Xournals

Academic Journal of Material Sciences

ISSN UA | Volume 01 | Issue 01 | June-2018

A Mini Review on: Fluorescent Sensors for Toxic Metal ions

Keyur D. Bhatt[1], Kavit S. Mehta[1], Bharat A. Makwana[2], and Surbhi V. Upadhyay[3]

Available online at: www.xournals.com

Received 2nd January 2018 | Revised 8th April 2018 | Accepted 12th May 2018

Abstract:

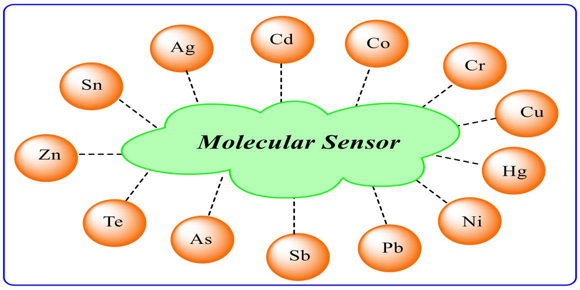
The development of molecular sensors for efficient detection of specific metal ion is an emerging area in chemistry because of their potential analytical applications in many different fields, including chemistry and biology, for determination of selectivity with various metal ions, fluorescent technique has been widely used. Fluorescent molecular metal ion sensors become increasingly important as tools for the quantitative real-time monitoring of metal ion concentration in biological samples. In such sensors, a metal chelating site is usually linked to fluorophore, and metal binding affects the fluorescence intensity of the compound.

Keywords: *Fluorescence sensor, Calix system, Metal ions, Macrocyclic compounds*

Authors:

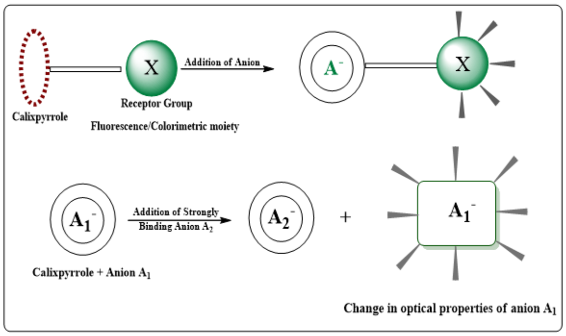
1. *Mehsana Urban Institute of Sciences, Ganpat University, Kherva-384012, India*
2. *Department of Chemistry, H.V.H.P. Institute, Kadi Sarva Vishwavidyalaya, Kadi, India*
3. *Department of Chemistry, Kamani Science College and Prataprai Arts College, Saurashtra University, Amreli, Gujarat-365601*

Introduction



Macrocyclic chemistry is different from the other because it deals with synthetic molecular systems that are held together by weaker non-covalent interactions, such as electrostatic forces, hydrogen bonds, π-π stacking interactions, van der Waals forces, or hydrophobic effects[1-3]. Toxic metals are extensively used in industrial, agricultural and military purposes for several decades of time. These are now widely dispersed in a range of different forms, and there are environmental problems arising from their mining, extraction and purification[4-6]. Not only cations, the anions, specially halides and oxo anions play a fundamental role for resolving various chemical, biological and environmental issues Toxic heavy metal ions such as Hg^{2+}, Pb^{2+} and Cd^{2+}, which are highly health hazardous, require detection of their presence in the environment in ppm level[7]. Specially lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, reproductive and nervous systems[8]. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Mercury has a number of effects on humans like disruption of the nervous system, damage to brain functions, DNA damage and chromosomal damage. Since anions are ubiquitous and play important roles in many biological and chemical systems, there is an increasing interest in the design and development of receptors that selectively recognize specific anions such as halides, NO_3^-, SO_4^{2-}, PO_4^{3-}, $H_2PO_4^-$. Among the range of biologically important anions, the fluoride anion has attracted growing attention due to its established role in preventing dental cares. Fluoride anion is also explored extensively as a treatment for osteoporosis, a type of fluoride toxicity that generally manifests itself clinically in terms of increasing bone density. Acetate is a critical component of numerous metabolic processes[9, 10]. Acetate production and oxidation rate have been frequently used as indicator of organic decomposition in marine sediments. Phosphate anions are very important anionic species in living organisms.

Naturally occurring phosphate-binding proteins (PBP) selectively and strongly bind hydrogen phosphate[11]. Development of suitable methods for detection of these ions, particularly in aqueous media, is desirable. In recent years, significant effort has been made for the development of highly sensitive techniques for selective detection of various hazardous cations and anions and also methods for monitoring the recognition event in solution[3, 12-14]. Among the various analytical methods that are available for the detection of cations and anions, flame photometry, atomic absorption spectrometry, ion sensitive electrodes, electron microprobe analysis, neutron activation analysis, etc., are expensive, often require large amount of sample and do not allow continuous monitoring. In contrast, the method based on fluorescence offers distinct advantages in terms of sensitivity, selectivity, time and sample required for analysis and moreover it is a nondestructive method of analysis[15-18]. Many researchers including chemists, biologists and environmentalists are intensively involved in the development of molecular sensors suitable for selective detection of various ions[19]. Such type of molecular sensors can be developed by the combination of an ion recognition unit with a luminescent fragment whose photo physical properties perturbed during the recognition process[20].



Optical sensor approach

The photo physical property[21] of the luminescent unit is sensitive to interactions between host and guest, and therefore can be used as a tool to monitor the recognition event[22]. Binding of ions to the recognition sites leads to changes in certain properties of the receptors such as colour, luminescence, excited-state lifetime and that serves as indicators of ion-recognition. For this purpose, fluorescent organic molecules have been widely used as fluorophore for the recognition of both cations and anions[23]. However, rhenium(I) and ruthenium(II)-polypyridyl complexes, which are highly luminescent, have also been used as fluorophore in designing chemisensors for cations, anions and biological molecules[24]. For designing of anion receptors, incorporation of metal-complex based fluorophores offers some advantages over organic molecules.

Conclusion

Designing of ionophores, various noncovalent interactions, such as hydrogen-bonding, electrostatic, hydrophobicity are mainly considered. For this purpose, both the open chain and macrocyclic units, which can effectively interact with the incoming ions, can be used. Macrocyclic ionophores are commonly used for the detection of cations, however they have also been used for anion recognition because of their ability to associate with anions by hydrogen-bonding interaction.

Acknowledgements

The authors gratefully acknowledge the financial assistance provided by GUJCOST, Gandhinagar and University Grant Commission (UGC), New Delhi. The authors also acknowledge CSMCRI (Bhavanagar), Ganpat University, CDRI (Lucknow) for providing instrumental facilities and INFLIBNET, Ahmedabad for e-journals.

References:

1. F. Giordanetto and J. Kihlberg, *Journal of medicinal chemistry*, 2013, **57**, 278-295.
2. L. F. Lindoy, K.-M. Park and S. S. Lee, *Chemical Society Reviews*, 2013, **42**, 1713-1727.
3. J. W. Steed and J. L. Atwood, *Supramolecular chemistry*, John Wiley & Sons, 2013.
4. Z. A. AlOthman, M. M. Alam and M. Naushad, *Journal of Industrial and Engineering Chemistry*, 2013, **19**, 956-960.
5. S. Clemens, *Biochimie*, 2006, **88**, 1707-1719.
6. J. Hall, *Journal of experimental botany*, 2002, **53**, 1-11.

References:

7. L. Zecca, C. Bellei, P. Costi, A. Albertini, E. Monzani, L. Casella, M. Gallorini, L. Bergamaschi, A. Moscatelli and N. J. Turro, *Proceedings of the National Academy of Sciences*, 2008, **105**, 17567-17572.

8. W. W. Au, *International journal of hygiene and environmental health*, 2002, **205**, 501-503.

9. G. Asher and U. Schibler, *Cell metabolism*, 2011, **13**, 125-137.

10. J. K. Nicholson and I. D. Wilson, *Nature Reviews Drug Discovery*, 2003, **2**, 668.

11. J. W. Johnson, D. C. Johnston, A. J. Jacobson and J. F. Brody, *Journal of the American Chemical Society*, 1984, **106**, 8123-8128.

12. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, *Computer networks*, 2002, **38**, 393-422.

13. E. R. Goldman, I. L. Medintz, J. L. Whitley, A. Hayhurst, A. R. Clapp, H. T. Uyeda, J. R. Deschamps, M. E. Lassman and H. Mattoussi, *Journal of the American Chemical Society*, 2005, **127**, 6744-6751.

14. B. A. Makwana, D. J. Vyas, K. D. Bhatt, S. Darji and V. K. Jain, *Applied Nanoscience*, 2016, **6**, 555-566.

15. K. D. Bhatt, H. S. Gupte, B. A. Makwana, D. J. Vyas, D. Maity and V. K. Jain, *Journal of fluorescence*, 2012, **22**, 1493-1500.

16. K. D. Bhatt, B. A. Makwana, D. J. Vyas, D. R. Mishra and V. K. Jain, *Journal of Luminescence*, 2014, **146**, 450-457.

17. K. D. Bhatt, D. J. Vyas, B. A. Makwana, S. M. Darjee and V. K. Jain, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 2014, **121**, 94-100.

18. K. D. Bhatt, D. J. Vyas, B. A. Makwana, S. M. Darjee, V. K. Jain and H. Shah, *Chinese Chemical Letters*, 2016, **27**, 731-737.

19. T. D. James, K. S. Sandanayake and S. Shinkai, *Nature*, 1995, **374**, 345.

20. Y. Kubo, S. y. Maeda, S. Tokita and M. Kubo, *Nature*, 1996, **382**, 522.

21. A. Tsuboyama, K. Kuge, M. Furugori, S. Okada, M. Hoshino and K. Ueno, *Inorganic chemistry*, 2007, **46**, 1992-2001.

22. K. M.-C. Wong and V. W.-W. Yam, *Accounts of chemical research*, 2011, **44**, 424-434.

23. M. H. Lee, J. S. Kim and J. L. Sessler, *Chemical Society Reviews*, 2015, **44**, 4185-4191.

24. J. Du, M. Hu, J. Fan and X. Peng, *Chemical Society Reviews*, 2012, **41**, 4511-4535.