Metal-doped Zinc Oxide Nanochip for Surface-Enhanced Raman Spectroscopic Sensing of Opioid in Water

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Opioid abuse is a significant public health problem. Despite over 130 overdose deaths a day and two million Americans with some form of opioid addiction, there are still very few predictive tools available to map and monitor this crisis. In this study, we fabricated silver (Ag) doped ZnO nanoarrays and utilized them as portable, label-free, and efficient surface-enhanced Raman spectroscopy (SERS)-based sensors. ZnO has become popular in biosensor applications due to its excellent electrochemical and optoelectronic properties, low-cost production, versatility, and relative eco-friendliness; however, its potential as an efficient nanoscale plasmonic sensor in liquids has not been well-studied. Our nanochips were synthesized via a custom hydrothermal growth protocol; the resulting structures' geometry, dimensions, and Ag-doping uniformity were then characterized using a Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDAX). We evaluated the nanochips' opioid sensing performance on commercially-available opioid-containing solutions. Specifically, we tested our device on solutions containing oxycodone, a potent and commonly abused opioid. After optimizing key experimental parameters such as ZnO growth size and Ag-ZnO ratio, we grew and dispersed Ag nanoparticles onto the ZnO nanoarray to form the completed sensing platform. Opioid-containing solutions at varying concentrations were tested using SERS to characterize our nanochip's sensitivity and specificity. We demonstrated that our sensor could reliably detect opioid concentrations as low as 0.001 mg/mL, showing that these ZnO nanochips could provide a high-throughput, scalable method for mapping remarkably detailed patterns of drug use and a powerful tool to detect emerging public health threats.

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