# Rapid Inexpensive Measurement of Iodide in Urine Samples

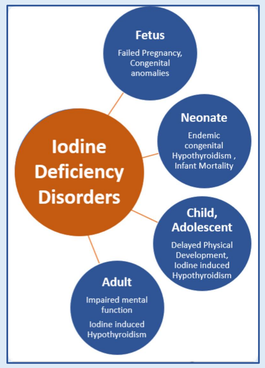
Joisha Girme, Purnendu K Dasgupta

University of Texas at Arlington , Department of Chemistry and Biochemistry

## Introduction

Iodine is essential to all mammalian life; it is a crucial element for the human body to synthesize thyroid hormones. Insufficient intake may lead to Iodine Deficiency Disorders (IDD) that initially manifests itself by the enlargement of the thyroid gland. Despite its pivotal role, population-wide Iodine intake is inadequate in many countries, iodized salt is assumed to address this issue. However, in the US, only 20% of the salt we consume is iodized.

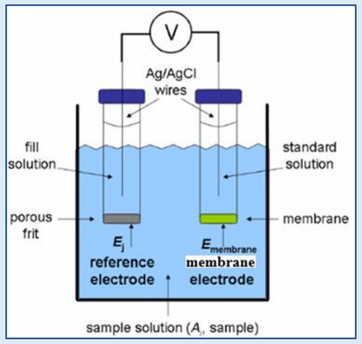
| Adults and School aged children | |
|---|---|
| **Iodine concentration (µg/L)** | **Sufficiency** |
| **<20** | severe defficiency |
| **20-49** | moderate defficiency |
| **50-99** | mild defficiency |
| **100-199** | Adequate |
| **200-299** | More than adequate |
| **>300** | Excess |
| **Pregnant Women** | |
| **Iodine concentration (µg/L)** | **Sufficiency** |
| < 150 | Deficient |
| 150-249 | Adequate |
| 250-499 | Above requirements |
| >500 | Excess |
| **Lactating Women and children aged <2 years** | |
| **Iodine concentration (µg/L)** | **Sufficiency** |
| < 100 | Insufficienct |
| ≥100 | Adequate |




A particular concern centers on the health of pregnant women as well as the neurodevelopment of the fetus and then the infant. A substantial fraction of pregnant women have been reported to be iodine deficient and about 47 % of lactating mothers may not be providing their infants with adequate iodine.

Iodine nutrition is typically measured through urinary iodine excretion. While ICP-MS is presently considered the gold standard for this measurement, there is clearly a need for routine in-office iodine measurement by obstetricians and pediatricians.

## Ion Selective Electrodes




$$E_M = E_s - E_{ref} = - S * \log [I^-]$$

$E_s$ : Sensing electrode

$E_{ref}$, (a constant) : Reference electrode

S: Nernstian slope, 2.3RT/nF ~ 59 mV/ decade for monovalent ion

F: Faraday's Constant, n = Number of electrons transferred

| Composition of Normal Urine | |
|---|---|
| **Constituents** | **Amount present** |
| **Water** | 95% |
| **Urea** | 9.3 to 23.3 gram/liter |
| **Chloride** | 1.87 to 8.4 gram/liter |
| **Sodium** | 1.17 to 4.39 gram/liter |
| **Potassium** | 0.750 to 2.61 gram/liter |
| **Creatinine** | 0.670 to 2.15 gram/liter |
| **Sulfur** | 0.163 to 1.80 gram/liter |

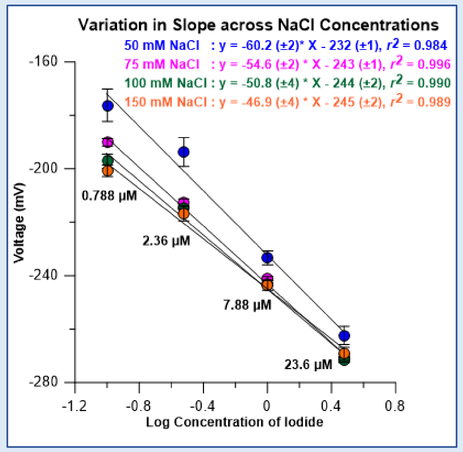
Chloride concentration
53 mM – 237 mM

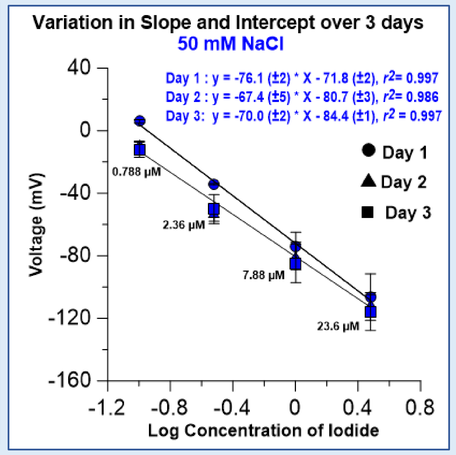
- Chloride is **isomorphous** to Iodide and competes with it at the lattice sites of the sensing membrane.
- In an Iodine deficient person, Iodide is as low as < 100 µg/L ( ~ 1 µM) and can go down to 0.2 µM ( 25.4 ppb).

## Performance of Commercially derived ISE in Varying Chloride Concentrations

**Experimental Method**

- Iodide concentrations ranging from 0.788 - 23.6 µM were measured in the presence of varying concentrations of Chloride (50 – 150 mM).
- Using multiple days of analysis, a two-parameter equation was derived which helps predict the iodide concentration in urine when the Chloride concentrations are known.

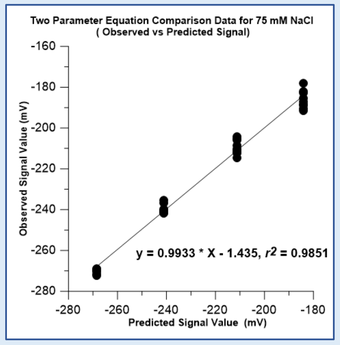



## Deriving a Relationship between Chloride and Iodide Concentration

**Two Parameter Equation**

**y = (0.0679±0.00185*NaCl, mM – 62.2±0.21)* log (I, mg/L) - (0.0135±0.0035)* NaCl, mM -240.1 ± 0.39**



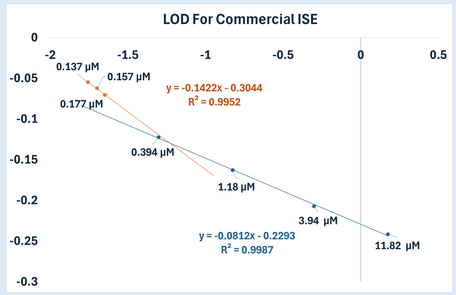

### Takeaway

✓ The observed vs predicted values are in close agreement to one another.

✓ If chloride concentration is known, we can determine a chloride corrected iodide concentration.

## Limit of Detection Determination in Potentiometry

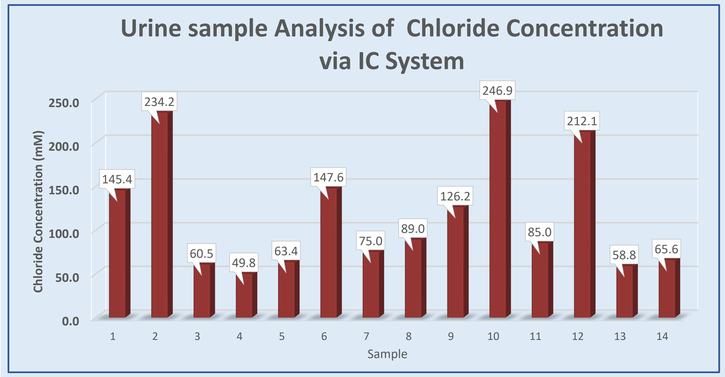
- In ISEs, the response has a fixed linear slope of ideally 59 mV/decade at higher concentrations.
- At lower concentrations, a well-defined part (~ 50 %) of the primary ions are replace by the interfering ion at the sensing membrane of the electrode, thus response to other ions govern the slope.
- The concentration corresponding to the intersection of these lines is considered the LOD.




**Tested out LOD in presence of 50 mM NaCl**
**LOD : 0.433 µM (55 µg/L)**

## Determination of Chloride Concentrations in Spot Urine Samples via Ion Chromatography

- Urine samples were diluted 100-fold prior to being filtered through a cation exchange resin to remove any Compounds that would reduce the functionality of the column.
- Following that the samples were then analyzed for chloride concentration on the Dionex IC25.
- The Population for this study comprised of 14 Individuals.




## Conclusion and Future Works

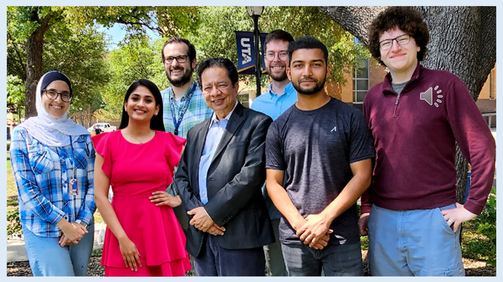
- Make our own AgI electrodes that will have better precision and reproducibility .
- Investigate incorporation of new ionophore combinations to measure low levels of iodide in Urine samples.
- Explore Amperometry and Coulometry as approaches for measuring iodide.

## References

1) https://www.who.int/data/nutrition/nlis/info/iodine-deficiency

2) Özbek, O.; Berkel, C. Recent Advances in Potentiometric Analysis: Paper–Based Devices. *Sensors International* **2022**, *3*, 100189. https://doi.org/10.1016/j.sintl.2022.100189.

## Acknowledgments



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