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DEVELOPMENT OF A LOW-COST GOLD NANOPARTICLE-MODIFIED CARBON FIBRE MICROELECTRODE FOR SENSITIVE DETECTION OF TOXIC ARSENIC(III)

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Arsenic is one of the most toxic elements naturally found on Earth and is introduced into the environment through anthropogenic activities. Among its various forms, inorganic arsenic, particularly As(III), is considered the most toxic. Developing field-portable techniques for measuring arsenic in water and food is crucial in safeguarding human and animal health. Electroanalytical techniques are well-suited for this purpose, offering miniaturisation and lower cost compared to methods such as atomic absorption and emission spectroscopic methods. Modified macroelectrodes incorporating gold nanoparticles and voltammetry have shown promise in quantifying As(III) in aqueous media. However, their lengthy deposition steps limit real-world applications. To address this limitation, a carbon microelectrode, which is commercially available, ranging from $100 to $150, has been fabricated using an inexpensive home-built setup at one-quarter the cost of commercial electrodes. The instrumental setup developed consisted of a nichrome wire, a variable power supply and a vacuum system, enabling the fabrication of microelectrodes by sealing carbon fibre within a glass capillary. The potential applied for sealing the electrode and the sealing time were optimised to obtain a well-sealed electrode. A home-built polishing system was used to expose the electrode surface, cutting with the grit papers (1000, 2000 and 3000) and followed by polishing with alumina powder. The fabricated electrode was characterised using cyclic voltammetry, showing a limiting current of 6.45 nA. Gold nanoparticles were electrodeposited onto the microelectrode within the potential range of –0.5 V to 1.5 V. The number of deposition cycles was optimised to 15, yielding the highest reducible current for As(III). Anodic stripping voltammetry was then employed to construct a calibration curve, giving an R^2 value of 0.96 under optimised conditions of –0.5 V stripping potential and 5 min deposition time. Under these conditions, a detection limit of 10 nM was achieved.

Keywords: Arsenic detection, As(III) toxicity, Carbon fibre microelectrode, Electrochemical sensing, Gold nanoparticle