A Reusable Electrochemical Aptasensor for the Sensitive Detection of Pb(II) with an Electrodeposited AuNP-Modified Electrode based on the Formation of a Target-Induced G-Quadruplex

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A label-free and reusable electrochemical aptasensor for Pb(II) detection using the G-quadruplex-Pb(II) binding interaction and target-induced strand release is proposed. This strategy is based on the changes in the electrochemical impedance spectroscopy (EIS) results caused by the separable structure of aptamer DNA rich in guanine. Additionally, a controllable gold nanoparticle (AuNP) layer was electrochemically reduced on a glassy carbon electrode (GCE) surface as the modified substrate for aptamer DNA. The AuNPs provided a large surface area and more active sites during immobilization and hybridization, which enhanced the EIS signal. In the presence of Pb(II), the EIS intensity of the aptasensor decreased significantly due to the special interaction between Pb(II) and G4-DNA, which prompted the aptamer to construct a G-quadruplex and caused the two DNA strands to untwist. This untwisting resulted in the release of G4-DNA. The aptamer probe structure of the double strand was then altered to a single strand because of the formation of the Pb(II)-G-quadruplex compound by the binding of Pb(II) on the aptamer. This binding changed the electron transfer kinetics between the surface of the electrode and the aptamer DNA strand, leading to a decrease in the EIS response. Results show that the charge transfer resistance decreased linearly and proportionally to the log function of the Pb(II) concentration from 0.001 to 100 µg/L. Moreover, the developed aptasensor demonstrated a high selectivity toward Pb(II), and the calculated detection limit was 0.0046 nM (S/N = 3), which indicated that our proposed electrochemical aptasensor was capable of Pb(II) detection at a trace level.

Keywords: Electrochemical impedance spectroscopy, biosensor, target-induced strand release, Pb(II) detection, gold nanoparticles, electrochemical aptasensor

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