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Ionophore-Based Materials for Selective Optical Sensing of Iron(III)

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Abstract : Development of selective, fast-responsive, and economical sensors for diverse ions detection and determination is one of the most extensively studied areas due to its importance in the field of clinical, environmental and industrial analysis. Among chemical sensors, vast popularity has gained ionophore-based optical sensors, where the generated analytical signal is a consequence of the molecular recognition of ion by the ionophore. Change of color occurring during host-guest interactions allows for quantitative analysis and for 'naked-eye' detection without the need of using sophisticated equipment. An example of application of such sensors is colorimetric detection of iron(III) cations. Iron as one of the most significant trace elements plays roles in many biochemical processes. For these reasons, the development of reliable, fast, and selective methods of iron ions determination is highly demanded. Taking all mentioned above into account a chromogenic amide derivative of 3,4-dihydroxybenzoic acid was synthesized, and its ability to iron(III) recognition was tested. To the best of authors knowledge (according to chemical abstracts) the obtained ligand has not been described in the literature so far. The catechol moiety was introduced to the ligand structure in order to mimic the action of naturally occurring siderophores-iron(III)-selective receptors. The ligand–ion interactions were studied using spectroscopic methods: UV-Vis spectrophotometry and infrared spectroscopy. The spectrophotometric measurements revealed that the amide exhibits affinity to iron(III) in dimethyl sulfoxide and fully aqueous solution, what is manifested by the change of color from yellow to green. Incorporation of the tested amide into a polymeric matrix (cellulose triacetate) ensured effective recognition of iron(III) at pH 3 with the detection limit 1.58×10^{-5} M. For the obtained sensor material parameters like linear response range, response time, selectivity, and possibility of regeneration were determined. In order to evaluate the effect of the size of the sensing material on iron(III) detection nanospheres (in the form of nanoemulsion) containing the tested amide were also prepared. According to DLS (dynamic light scattering) measurements, the size of the nanospheres is 308.02 ± 0.67 nm. Work parameters of the nanospheres were determined and compared with cellulose triacetate-based material. Additionally, for fast, qualitative experiments the test strips were prepared by adsorption of the amide solution on a glass microfiber material. Visual limit of detection of iron(III) at pH 3 by the test strips was estimated at the level 10^{-4} M. In conclusion, reported here amide derived from 3,4- dihydroxybenzoic acid proved to be an effective candidate for optical sensing of iron(III) in fully aqueous solutions. N. L. kindly acknowledges financial support from National Science Centre Poland the grant no. 2017/01/X/ST4/01680. Authors thank for financial support from Gdansk University of Technology grant no. 032406.

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