Development of Biosensors for Real Time Analysis of Perchlorate in Water

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Perchlorate (ClO_4) contamination of ground water is a widespread problem in the U.S., which can adversely affect human health and wildlife. We report the development of a highly sensitive method for real time detection ClO_4 detection in water.

Perchlorate (ClO_4^-) contamination of ground water is a widespread problem in the United States, which can adversely affect human health and wildlife. Current methods for detecting and quantifying ClO_4^- in water are time consuming, expensive, and subject to error due to complex procedures and various interferences. Thus, there is an urgent need to develop a method that can accurately detect and measure low concentrations of ClO_4^- in the field.

In the first year of this study (July 2004 to June 2005) we constructed and characterized a biosensor for the rapid determination of ClO_4^- in water by employing a ClO_4^-reductase from a novel perchlorate-reducing bacterium (*Dechloromonas* sp. perc1ace). Using a 3 mm GCE (glass carbon electrode), we successfully constructed a ClO_4^- sensing bio-electrode by coating an aliquot of the enzyme on a nafion (ion-exchange matrix) layer pre-coated on the polished surface of the GCE.

Amperometric [i/t] measurements revealed linear increases in current in relation to time and ClO_4^- concentration. The biosensor responded strongly to ClO_4^- at concentrations as low as 1 μg/L and the sensor displayed a linear response to ClO_4^- concentrations in the range 25 to 100 μg/L. Response time to ClO_4^- at 100 μg/L was approximately 111±28 seconds. Kinetic evaluation of the sensor response to ClO_4^- at 25 to 100 μg/L revealed a first order reaction (r^2 > 99%) with k values of 10.3, 24.2, 33.9 and 48.2 at 25, 50, 75 and 100 μg/L, respectively.

A strong linear correlation was established between biosensor response (nA) and ion-chromatography conductivity readings (μS) in the 25 to 100 μg/L linear domain of the biosensor. Biosensor response to ClO_4^- was maximal at an applied potential range of –0.6 to –1.0V. ClO_4^- reduction current increased with increase in pH and was maximal in the range of 7.6 to 8.0.

The ClO_4^- biosensor displayed excellent stability after repeated use (24 analyses conducted on a single day over a 10-h period at room temperature). Nitrate concentrations below the drinking water regulatory limit (<45 mg/L NO_3^-) did not interfere with ClO_4^- biosensor performance. Analysis of a natural ground water sample collected from the field with the ClO_4^- biosensor and ion-chromatography revealed comparable readings of 418 ± 24 μg/L and 367±9 μg/L, respectively. This study indicates great potential for the development of a potable and field deployable biosensor for real time analysis of ClO_4^- in water.

Publications

Frankenberger, W.T., Development of a Perchlorate Reductase-Based Biosensor for Real Time Analysis of Perchlorate in Water. *Biosensors and Bioelectronics* (submitted).

Collaborative Efforts

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