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Development of 8-hydroxyquinoline derivatives as fluorescence sensors for Zn^{2+} detection

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Zinc (Zn^{2+}) is the second most abundant transition metal ion in the human body and plays a crucial role in numerous biological, environmental, and industrial processes. This study aimed to synthesize ester derivatives of 8-hydroxyquinoline (8-HQ), develop them as fluorescent chemosensors, and investigate their selectivity towards Zn^{2+} ions. Three 8-HQ ester derivatives; (8-hydroxyquinolin-5-yl)methyl benzoate (1), (8-hydroxyquinolin-5-yl)methyl 4-methoxybenzoate (2), and (8-hydroxyquinolin-5-yl)methyl 4-trifluoromethylbenzoate (3) were successfully synthesized as fluorescent sensors for Zn^{2+} detection. The synthesis involved a two-step process: first, 8-HQ was converted to 5-hydroxymethyl-8-hydroxyquinoline (5-HMHQ); subsequently, Steglich esterification was performed using benzoic acid and para-substituted benzoic acids ($–OCH_3$ and $–CF_3$) as carboxylic acid components and 5-HMHQ as the alcohol component. The coupling reagent N,N′-dicyclohexylcarbodiimide (DCC) and the catalyst 4-dimethylaminopyridine (DMAP) were used in CH_2Cl_2 at room temperature. The by-product, dicyclohexylurea (DCU), was removed via acid washing followed by column chromatography. The absorption spectra of the derivatives displayed two distinct peaks corresponding to the free and Zn^{2+}-complexed forms at the wavelengths 317 nm and 400 nm for (1), 316 nm and 393 nm for (2), 318 nm and 397 nm for (3). Fluorescence emission spectra, obtained upon excitation at the absorption maxima of the free probes; 317 nm for (1), 316 nm for (2), and 318 nm for (3), revealed fluorescence quenching and the formation of metal–ligand complexes upon Zn^{2+} addition. All three compounds exhibited iso-emissive points in their emission spectra, indicating equilibrium between free and bound forms, with metal-to-ligand binding stoichiometries of 1:1, 1:2, and 1:3. These results demonstrate that the synthesized 8-HQ derivatives are effective fluorescent probes for the sensitive and selective detection of Zn^{2+} ions through ratiometric response and fluorescence enhancement.

Keywords:

8-hydroxyquinoline ester derivatives; Zn^{2+}; Steglich esterification; fluorescent chemosensors