Development of a Phosphate Biosensor for Soil & Groundwater

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Abstract

Uranium contamination in soil and groundwater sediments is a monumental problem in Hanford, WA. Since phosphate(PO₄³⁻) plays an important role by binding and precipitating uranium in the field, a limited amount of this compound should be injected. In contrast, excess amount of (PO₄³⁻) causes eutrophication (increase in the concentration of chemical nutrients) in the environment. In order to provide the optimum phosphate concentration in the field, continuous field-deployable and reliable (sensitive, accurate) monitoring techniques are crucial. Therefore, an enzyme-linked phosphate sensor is being developed by using advanced materials for enhancing the sensitivity of the existing sensors.

Introduction

Uranium-Phosphate Interaction

Uranium in the environment usually exists in +6 and +4 states. Studies have shown that uranium in the presence of inorganic phosphate (PO₄³⁻) reduces to the +4 state (precipitation), which immobilizes the uranium [1]. The figure below shows the uranium-phosphate interaction.

![Uranium-Phosphate Interaction](image)

Method

In order to develop the sensor, Pyruvate Oxidase (POX) was immobilized on gold-coated polymers and nano-structured advanced materials. The final product of the enzyme-substrate (POX-pyruvate) reaction, hydrogen peroxide (H₂O₂), was measured via electrochemical techniques. As the phosphate solution was added to the reaction cell, the obtained output signal was recorded via amperometry.

The enzyme-substrate reaction is demonstrated below.

![Enzyme-Substrate Reaction](image)

Experimental Setup

A conventional three-electrode electrochemical amperometric method was used to determine the current change which is interpreted to phosphate concentration.

Results

![Results Graph](image)

Conclusions

The low concentration of the [PO₄³⁻] solutions were detected and quantified via using the newly developed enzyme-linked biosensor in our laboratory. Further in situ studies need to be performed to assess if the device is field deployable.

Future Work

Upon successful completion of biosensor, there will be an endeavor towards in situ application and field deployed wireless sensing.

Acknowledgements

Touhidur Rahman, Ph.D., Oak Ridge National Lab.

References