Nanomaterial Sensing Advantages: Electrochemical Behavior, Optimization and Performance of f-MWCNTs/CS/PB/AuE towards Aluminum Ions (Al^{3+}) in Drinking Water

ABSTRACT

Modern technology has been evolving towards nanotechnology due to the materials that can be transformed and manipulated on micro and nanoscales. In terms of detection, nanomaterials offer substantial sensing advantages, particularly in terms of enhanced sensitivity, synergistic effect, stability and selectivity. The immobilization of nanoparticles could alter the physicochemical properties of the electrode's surface depending on the type of materials synthesized and employed. This research examined the synthesis of multiwalled carbon nanotubes (MWCNTs) and chitosan (CS), as well as the immobilization of Prussian blue (PB) on the surface of a bare gold electrode (AuE). These materials have been reported to have strong electrical conductivity and nanomaterial compatibility. In contrast, aluminum has been described as a replacement for traditional water quality treatment processes, such as chlorination and ozonation. Aluminum concentrations must be monitored despite the use of chemical treatment for water quality. Hence, excessive levels of exposure frequently result in neurotoxic effects including Alzheimer's and Parkinson's disorders. In this experiment, the optimal conditions for f-MWCNTs, CS, PB, and AuE for the detection of Al3+ are phosphate-buffered saline (PBS) (0.1 M, pH 2) with 5 mM Prussian Blue; scan rate = 0.25 Vs^{-1}; accumulation duration = 25 s; and volume = 10 mL (ratio of 4:6). The performance of f-MWCNTs, CS, PB, and AuE was measured between 0.2 and 1 ppm with a correlation coefficient of R2 = 0.9853 (y = 0.0387x + 0.0748). The limit of detection (LOD) of the modified electrode was determined to be 0.002 ppm, with a recovery of 98.66–99.56%. The application of nanoparticles resulted in various advantages, including high conductivity, a simple, less time-consuming preparation technique, and enhanced sensitivity and stability for detecting the lowest concentration of Al^{3+}in drinking water.