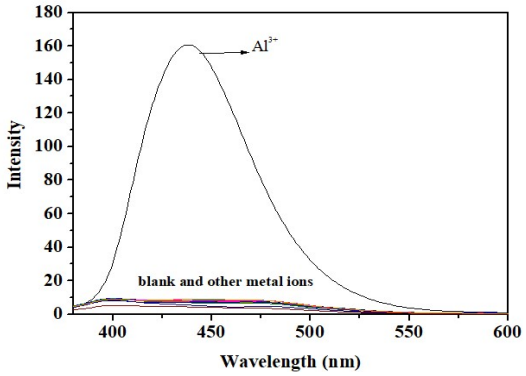


Figure1. Fluorescence emission spectra of different metal ionson P in ethanol

Fluorescent titration experiment of P with Al^{3+}: In order to study the sensitivity of P on the detection of Al^{3+}, fluorescent titration experiment was carried out (Figure 2). The experiment results showed that P had a good linear relationship with Al^{3+} with wide concentration range of 4-10 μM, and the detection limit was 1.33μM (based on LOD=3σ/s, σ was the standard deviation of blank solution, S was the slope of calibration curve).

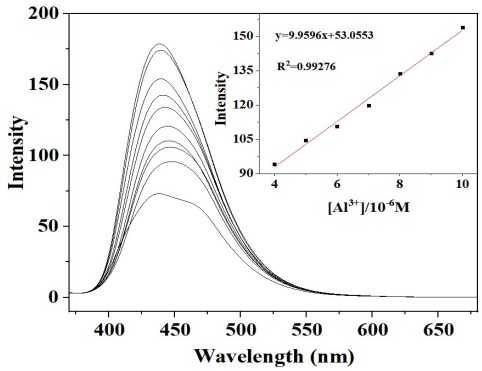


Figure 2. Fluorescent titration experiment of P with Al^{3+}.Inset: linear plot of P with Al^{3+} concentration

Combination mode of P with Al^{3+}: It was determined by equimolar continuous change method to evaluate the combination ratio of Pwith Al^{3+}. Judging from the results in the Figure 3, when [P]/ [Al^{3+}] was close to 0.5, the intensity at 442 nm was maximum and the possible combination patterns were shown in the Figure 4, the carbonyl oxygen on the naphthalene ring and the nitrogen atom on ethylenediamine may participate in the coordination.

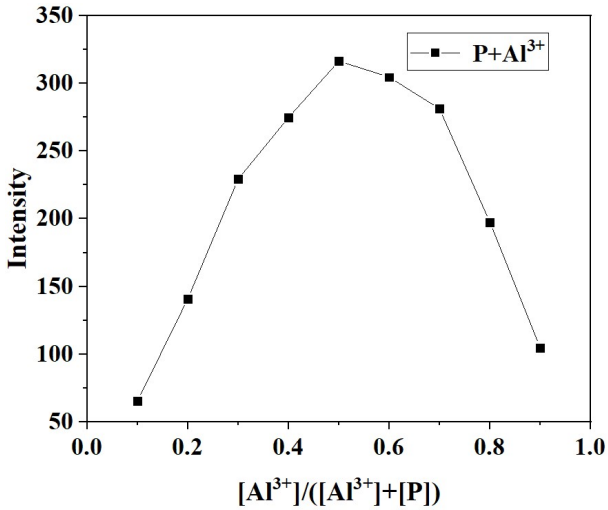


Figure 3. Job's-plot of P-Al^{3+}, and the total concentrations of P and Al^{3+} was kept as 50 μM.

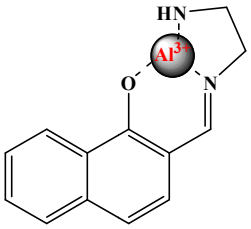


Figure 4. Proposed combination of P and Al^{3+}

CONCLUSION

An Al^{3+}-selective fluorescent probe was successfully characterized, compared other tested metal ions, this probe showed good selectivity and sensitivity to Al^{3+}. This study will promote the development of the design of ligands for the detection of Al^{3+}.

ACKNOWLEDGMENT

This work was financially supported by Hainan Province Science and Technology Special Fund (No.ZDYF2022SHFZ076, ZDYF2022SHFZ307) and the Natural Science Foundation of Hainan Province (No. 820RC626, 821RC559) and the Research and Training Foundation of China (No. S202111810005).

REFERENCES

Gao, L. X. C. C. Deng, J. Xiong, P. P. Zhu, Q. Chen and K. J. Tan, A sensitive ratiometric fluorescence method for visual detection of aluminum ion based on chelation-enhanced photoluminescence. Microchemical Journal,150 (2019) 104096.

Kaur, B. A. Gupta and N. Kaur, A simple schiff base as a multi responsive and sequential sensor towards Al^{3+}, F^- and Cu^{2+} ions. Journal of Photochemistry and Photobiology A: Chemistry, 389 (2020) 112140.

Anu, D. P. Naveen, R. Rajamanikandan and M. V. Kaveri, Development of hydrazide based fluorescence probe for detection of Al^{3+} ions and application in live cell image. Journal of

Photochemistry and Photobiology A: Chemistry,405(15) (2021) 112921.

Gul, A. M. Oguz, A. N. Kursunlu and M. Yilmaz, A novel colorimetric/fluorometric dual-channel sensor based on phenolphthalein and Bodipy for Sn (II) and Al (III) ions in half-aqueous medium and its applications in bioimaging. Dyes and Pigments, 176 (2020) 108221.

Kshirsagar, N. R. Sonawane, P. Patil,J. Nandre, P. Sultan, S. Sehlangia, C. P. Pradeep, Y. Wang, L. x. Chen and S. K. Sahoo, Fluorescent chemosensor for Al(III) based on chelation-induced fluorescence enhancement and its application in live cells imaging. Inorganica Chimica Acta,511 (2020) 119805.

Tian, L. J. Xue, S. L. Li, Z and Y. Yang, A novel chromone derivative as dual probe for selective sensing of Al(III) by fluorescent and Cu(II) by colorimetric methods in aqueous solution. Journal of Photochemistry and Photobiology A: Chemistry, 382 (2019) 111955.

Dhineshkumar, E. M. Iyappan and C. Anbuselvan,A novel dual chemosensor for selective heavy metal ions Al^{3+}, Cr^{3+} and its applicable cytotoxic activity, HepG2 living cell images and theoretical studies. Journal of Molecular Structure, 1210(2020) 128033.

Yin, P. C. W. W. Ma, J. Q. Liu, T. T. Hu, T. Wei, J. B. Chen, T. D. Li and Q. F. Niu, Dual functional chemosensor for nano-level detection of Al^{3+} and Cu^{2+}: Application to real samples analysis, colorimetric test strips and molecular logic gates. Microchemical Journal, 180 (2022) 107557.

Liang, J. H. B. Liu and J. Wang, Pyrene-based ratiometric and fluorescent sensor for selective Al^{3+} detection. Inorganica Chimica Acta, 489 (2019) 61-66.

Ali, R. F. M. Alminderej, S. Messaoudi and S. M. Saleh, Ratiometric ultrasensitive optical chemisensor film based antibiotic drug for Al(III) and Cu(II) detection. Talanta, 221 (2021)121412.

Guo, X. C. C. X. Guo, Y. J. Xing, Y. Y. Liu, K. H. Wei, M. Y. Kang, X. F. Yang, M. S. Pei and Guangyou Zhang, A novel Schiff base sensor through "off-on-off" fluorescence behavior for sequentially monitoring Al^{3+} and Cu^{2+}. Journal of Photochemistry and Photobiology A: Chemistry, 430 (2022) 113990.

Zhang, Q. R. Ma, Z. Y. Li andZ. Z. Liu, A multi-responsive crown ether-based colorimetric/fluorescent chemosensor for highly selective detection of Al^{3+}, Cu^{2+} and Mg^{2+}. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 228 (2020) 117857.

Zhang, S. Z. Y. Wang and H. Y. Xu, A new naphthalimide-picolinohydrazide derived fluorescent "turn-on" probe for hypersensitive detection of Al^{3+} ions and applications of real water analysis and bio-imaging. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 275 (2022) 121193.

Wu, K. J. S. Hu, X. F. Cheng, J. X. Li and C. H. Zhou, A superior luminescent metal-organic framework sensor for sensing trace Al^{3+} and picric acid via disparate charge transfer behaviors. Journal of Luminescence, 219 (2020) 116908.

Das, B. M. Dolai, A. Ghosh, A. Dhara, A. D. Mahapatra, D. Chattopadhyay, S. Mabhai, A. Jana, S. Dey and A. Misra, A bio-compatible pyridine-pyrazole hydrazide based compartmental receptor for Al^{3+} sensing and its application in cell imaging. Analytical Methods, 13 (2021) 4266-4279.

Liu, X. H. C. Y. Shao, T. D. Chen, Z. J He and G. F. Du, Stable silver nanoclusters with aggregation-induced emission enhancement for detection of aluminum ion. Sensors and Actuators B: Chemical, 278 (2019) 181-189.

Mathivanan, M. B. Tharmalingam, T. Devaraj, A. Murugan,C. H. Lin, M. Jothiand B. Murugesapandian, A new 7-diethylamino- 4-hydroxycoumarin based reversible colorimetric/fluorometric probe for sequential detection of Al^{3+}/PPi and its potential use in biodetection and bioimaging applications.New Journal of Chemistry, 45 (2021) 6067-6079.

Kaur, R. N. Kaur, A. Kuwar, and N. Singh, Colorimetric sensor for detection of trace level Al(III) in aqueous medium based on organic-inorganic nanohybrid. Chemical Physics Letters, 722 (2019) 140-145.

Mehul, R. K. I. M. Naved, Z.V.P. Murthy, and S. K. Kailasa, Designing of glutathione-lactose derivative for the fabrication of gold nanoclusters with red fluorescence: Sensing of $Al^{3+}$and Cu^{2+} ions with two different mechanisms. Optical Materials, 100(2020) 109704.

Zhao, G, C. X. Yi, G. Wei, R. Wu, Z. Gu, S. Guang and H. Xu, Molecular design strategies of multifunctional probe for simultaneous monitoring of Cu^{2+}, Al^{3+}, Ca^{2+} and endogenous l-phenylalanine (LPA) recognition in living cells and zebrafishes. Journal of Hazardous Materials, 389(2020) 121831.

Singha, D. A. Pal, H. Uyama, P. Roy and M. Nandi, Discriminatory behavior of a rhodamine 6G decorated mesoporous silica based multiple cation sensor towards Cu^{2+} and Hg^{2+} vis-à-vis Al^{3+}, Cr^{3+} and Fe^{3+}: selective removal of Cu^{2+} and Hg^{2+} from aqueous media. Dalton Transactions, 50(2021) 12478-12494.

Sun, J. Q. Y. F. Li, S. Shen,Q. M. Yan, G. M. Xia and H. M. Wang, A squaraine-based fluorescence turn on chemosensor with ICT character for highly selective and sensitive detection of Al^{3+} in aqueous media and its application in living cell imaging. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 228(2020) 117590.

****