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A new Rhodamine-based visual and fluorometric probe for selective detection of trivalent cations

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Abstract: A novel rhodamine-based probe **L** has been designed and synthesized. Probe **L** acted as a colorimetric and fluorescent "turn on" probe for trivalent ions with high selective over other monovalent or divalent ions in CH_3OH:Tris (8:2). Furthermore, probe **L** exhibited low detection limits toward these trivalent ions (Fe^{3+}, Al^{3+} and Cr^{3+}) which could make it attractive in trivalent ions detection.

Keywords: Colorimetric sensor, fluorometric probe , Trivalent metal cations, Rhodamine B

Introduction

Nowadays, toxic metal contaminations are growing due to manufacturing process such as pigments, electroplating, and mining industries which release various amounts of heavy metals. As a result, unsafe drinking water and food with metal contamination especially in developing countries make people at great risk of diseases. Thus, many works have led to detect the toxic metal ions such such as lead,[1] silver,[2] cadmium,[3] zinc,[4, 5] chromium,[6] iron,[7] aluminum,[8, 9] and so on in water and foods. Among those metal ions, trivalent metal ions especially Fe^{3+}, $Al^{3+}$and Cr^{3+} play an important role in human health. For example, Fe^{3+} is connected with enzyme catalysis and cellular metabolism.[10] The disorder of Fe^{3+} may lead to several diseases such as Parkinson's disease, Huntington's and Alzheimer's diseases.[11-13] Excess usage of Al^{3+} could disturb the normal physiology, resulting in headache, memory loss, Alzheimer's disease, and anemia.[14, 15] The deficiency of Cr^{3+} will make people suffer from diabetes and cardiovascular diseases and the excess of Cr^{3+} will do harm to cellular structures.[16] Thus, the detection of Fe^{3+}, Al^{3+} and Cr^{3+} is a pressing need for human health.

Various methods, such as Inductive Coupled Plasma Emission Spectrometer (ICP), X-ray Photoelectron Spectrometer (XPS) and Atomic fluorescence spectroscopy (AFS), have been used for heavy metal detection.[17-19] However, these methods often require extensive procedures, sophisticated instrumentation. Compared with these complicated methods, optical probes are inexpensive, simple and rapid. A huge number of fluorescent probes have been reported.[20-30] However, most of them are useful to detect divalent metal ions or monovalent metal ions.[31-34] The detection of trivalent metal ions is still a great need.[8, 35] Both Fe^{3+} and Cr^{3+} are paramagnetic in nature. As a result, they mostly behave as fluorescence quenchers making it difficult to develop a turn-on fluorescence probes.[36] In contrast to Fe^{3+} and Cr^{3+}, Al^{3+} is diamagnetic which often enhances the fluorescence when binding to the sensor. Nevertheless, the detection of Fe^{3+}, Al^{3+} and Cr^{3+} using different sensor is exhausted. Single probes for multiple functions have attracted great attention due to the more efficient analysis and less expensive. However, detecting all of these trivalent cations simultaneously by single sensor is rarely reported.[37-39]

Herein, we report the design and synthesis of novel probe **L** based on Rhodamine which is well-known as a good chromophore and fluorophore. The detailed synthetic process of the probe is shown in Scheme 1. The probe showed remarkable color change and also "turn on" fluorescence in the presence of M^{3+}(Fe^{3+}, Al^{3+} and Cr^{3+}).