Low-Cost Electrochemical Arsenic Detection (LEAD): A Novel Quantitative, Portable and Ultra-Sensitive Arsenic Sensor Using Pencil Lead

Rawashdeh, Aseel (School: L C Anderson High School)

Due to its toxic effects, such as heart, neurological, and skin diseases, elevated arsenic in water/soil is the 6th leading cause of nonaccidental death globally. While arsenic filtration technology is accessible, trace arsenic detection remains a significant challenge. Existing arsenic tests, like ICP-MS and colorimetric assays, require expensive laboratory instrumentation or have detection limits above the 10ppb WHO limit. In this work, a novel electrochemical arsenic sensor design was fabricated using graphite pencil-lead (<$0.10/test). Due to advantages like high sensitivity, easy miniaturization, and user-friendly techniques, electrochemical sensors are widely utilized (commercial nitric-oxide and blood-glucose sensors). In this study, square-wave anodic stripping voltammetry (SWASV) is utilized to accumulate arsenic(III) on gold-modified pencil graphite in the preconcentration step, then the oxidation current is measured in the stripping step. After optimization, the sensor demonstrated exceptional sensitivity and linearity, comparable to advanced lab analysis, with one of the lowest detection limits reported in the literature (0.0106ppb,R^2=0.98), likely attributed to its distinctive 3D-geometry. SEM/EDX analysis reveals a full coating of gold-nanostructures (70-200nm), increasing electrochemical surface area. No interference was observed from six heavy metals due to arsenic's unique electrochemical footprint. The sensor showed high reproducibility (RSD=2.98%,n=10) and reusability (RSD=0.56%,n=20), reducing each test cost to <$0.01. The sensor demonstrated high linearity in groundwater and excellent reproducibility in soil (RSD=3.6%,n=10). This research presents a reliable, low-cost, and ultrasensitive field arsenic quantification system for low-resource regions.

Awards Won:
Third Award of $1,000