ZnO-benzimidazole and ZnO-Schiff base composite for selective detection of metal ions

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Abstract

Zn^{2+} and Mg^{2+} ions are crucial elements in many physiological processes. Zn^{2+} participates in enzymatic reactions, neurotransmission, or apoptosis.

he dysregulation of Zn^{2+} levels in organisms leads to neurological diseases such as Alzheimer's or Parkinson's. Mg^{2+} ions play a significant role in protein and nucleic acid production, ion transport pump control, or skeleton maintenance. Low concentration of magnesium ions in cells causes neuromuscular problems, muscle spasms, convulsions, or hypertension. The luminescence sensors of metal ions are of great attention because of their low cost, non-invasive monitoring, fast response, and ease of use. Therefore, the design and validation of photoluminescence compounds and composites sensitive towards Zn^{2+} and Mg^{2+} ions could solve actual scientific problems.

Imines such as benzimidazole derivatives or Schiff bases are known for their luminescence, sensitivity, and biological properties. The change of the donor atoms, e.g., N, O, S, can increase steric and electronic effects to tune charge transfer processes and, consequently, change their optical properties.

Despite good selectivity, imines have several main disadvantages for optical sensor applications: the suspensions degrade with time, are unstable, and exhibit photobleaching properties under light irradiation. Thus, the actual scientific tasks are transferring the Schiff bases to solid-state substrates, increasing the active surface area, and stabilising properties.

Benzimidazoles are a class of heterocyclic aromatic organic compounds built of a benzene ring condensed with an imidazole ring; their derivatives have a broad spectrum of properties, including the fields such as chemistry and biology exhibiting optical, antibacterial, antifungal, and biocidal properties and were used as optical lasers and polymer dyes in optoelectronics.

ZnO is a semiconductor with a high band gap (3.2 eV) and room-temperature photoluminescence (380 nm and 550 nm).

Schiff bases and ZnO nanostructures were used as composites for wound dressing applications. Moreover, Schiff bases are used as precursors for the synthesis of ZnO.

The combination of ZnO and Schiff bases for sensory applications has not yet been explored.

The sensitivity, selectivity, and limit of detection of benzimidazole derivatives to Zn^{2+} and Mg^{2+} ions were obtained. The stability of the sensor signal was discussed. Additionally, we report on a new ZnO-imine composite (ZnO_{nf}-**ligand**) for use as an optical chemical sensor.

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