Abstract

In the present doctoral thesis, the structural modification of the rhodamine B indicator and the influence of synthetic procedures on the optical and sensor properties of the indicator is described.

Rhodamine B was structurally modified with ethylene diamine and examined how a seemingly small structural change affected the properties of the indicator. The synthesized RhB-EDA fluorescent indicator shows interesting optical sensor properties, and high sensitivity and selectivity to Ag^+ ions among all the tested metal ions (K^+, Mg^{2+}, Cu^{2+}, Ni^{2+}, Fe^{2+}, Pb^{2+}, Na^+, Mn^{2+}, Li^+, Al^{3+}, Co^{2+}, Hg^{2+}, Sr^{2+}, Ca^{2+}, Ag^+, Cd^{2+} in Zn^{2+}), while the well-known Rhodamine B (RhB) fluorescent probe shows much less sensitivity to Ag^+ ions, but high sensitivity to Fe^{2+} ions. The new RhB-EDA fluorescent indicator has has the ability to detect Ag^+ ions up to µM concentrations by using the fluorescence quenching approach. The probe displayed a dynamic response to Ag^+ in the range of $0.43\ 10^{-3} – 10^{-6}$ M with a detection limit of 0.1 µM. The sensing system of an RhB-EDA novel fluorescent probe was optimised according to the spectral properties, effect of pH and buffer, photostability, incubation time, sensitivity, and selectivity. Since all the spectral and sensing properties were tested in green aqueous media, although many other similar sensor systems rely on organic solvent solutions, the RhB-EDA sensing probe may be a good candidate for measuring Ag^+ ions in real-life applications.

Subsequently, the ethylenediamine-modified indicator was further modified with methylacrylate and again with ethylenediamine, and the optical and sensor properties were checked again. The synthesized RhB-EDA-MA-EDA indicator showed interesting optical properties. The modification changed the wavelength of excitation and emission after the first and second structural modification, and at the same time we also influenced the Stokes shift of the indicators. In the framework of this dissertation, we managed to form a rhodamine derivative with an above-average Stokes shift. The structural modification of the baseline indicator also significantly affected its selectivity.

Among all the metal ions tested (K^+, Mg^{2+}, Cu^{2+}, Ni^{2+}, Fe^{2+}, Pb^{2+}, Na^+, Mn^{2+}, Li^+, Al^{3+}, Co^{2+}, Hg^{2+}, Sr^{2+}, Ca^{2+}, Ag^+, Cd^{2+} in Zn^{2+}), RhB-EDA-MA-EDA showed non-selective sensitivity to Hg^{2+}, Fe^{2+}, Al^{3+} and Zn^{2+}. The new fluorescent indicator RhB-EDA-MA-EDA showed a dynamic response to Al^{3+} ions in the range of $4\ 10^{-3} – 4\cdot10^{-7}$ M at an excitation wavelength of 274 nm with a detection limit of 0.2 µM. At the same time, at an excitation wavelength of 393 nm, it also showed a dynamic response to Fe^{2+} ions in the range of $5\ 10^{-4} – 6\ 10^{-6}$ M with a detection limit of 4 µM. The detection system of the new RhB- EDA-MA-EDA indicator has been optimized according to spectral properties, pH and buffer effect, photostability, incubation time and sensitivity. Given the detection limit and

concentration range of the indicator for the detection of Fe^{2+} and Al^{3+} ions, the indicator RhB-EDA-MA-EDA could be suitable for measuring these ions in the environment.

In the context of this dissertation, we found that the optical and sensor properties of the indicator changed in an unpredictable, completely random way depending on the structural modification. Each modification step had a different impact on the optical and sensor properties.