Ion selective electrode (ISE)

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Introduction

• Ion selective electrode (ISE) is an analytical technique used to determine the activity of ions in aqueous solution by measuring the electrical potential.
• Specific ion dissolved in a solution create an electrical potential, which can be measured by a voltmeter or pH meter.
• The strength of this charge is directly proportional to the concentration of the selected ion.
Principle

- ISE consists of a thin membrane
- Only specific ion can be diffuse.
- By measuring the electric potential generated across a membrane by “selected” ions, and comparing it with reference electrode.
- And net charge is determined.
Potentiometry

- **Potentiometry**
  - Use of Electrodes to Measure Voltages that Provide Chemical concentration

- **Indicator Electrode:**
  - Electrode that responds to analyte

- **Reference Electrode:**
  - Second ½ cell at a constant potential

- Cell voltage is difference between the indicator and reference electrode
Reference Electrode

Silver-Silver Chloride Reference Electrode

\[ \text{AgCl}(s) + e^- \rightleftharpoons \text{Ag}(s) + \text{Cl}^- \]
Types of ISE

- Glass membrane
- Solid state electrode
- Liquid based electrode
- Compound electrode
Glass Membrane Electrode

- This method uses the electrical potential of pH-sensitive electrodes as a measurement signal.
- The glass electrode is the most commonly used sensor.
- Not having the disadvantages of the optical methods, it can be used almost universally.
Solid State Electrode

- Electrode body of Inorganic crystalline polymer.
- E.g. Special Epoxide Resin with excellent mechanical properties.
- High temperature stability.
Liquid based electrode

- Formed by a very thin layer of an organic liquid.
- Membrane is like jelly
- Impermeable to water
- Only to allow to pass certain ion.
- Organic material
  - Carbon tetrachloride
  - Benzene
  - Mesitylene
Compound electrode

- Electrode have membrane of multiple type
Electrolytes

- Type of ions
  - Cations – Positive charge
    - move toward the cathode
      - Na\(^+\) = Extracellular – Brain Activity
      - K\(^+\) = Intracellular – Heart & Muscle
      - Ca\(^+\) = Extracellular – Heart & Muscle
      - H\(^+\) = Extracellular - Acidic
  - Anions – Negative charge
    - move toward the anode
      - Cl\(^-\) – Extracellular
      - HCO\(_3\) – Extracellular - Basic
Sample Collection

• Serum
  • Collected in heparin bulb
  • Plain
  • EDTA can not be use for doing electrolyte
    • EDTA is chelating agent & anti-coagulant.
    • It chelat with all ions of blood
    • So interfere with concentration of ions

• Urine
  • Collected in plain vacuette
Types of Heparin vacuette

- Ammonium
- Lithium = Lithium+ heparin
- Sodium= Sodium+ heparin

For measure the sodium

- lithium heparin vacuette
- ammonium heparin vacuette

Use of sodium vacuette gives false high sodium concentration.
Routinely measured electrolytes

Sodium
- (90%) Major cation
- Extracellular fluid **outside cells**

Normal values
- Serum = 135-145 mEq/L
- Urine (24 hr) = 40-220 mEq/L

Functions
- Influence on regulation of body water
- Osmotic activity
- Central - Neuromuscular activity
Hyponatremia

- Hyponatremia <135 mEq/L
  - Increased Na+ loss
  - Causes
    - Diabetes mellitus
    - Diabetic Ketoacidosis
      -- Because of diuresis
    - Severe diarrhea & Severe Vomiting
Hypernatremia

- Excess water loss resulting in dehydration (relative increase)
  - Dehydration from inadequate water intake
  - Dehydration due severe diarrhea
  - Diabetes insipidus
  - Burns
Potassium (K)

- (2%) major cation
- Intracellular fluid inside cell

Normal value

- Serum - 3.5-5.3 mEq/L
- Urine - 25-125 mEq/L

Function

Heart muscle contraction

Increase or Decrease K+ = Arrhythmiasis
Hypokalemia

- Hypokalemia = a low level of potassium (K⁺) in the blood serum.
- Diarrhea
- Medications like furosemide (diuretic)
- Dialysis
- Diabetes insipidus
- Hyperaldosteronism
Hyperkalemia

- Increased K concentration

- Causes
  - Acute Renal failure
  - Chronic Renal failure
  - Acidosis (Diabetes mellitus)
    - H+ competes with K+ to get into cells & to be excreted by kidneys
    - Decreased insulin promotes cellular K loss
    - Hyperosomolar plasma (from ↑ glucose) pulls H₂O and potassium into the plasma.
ELECTROLYTE SHIFTS

**Acidosis**
Compensatory Response

- $\text{H}^+$ buffered intracellularly
- Hyperkalemia

**Alkalosis**
Compensatory Response

- Tendency to correct alkalosis
- Hypokalemia
Chloride (Cl⁻)

Chloride
   Major cation
   Extracellular fluid
Normal value
   - Serum – 100-110 mEq/L
   - 24 hour urine – 110-250 mEq/L
      varies with intake
   - CSF – 120-132 mEq/L
Hypochloremia

Same as Hyponatremia

- congestive heart failure
- Severe diarrhea
- Severe vomiting
- drugs such as
  - Laxatives
  - diuretics
  - corticosteroids
  - Bicarbonates.
Hyperchloremia

• Same as Hypernatremia
• Increased serum Cl
  – dehydration
  – renal tubular disease
  – metabolic acidosis
Advantages

1. Good Linearity
2. Good precision
3. Less chance of damage
4. No consumption require
5. Non-contaminating.
7. Less interference from serum color & turbidity.
Limitations

1. Electrodes can be blocked by proteins.
2. Interference by other ions.
3. Electrodes are fragile.
4. Limited electrode life – 3 to 4 months.
Application of ISE

- Electrolyte
  - Sodium
  - Potassium
  - Calcium
  - Lithium
  - Iodine
  - Magnesium
  - Chloride
  - Fluoride

- Glucose

- Urea

- Arterial Blood Gas Analysis
  - pO2
  - pCO2
  - pH
  - HCO3-