Facile Synthesis of Novel Rhodamine-Derived Dual-Mode Colorimetric and Fluorescent Sensor for Mercury(II) Detection in Water

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Mercury is a highly toxic heavy metal that poses a serious risk to human health and the environment, affecting an estimated 19 million people worldwide. In aquatic systems, inorganic mercury, particularly Hg2+, can be converted by microorganisms into methylmercury, a highly toxic organic species that readily bioaccumulates and biomagnifies through the food chain. Therefore, developing effective and sensitive sensors for Hg2+ detection is critically important. Recently, rhodamine-derived sensors have been widely studied due to their unique colorimetric and fluorescent “turn-on” responses triggered by spirolactam ring opening. However, many existing sensors still face limited instability under certain conditions and complex synthesis procedures. To address these challenges, we developed a facile synthesis method for a novel rhodamine-based Hg2+ sensor with improved selectivity and practical applicability. Rhodamine B was initially activated by POCl3, followed by reaction with 2-thiophenemethylamine to yield an amide-thiophene derivative. The amide group was then converted into a thioamide using Lawesson’s reagent. The sensor structure was confirmed by 1H-NMR, 13C-NMR, FTIR, and HRMS. The sensor enabled fast and selective Hg2+ detection in MeCN/H2O, with a visible color change to pink and significant fluorescence enhancement within 5 minutes. It exhibited a detection limit of 159 μM, good stability across pH 3–9, and high photostability. We also demonstrated its practical potential with detection in a real water sample and developed a smartphone-integrated alternative. This work highlights a promising synthesis strategy and a sensor that translates into portable mercury detection, with potential applications in rapid test kits for water safety and environmental protection.

Awards Won:

Fourth Award of $600

American Chemical Society: Third Award of $2,000