Development of a Low-Cost Grating-Based Surface Plasmon Resonance Sensor for Detection of Waterborne Toxins

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The World Health Organization (WHO) states over 2 billion people lack access to safe drinking water, exposing them to heavy metals, pesticides, and microbial toxins that cause cancer and developmental disorders. Surface Plasmon Resonance (SPR) is an optical biosensing technique that enables early toxin detection by identifying nanoscale molecular interactions through refractive index changes at a metal-dielectric interface. Current Grating-based SPR sensors require nanoscale etching, which makes them expensive and limited to specialized laboratories. To address this, a low-cost SPR sensor was developed using commercial optical discs (BD-R, DVD-R, CD-R), which already contain nanoscale gratings. Discs were sputtered with 40-70 nm Ag or Cu films, integrated into a microfluidic flow cell, characterized under front- and back-side illumination using wavelength-modulated spectroscopy and rigorous coupled-wave analysis (RCWA). The results showed (1) Ag-coated discs exhibited sharp and intense resonances, while Cu-coated discs produced broader dips due to higher intrinsic losses. (2) Front-side illumination provided stronger SPR excitation, whereas back-side illumination exhibited a complicated spectrum due to the substrate. (3) BD-R made the most distinct resonances and the closest match between the measured spectra and RCWA simulations. Using front-side silver-coated BD-R sensors showed the highest performance of accurate SPR resonances and confirmed that accessible optical discs can achieve plasmonic detection. This provides a low-cost, portable method for monitoring toxins in aquatic environments, especially regions where limited testing equipment contribute to chronic illness. Future work will enable accurate lead detection and improve portability for on-site testing.

Awards Won:

Third Award of $1,200

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