Electrochemical sensors

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What is a Sensor??

A sensor is a device that measures a physical quantity and converts into a signal which can be read by an observer or by an instrument.

The signal produced by the sensor is equivalent to the quantity to be measured.

The origin of the word sensor comes from the Latin sentire, it means *to feel*.

Classification of sensors

Basically, the sensors are classified into active and passive sensors.

Active sensors

Sensors that require power supply are called as active Sensors.

Examples: Electrochemical sensors, and digital clinical devices (Glucometer, pulse meter etc.,)

Passive sensors

Sensors that do not require power supply are called as Passive Sensors.

Example: Hg thermometer, non-digital sphygmomanometer, and disposable pregnancy test kit etc.,

Electrochemical sensors

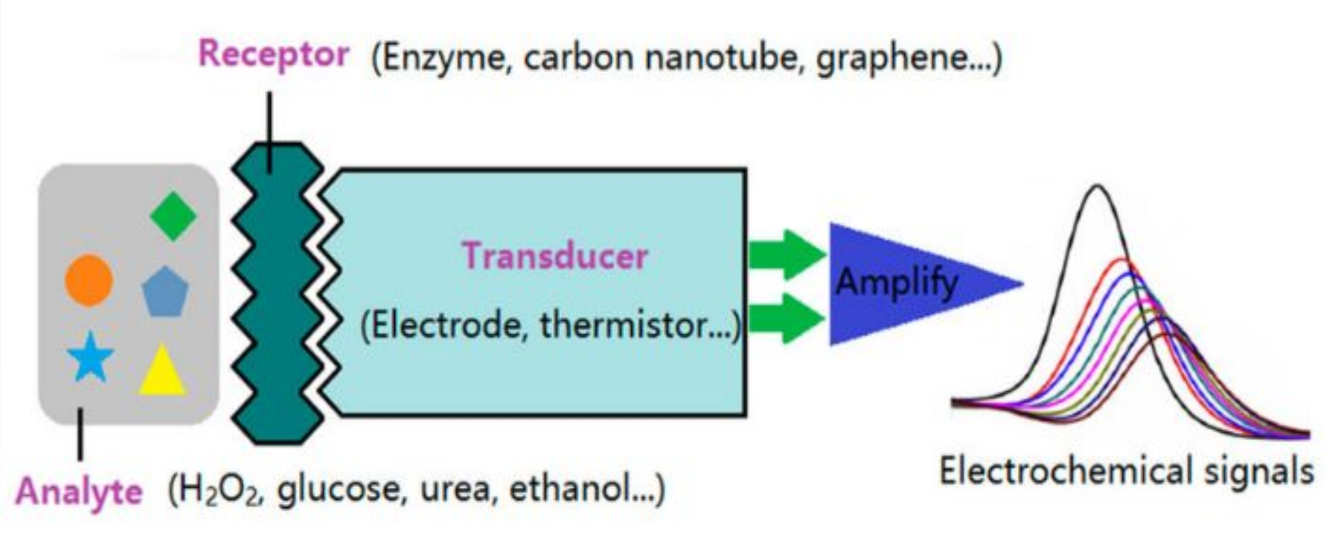
According to IUPAC, an electrochemical sensor is defined as "a self-contained integrated device, which is capable of providing specific quantitative or semi-quantitative analytical information"

OR

a device, that convert the information associated with electrochemical reactions (the reaction between an electrode and analyte) into an applicable qualitative or quantitative signal.

Electrochemical sensors are based on the measurement of changes in current, potential, conductance due to the interaction of the target molecule with the electrode materials on the sensing surface.

Principle of Electrochemical sensors



- **The electrochemical sensor consists of transducer component covered by recognizer component (receptor). The recognizer element chemically interacts with analyte and signal is generated. The electrochemical transducers transform the chemical signal into electrical signals.**
- **The increase/decrease in current/potential/resistance will be directly proportional to the concentration of analyte.**

Classification of electrochemical sensors

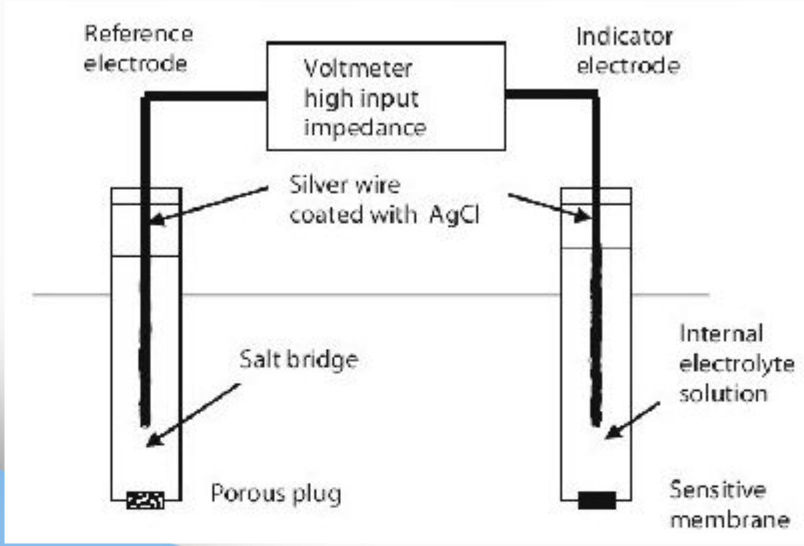
The electrochemical sensors are mainly divided into three types:

1. **potentiometric,**
2. **conductometric, and**
3. **amperometric/voltammetric.**

Potentiometric sensors:

The potentiometric sensor measures the potential of working or indicator electrode (Pt) by coupling with secondary reference electrode (SCE or Ag/AgCl).The potential of the working electrode will be dependent on a particular analyte and its concentration in the solution.

Eg. Ion selective electrodes (Glass electrode) and Potentiometers used in potentiometric titrations (Potentiometric titration of FAS versus $K_2Cr_2O_7$).



Conductometric sensors:

These sensors measure the conductivity of the medium, which is directly related to the amount of particular ions present in the medium.

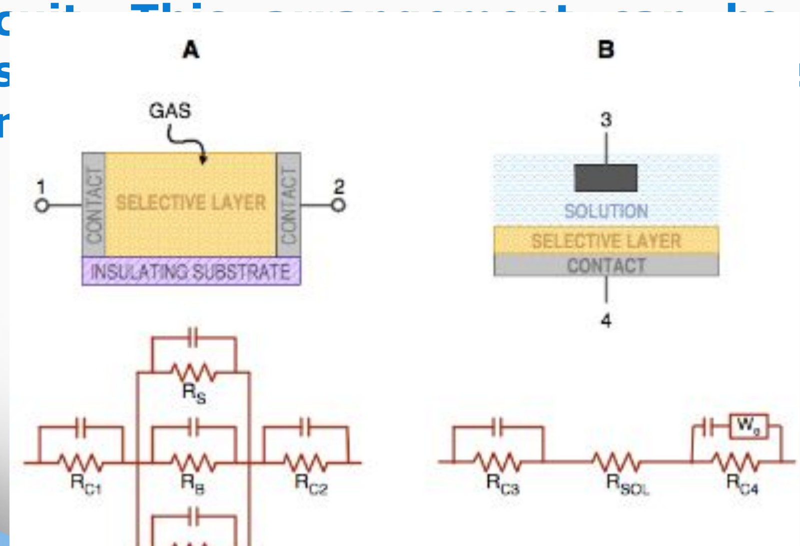
This is based on modulation of resistivityThis is based on modulation of resistivity of the selective material. Because the reciprocal of resistivity is conductivity, these sensors are interchangeably called conductometric sensors or chemiresistors.

Eg. Gas sensors and Conductivity meters used in conductometric titrations (Eg. Conductometric titration of Acid mixture versus strong base).

These sensors are in two main formats:

In the first one (A), some material which can change its conductivity upon interaction with a chemical species is clamped between two contact electrodes and the resistance of the entire device is measured. Such arrangement is typical for chemiresistors, used for sensing in gases.

In the second version (B), the chemically interactive layer is at the top of an electrodeIn the second version (B), the chemically interactive layer is at the top of an electrode, which is immersed in the solution of electrolyteIn the second version (B), the chemically interactive layer is at the top of an electrode, which is immersed in the solution of electrolyte. A suitable counter-electrode is provided that completes the electrical circ … typically found in various biosensors … esponse is obtained due to biological ir



Amperometric/voltammetric sensors:

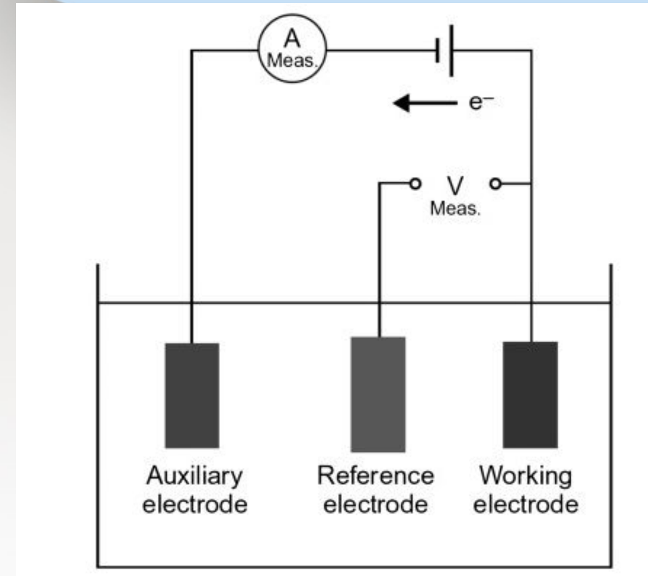
- Amperometric sensors are sensitive analytical systems that measure current as a result of an electroactive substance that loses (oxidation) or gains (reduction) an electron while undergoing an electrochemical reaction.
- These sensors measures the current between working/indicator and reference electrode which will be directly proportional to the the concentration of the species that is oxidised or reduced.
- This works on the basis of Ohm's Law.
- The redox process at the electrodeThe redox process at the electrode represent charge transfer reactions that can proceed in either direction (oxidation or reduction) each with its own velocity.
- Those velocities relate to the value of the charge transfer resistance of the redox reaction.
- Some electrochemical reactions proceed very fast in both directions and their charge transfer resistance is very low. We call such reactions "reversible".
- On the other hand some reactions are very slow and their charge transfer resistance is very high. We call such electrode reactions "irreversible".
- Thus, the relative speed of an electrochemical reaction can be related to its equivalent charge transfer resistance.

The electrochemical cell set up, with voltammetric sensors consists of

i) working electrode (e.g. GCE, acts as the transducing element)

ii) auxiliary/counter electrode (e.g. Pt electrode, acts to complete the circuit)

iii) reference electrode (e.g. Ag/AgCl electrode, used to establish a stable potential).



Advantages of electrochemical sensors

The electrochemical sensors have several advantages like,

- **simple,**
- **low cost,**
- **portable,**
- **rapid,**
- **no sample pretreatment involving tedious steps are required,**
- **highly sensitive and selective,**
- **possess lower detection limits (LODs) and**
- **very quick with respect to analysis time in real samples**

Applications of electrochemical sensors

The range of applications where electrochemical sensors are in use are:

- gas sensors, such as those used in homes to detect CO,
- heavy metal sensors for water quality analysis (arsenic, cadmium, nickel, mercury, chromium, zinc, and lead),
- pH (H^+ ion monitoring),
- biosensors used for monitoring glucose, cholesterol, urea, enzymes, proteins, amino acids etc.,
- hydrocarbon, alcohol, and ketone sensors for measuring motor oil degradation,
- to detect the presence of toxic gases such as H_2S, Cl_2, and SO_2, and variation of oxygen in the air,
- Pharmaceutical compositions etc.,..


THANK YOU