



Article

Polyethyleneimine-Directed In Situ Gold Deposition on Gallium Nitride Nanoparticles for Enhanced Electrochemical Detection of Erythromycin

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Abstract

Hybrid nanomaterials that integrate surface functionality, colloidal stability, and efficient electron-transfer pathways are highly attractive for improving electrochemical sensing performance. Herein, we report the fabrication and evaluation of polyethyleneimine-functionalized gallium nitride nanoparticles (GaN) decorated with gold nanoparticles (GaN-PEI-Au) as a tunable electrode modifier for enhanced differential pulse voltammetry (DPV) detection of erythromycin. Branched polyethyleneimine was employed as a multifunctional interfacial layer to stabilize GaN dispersions, introduce amine-rich surface chemistry, and enable in situ gold nanoparticle formation at the GaN-PEI. The optimized GaN-PEI-Au material exhibited high colloidal stability, a characteristic Au localized surface plasmon resonance in the ~520–525 nm range, and well-defined Au nanoparticles attached to the GaN surface. When applied as an electrode coating, GaN-PEI-Au significantly enhanced the erythromycin oxidation response compared to bare Au and GaN-PEI interfaces, consistent with synergistic increases in electroactive surface area and interfacial charge-transfer efficiency. Under optimized DPV conditions, GaN-PEI-Au-modified electrodes enabled quantitative erythromycin determination with a linear range of 5 nM–2 µM ($R^2 = 0.990$), sensitivity of $1.32 \times 10^{-3} \mu\text{A nM}^{-1}$, and a limit of detection of 52.5 nM, while maintaining stable baseline behavior during repeated scans. The reported GaN-PEI-Au nanocomposites represent a robust platform for sensitive electrochemical detection of pharmaceutical compounds.



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