ISSN (Online) : 2348 - 2001

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

CHEMOSENSOR AND ITS APPLICATIONS

Poonam Rani
Department of Chemistry
Guru Jambheshwar University of Science & Technology
Hisar-125001, Haryana, India

Abstract

A molecular sensor or chemosensor is a molecule that teams up with an analyte to convey a discernable change. Nuclear sensors join sub-nuclear affirmation with some sort of reporter so the proximity of the guest can be viewed. The term supramolecular investigative science has starting late been founded to delineate the utilization of nuclear sensors to descriptive science. Early instances of nuclear sensors are crown ethers with broad proclivity for sodium particles yet not for potassium and sorts of metal distinguishing proof by assumed complexones which are standard pH markers retrofitted with sub-nuclear get-togethers delicate to metals. This receptor-spacer-feature writer thought is a rehashing subject consistently with the journalist demonstrating photoinduced electron trade (PET). One delineation is a sensor delicate to heparin. A chemoreceptor, also known as chemosensor, is a specialized sensory receptor cell which transduces (responds to) a chemical substance (endogenous or induced) and generates a biological signal. This signal may be in the form of an action potential if the chemoreceptor is a neuron (nerve cell) or in the form of a neurotransmitter that can activate a nearby nerve fiber if the chemosensor is a specialized sensory receptor cell, such as the taste receptor in a taste budor in an internal peripheral chemoreceptor such as the carotid body. In more general terms, a chemosensor detects toxic or hazardous chemicals in the internal or external environment of the human body and transmits that information to the central nervous system, (and rarely the peripheral nervous system), in order to expel the biologically active toxins from the blood, and prevent further

consumption of alcohol and/or other acutely toxic recreational intoxicants. This manuscript underlines the different aspects of chemosensor and its applications in multifaceted perspectives.

Keywords: Applications of Chemosensor, Chemosensor, Perspectives with Chemosensor

Introduction

"A chemosensor is molecule of abiotic origin that signals the presence of matter or energy" (A. W. Czarnick)

Working mode includes the following

- A receptor capable to selectively bind the analyte
- A site with some tunable moelcular property
- A transduction mechanism that converts the recongintion into a modification of the tunable property => signal

In principle, any measurable molecular property can be used

Sensor: device that interacts reversibly with an analyte with measurable signal generation.

A chemosensor is not a sensor, strictly speaking, as it is not a device, but it can be the active part of the device.

Fluorescent chemosensor : Chemosensor that generate a fluorescence signal

Need of fluorescence

- Sensitivity (even single molecule detection is possible)
- High spatial and temporal resolution
- Low cost and easily performed instrumentations

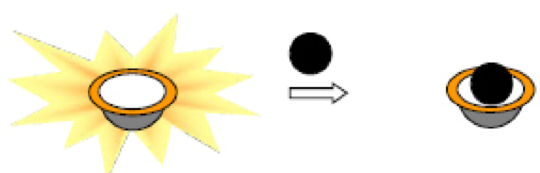
ISSN (Online) : 2348 - 2001

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

Which signal do we measure with fluorescent chemosensors?

- Fluorescence quenching (ON-OFF)
- Fluorescence increase (OFF-ON)
- Emission spectrum shape modification (ratiometric)
- Life-time
- Emission anisotropy

Intrinsic Chemosensor



Design: the donor atoms for the complexation of the substrate are part of the fluorophore system, therefore the analyte binds to a receptor subsite which is an integrated part of the fluorophore aromatic system.

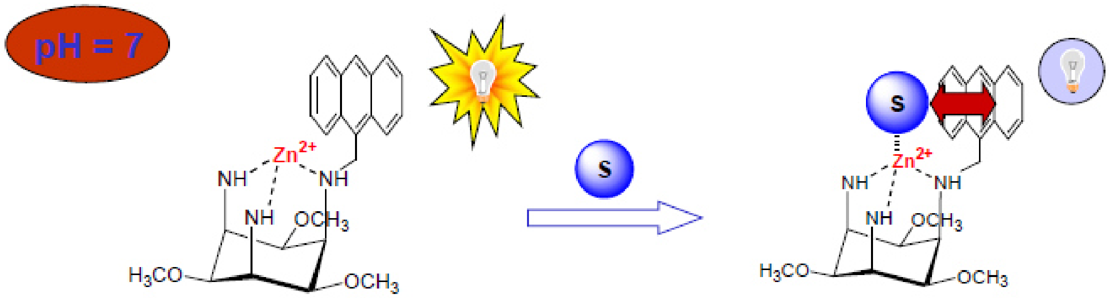
Advantage: the direct interaction between the bound substrate and the fluorophore automatically leads to the modification of the emission properties. The transduction mechanism is somehow intrinsic to the chemosensor structure.

Weakness: rigidity of the design. They have to be designed around the substrate and any modification of the binding site may results in a change of the emission properties of the dye and *vice versa*.

Self-Assembled Chemosensors: ATMCA·Zn(II) (Organic Anions)

ISSN (Online) : 2348 - 2001

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)



A organic substrate (anions) may bind to the Zn(II) ions forming a ternary complex. If the substrate is able to interact with the fluorophore this may result in the quenching of the fluorescence emission.

Single-wavelength excitation ratiometric zinc chemosensors: The signal derived from a fluorescence microscopy image of a cell stained with a zinc-specific chemosensor allows the determination of the presence of zinc. Relative emission increases can reasonably be correlated with increases of [Zn2 +] free but the fluorescence quantum yield of the sensor is in most cases solvent dependent. Since the solvent properties of the local environments in which the sensors accumulate are not known, the absolute emission measured cannot be correlated directly with the concentration of zinc. However, the measurement of absolute [Zn2+] free can be achieved by using a ratiometric sensor.

In the host guest chemistry the term chemosensor is more closely associated with a molecular event. Sensor is a system that on stimulation by any form of energy undergoes change in its own state and thus one or more of its characteristics. This change is used to analyze the stimulant both qualitatively and quantitatively. The optical and photo-physical changes in a molecule are found more valuable in this regard. These receptor molecules exhibit selective response to specific ions or neutral species to be used as chromosensors. An appropriate definition of a chemical sensor is the “Cambridge definition” Chemical sensors are miniaturized devices that can deliver real time and on-line information on the presence of specific compounds or ions in even complex samples. Chemical sensors employ specific transduction techniques to yield analyte information. The most

ISSN (Online) : 2348 - 2001

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

widely used techniques employed in chemical sensors are optical absorption, luminescence, redox potential etc. but sensors based on other spectroscopies as well as on optical parameters, such as refractive index and reflectivity, have also been developed.

Various neutral and ionic species find widespread use in physiology, medical diagnostics, catalysis and environmental chemistry. As cations and anions are prevalent in both heavy industry and in farming and as such in the environment, chemosensors are beginning to find many applications more so because the role of ions is being better understood now. Different cations such as Ag^{+}, Cu^{2+}, Co^{2+}, Hg^{2+} etc. are relevant in different fields. Just to cite a few examples, Ag^{+} is useful in radio-immunotherapy and photographic technology. It inhibits the growth of bacteria and fungi and reduces the risk of bacterial and fungal infection and also finds use in cancer immunotherapy, deodorizing clothes and agricultural sterilizing agent. Hg^{2+} causes environmental and health problems. A wide variety of symptoms are observed upon exposure including digestive, kidney and especially neurological diseases. The level of this ion is therefore an object of strict regulation and should not exceed 1 $\mu g\ L^{-1}$. Cobalt is an essential element, required for the coenzyme vitamin B_{12} and also believed to be cardiotoxic and may cause lung damage. Copper is necessary for the growth, development, and maintenance of bone, connective tissue, brain, heart and many other body organs. It is involved in the formation of red blood cells, the absorption and utilization of iron and the synthesis and release of life-sustaining proteins and enzymes. These enzymes in turn produce cellular energy and regulate nerve transmission, blood clotting and oxygen transport. It stimulates the immune system to fight infections, repair injured tissues and promote healing. It also helps to neutralize "free-radicals" which can cause severe damage to cells. Similarly in case of anions few examples may include chloride sensing which is now being used for environmental monitoring. Chloride ion measurements can aid the monitoring of landfills for leaks, tracing the movement of pollutants within a natural water body and detection of salt water intrusion into drinkable ground or surface waters. The monitoring of nitrate levels is used to trace pollution from agriculture (nitrate fertilizers), for checking fish farms and other aquaculture for waste build-up and for surveying nutrient levels in natural water bodies. The excess of fluoride can lead to fluorosis which is fluoride toxicity and results in increase in bone density. The F^{-} ion is important in clinical treatment for osteoporosis and detection of fluoride

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

toxicity resulting from over accumulation of F- in bone. There are many anions either used as, or are the products of, the degradation or hydrolysis of chemical warfare agents for example fluoride, which is the decomposition product of Sarin gas found in many nerve agents.[7] Cyanide is highly toxic to animals any type of release into the environment can lead to serious problems.[8,9] But it is used in various industrial processes, including gold mining and electroplating, production of organic chemicals and polymers, such as nitriles, nylon, and acrylic plastics enhancing the chance of unwanted release.

From the above it is clear that detection of ions is vital as many industrial and agricultural processes can lead to the release of ions to the environment, if left unchecked these can have devastating effects. A major research effort is being focused towards finding inexpensive, reliable and simple ways of detecting ions in solution. Therefore finding new selective ion receptor systems is an important goal which involves sensor development, environmental remediation, selective separation and extraction of chemical species. The future envisages that greater interest and legal requirements for environmental, food and water monitoring will increase the need of detection of anionic species, selectively at more and more lower concentrations.

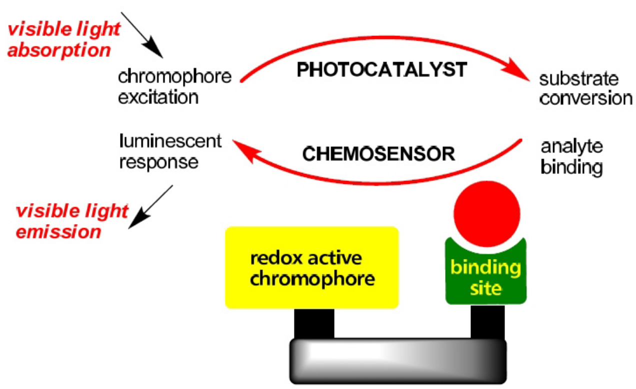


Figure 1: Photocatalyst and Chemosensor

Components

Design of the chemosensors consist of three components as shown; a chemical receptor capable of recognizing the guest of interest usually with high selectivity; a transducer or signaling unit

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

which converts that binding event into a measureable physical change and finally a method of measuring this change and converting it to useful information.

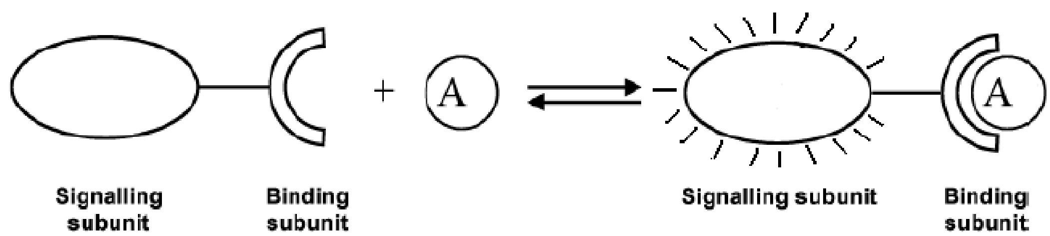


Figure 2. Binding of an analyte (guest) by a chemosensor (host), producing a complex with altered optical properties.

Depending on the type of signals produced on the binding event, sensors may be put into two categories; Electronic sensors or Optical sensors. The former produce signals in the form of changes in the electrochemical properties whereas the latter bring changes in the optical properties.

The Electronic Sensors are mainly categorized into five categories.

1. Ion-Selective Electrodes (ISEs)
2. Field-effect transistors (FETs)
3. Electroactive Sensors
4. Biosensors
5. Microelectrodes

Ion Selective Electrodes (ISEs) are used to measure some of the most critical analytes on clinical laboratory and point-of-care analysers. These analytes which include Na^+, K^+, Cl^-, Ca^{2+}, Mg^{2+} and Li^+ are used for rapid patient care decisions. Although the electrodes are very selective, they are not free of interferences. It is important for laboratories to have an understanding of the type and extent of interferences in order to avoid incorrect clinical

ISSN (Online) : 2348 - 2001

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

decisions and treatment. Immunosensors are analytical platforms that detect specific antigen-antibody interactions and play an important role in a wide range of applications in biomedical clinical diagnosis, food safety, and monitoring contaminants in the environment. Field-effect transistors (FET) immunosensors have been developed as promising alternatives to conventional immunoassays, which require complicated processes and long-time data acquisition. The electrical signal of FET-based immunosensors is generated as a result of the antigen-antibody conjugation. FET biosensors present real-time and rapid response, require small sample volume, and exhibit higher sensitivity and selectivity.

A biosensor is an analytical device, used for the detection of an analyte, that combines a biological component with a physicochemical detector. The sensitive biological element (e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc.) is a biologically derived material or biomimetic component that interacts (binds or recognizes) with the analyte under study. The biologically sensitive elements can also be created by biological engineering. The transducer or the detector element (works in a physicochemical way; optical, piezoelectric, electrochemical, etc.) transforms the signal resulting from the interaction of the analyte with the biological element into another signal (i.e., transduces) that can be more easily measured and quantified. The biosensor reader device with the associated electronics or signal processors that are primarily responsible for the display of the results in a user-friendly way. This sometimes accounts for the most expensive part of the sensor device, however it is possible to generate a user friendly display that includes transducer and sensitive element (holographic sensor). The readers are usually custom-designed and manufactured to suit the different working principles of biosensors. Microfabrication techniques and, in particular, complementary-metal-oxide-semiconductor (CMOS) technology have been used to devise chemo/biosensors as well as bioelectronic microsystems. Examples of micromachined bio- or chemosensors, such as cantilevers or micoelectrode arrays, will be shown, and the electrical interfacing of CMOS microelectronics with biological entities or electrogenic cells, i.e., cells that react upon electrical stimulation

International Refereed Journal of Reviews and Research
Volume 3 Issue 5 September 2015
International Manuscript ID : 23482001V3I5092015-02
(Approved and Registered with Govt. of India)

and, in turn, produce electrical signals (heart cells or neurons) are detailed. CMOS-based, fully integrated microelectrode arrays for bidirectional communication (stimulation and recording) with electrogenic cells are presented. These devices are capable of monitoring relevant electrophysiological responses of cells to electrical stimuli or to pharmacological agents with prospective applications in the field of bio-inspired information processing or pharmascreening.

Conclusion

Among the diverse sorts of sensors, optical sensors have greatly promising future. Since the diverse cations or anions are the fundamental bit of the biological, sustenance and water, so their affirmation and particular removal with high affectability (affirmation at cut down obsessions up to µm level) shapes a basic bit of engineered examine. The particular issues in the delineating of these sensors ought to be vanquished, which consolidate the going with examinations. The sensor expected for the molecule affirmation should be unfaltering, having satisfactory lifetime and the ability to work in water and the low affectability to the specialist pH are basic under customary conditions. The sensors being able to distinguish/see the diverse analytes in high-effect and liquid medium are particularly required. On the other hand to deal with the issue of sensor lifetime is to avoid it absolutely by using each sensor once. From this time forward the arrangement and amalgamation of unobtrusive and unimportant sensor, for instance, nonessential sensor strips or nanoparticle based optical globules astoundingly needed. These strips or spots indicate basic shading changes inside seeing particular molecule course of action. The optical sensors demonstrate high selectivity for a particular molecule inside seeing distinctive particles of tantamount nature. The arrangement and mix of sensors that can recognize little groupings of the molecule of energy for the closeness of other intruding particles is of broad premium.

References

[1] Xiang Y, Tong A, Jin P, Ju Y. New fluorescent rhodamine hydrazone chemosensor for Cu (II) with high selectivity and sensitivity. Organic Letters. 2006 Jun 22;8(13):2863-6.

[2] Xiang Y, Tong A. A new rhodamine-based chemosensor exhibiting selective FeIII-amplified fluorescence. Organic Letters. 2006 Apr 13;8(8):1549-52.

[3] Coskun A, Akkaya EU. Ion sensing coupled to resonance energy transfer: a highly selective and sensitive ratiometric fluorescent chemosensor for Ag (I) by a modular approach. Journal of the American Chemical Society. 2005 Aug 3;127(30):10464-5.

[4] Xu Z, Qian X, Cui J. Colorimetric and ratiometric fluorescent chemosensor with a large red-shift in emission: Cu (II)-only sensing by deprotonation of secondary amines as receptor conjugated to naphthalimide fluorophore. Organic letters. 2005 Jul 7;7(14):3029-32.

[5] Kim SK, Bok JH, Bartsch RA, Lee JY, Kim JS. A fluoride-selective PCT chemosensor based on formation of a static pyrene excimer. Organic letters. 2005 Oct 27;7(22):4839-42.

[6] Zhao Y, Zhang XB, Han ZX, Qiao L, Li CY, Jian LX, Shen GL, Yu RQ. Highly Sensitive and Selective Colorimetric and Off− On Fluorescent Chemosensor for Cu2+ in Aqueous Solution and Living Cells. Analytical Chemistry. 2009 Jul 27;81(16):7022-30.

[7] Chen CT, Huang WP. A highly selective fluorescent chemosensor for lead ions. Journal of the American Chemical Society. 2002 Jun 5;124(22):6246-7.

[8] Gunnlaugsson T, Leonard JP, Murray NS. Highly selective colorimetric naked-eye Cu (II) detection using an azobenzene chemosensor. Organic letters. 2004 May 13;6(10):1557-60.