

## Examples of Solid & Liquid ISEs

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The objective is to understand the various examples of Solid and Liquid Ion-Selective Electrodes.

### Solid Ion-Selective Electrodes

#### 1. pH Electrode (Glass Membrane Electrode):

- **Measures:**  $\text{H}^+$  ion concentration (pH).
- **Membrane:** Silicate glass membrane.
- **Applications:** Used in environmental monitoring, industrial processes, and biochemistry (e.g., enzyme activity measurement).
- **Advantages:** Highly accurate, widely applicable in aqueous solutions.
- **Reactions:**
$$\text{H}^+(\text{aq}) + \text{Glass membrane surface} \leftrightarrow \text{H}^+ \text{ adsorbed}$$
- **Challenges:** Requires frequent calibration, affected by high temperature and dehydration.
- **Interesting fact:** The pH electrode has been pivotal in both simple lab analyses and advanced industrial processes.

#### 2. Fluoride Electrode ( $\text{LaF}_3$ Crystal Electrode):

- **Detects:**  $\text{F}^-$  ions.
- **Membrane:**  $\text{LaF}_3$  crystal doped with europium.
- **Applications:** Water treatment, dental research, and industrial fluoride monitoring.
- **Advantages:** Extremely selective for fluoride ions.
- **Reactions:**
$$\text{LaF}_3(\text{s}) \leftrightarrow \text{LaF}_2^+(\text{s}) + \text{F}^-(\text{aq})$$
- **Challenges:** Interference from hydroxide ions ( $\text{OH}^-$ ) at high pH, requires careful maintenance of solution pH.

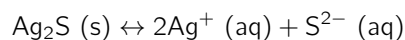
#### 3. Sodium Electrode (Glass Membrane Electrode):

- **Sensitive to:**  $\text{Na}^+$  ions.
- **Membrane:** Silicate glass.
- **Applications:** Clinical diagnostics, especially monitoring sodium levels in blood (important for heart and kidney function).
- **Advantages:** Good selectivity for sodium ions.
- **Reactions:**
$$\text{Na}^+(\text{aq}) + \text{Glass membrane} \leftrightarrow \text{Na}^+ \text{ absorbed}$$
- **Challenges:** Requires regular calibration and precise temperature control.
- Sodium ISEs have greatly improved treatments of electrolyte imbalances in critical care.

#### 4. Silver/Sulfide Electrode ( $\text{Ag}_2\text{S}$ Membrane):

- **Detects:**  $\text{Ag}^+$  or  $\text{S}^{2-}$  ions.
- **Membrane:** Silver sulfide ( $\text{Ag}_2\text{S}$ ).
- **Applications:** Silver refining, detection of sulfide ions in wastewater.
- **Advantages:** High sensitivity to both silver and sulfide ions.

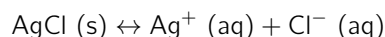
- **Reactions:**



- **Challenges:** May suffer interference from chloride ions, sensitive to high ionic strength solutions.

#### 5. Chloride Electrode (AgCl Membrane):

- **Measures:**  $\text{Cl}^-$  ions.
- **Membrane:** Silver chloride (AgCl).
- **Applications:** Used in monitoring seawater salinity, physiological chloride levels in blood and urine.
- **Advantages:** Reliable and selective for chloride ions.
- **Reactions:**



- **Challenges:** Calibration is difficult in highly saline solutions.

## Liquid Ion-Selective Electrodes

#### 1. Calcium Electrode (Liquid Membrane with Phosphoric Acid Diester):

- **Detects:**  $\text{Ca}^{2+}$  ions.
- **Membrane:** Liquid ion-exchanger with aliphatic diesters of phosphoric acid.
- **Applications:** Biological fluid analysis (e.g., calcium levels in blood, essential for bone health).
- **Advantages:** High selectivity for calcium ions.
- **Reactions:**



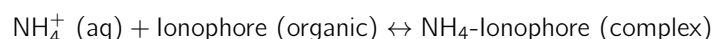
- **Challenges:** Prone to interference from magnesium ions in complex samples.
- **Interesting fact:** Calcium is crucial for muscle contraction, including the heart, making this electrode important in cardiology.

#### 2. Potassium Electrode (Valinomycin-Based Polymer Membrane):

- **Measures:**  $\text{K}^+$  ions.
- **Membrane:** Polymer-based with valinomycin as the ionophore.
- **Applications:** Widely used in clinical diagnostics for potassium level determination, critical in electrolyte balance.
- **Advantages:** Highly selective for potassium ions.
- Valinomycin selectively binds to  $\text{K}^+$  due to its molecular size, forming a stable complex.
- **Challenges:** Susceptible to interference from  $\text{NH}_4^+$  ions in certain samples.
- **Interesting fact:** In the U.S. alone, nearly 200 million blood potassium measurements are conducted annually using this electrode.

#### 3. Ammonium Electrode (Liquid Membrane with Ionophore):

- **Detects:**  $\text{NH}_4^+$  ions.
- **Membrane:** Liquid ionophore dissolved in an organic solvent.
- **Applications:** Common in water treatment, monitoring ammonia in agricultural runoff.
- **Advantages:** Good selectivity for ammonium ions, useful in environmental studies.
- **Reactions:**



- **Challenges:** Potential interference from potassium ions in some biological samples.

#### 4. Nitrate Electrode (Liquid Membrane with Organic Solvent):

- **Sensitive to:**  $\text{NO}_3^-$  ions.

- **Membrane:** Organic ion-exchanger in liquid membrane.
- **Applications:** Used in soil testing and water quality monitoring, particularly for nitrate pollution.
- **Advantages:** High sensitivity for nitrate ions.
- **Reactions:**

$$\text{NO}_3^- (\text{aq}) + \text{Ion-exchanger (organic)} \leftrightarrow \text{NO}_3\text{-exchanger (complex)}$$
- **Challenges:** Nitrate interference from other anions like chloride, sensitive to pH variations.
- **Interesting fact:** This electrode plays a crucial role in preventing harmful algal blooms by monitoring nitrate levels.

## References

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