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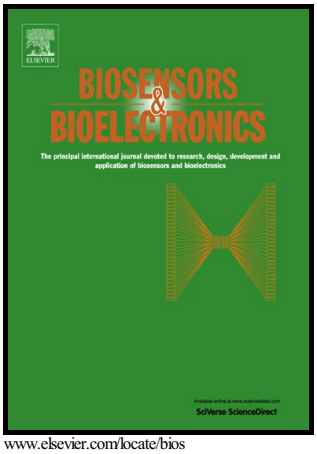


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# A wavelength-modulated localized surface plasmon resonance (LSPR) optical fiber sensor for sensitive detection of mercury(II) ion by gold nanoparticles-DNA conjugates

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Abstract

The study presented herein invesetigated an easy preparation, high performance, wavelength-modulated LSPR optical fiber chemosensor coated by gold nanospheres(AuNS) for $Hg^{2+}$ detection based on thymine-$Hg^{2+}$-thymine base pair mismatches and the coupled plasmonic resonance effect.Utilizing electrostatic self-assembly method, the high density and despersivity monolayer AuNS coated LSPR fiber sensor had the near field refractive index sensitivity up to 2016 nm/RIU. The single-strand probe DNA served as a binding element for free AuNS labelled-target DNA conjugates was attached to the monolayer AuNS by Au-S bond. In the present of $Hg^{2+}$, the coupled plasmonic resonance band between monolayer AuNS and free AuNS was produced by thymine-$Hg^{2+}$-thymine structure and leaded to red-shift of LSPR peak. Under the optimal conditions, the enlarged red-shift in peak of LSPR spectroscopy was linearly with the concentration of $Hg^{2+}$ in the range from $1.0\times10^{-9}$ to $5.0\times10^{-8}$ M with the coefficient of 0.976. The limit of detection was 0.7 nM(S/N=3). The specificity of the sensor was proved high by evaluating the response to other heavy metal ions. The proposed fiber sensor provided a label-free, miniature, low-cost approach for the $Hg^{2+}$ detection and had potential in real environmental evaluations.

**Keywords:**optic fiber sensor; gold nanoparticles; T-$Hg^{2+}$-T; interparticle coupling plasmon resonance; $Hg^{2+}$ detection

## 1. Introduction

Heavy metal pollution has become a global issue because of acute and chronic toxicity to biological organisms(Wu et al., 2006; Li et al., 2010). Due to its trace, grievous injury to human body, widely pollution, $Hg^{2+}$ ion is gaining more and more attention (Li et al., 2008). Therefore, monitoring of $Hg^{2+}$ levels in water is necessary in terms of waste management, environmental analysis, toxicology, water safety and water quality. Currently the traditional detection methods for $Hg^{2+}$ ion mainly include cold atomic fluorescence(Yu et al., 2004), inductively coupled plasma(Mcshane., 2008), cold atomic absorption spectrophotometry(Gil et al., 2006). Although these methods offer high selectivity and sensitivity, they also have the disadvantages of expensive, nonportable, labor-intensive and time-consuming. Therefore, simple, rapid, portable, cost-effective sensor is highly needed. Recently, using peptide(Du et al., 2011), oligonucleotides(Xu et al., 2015),fluorescent indicators(Wang et al., 2016), carbon nanotube(Yao et al., 2016), grapheme(Liu et al. 2017) and other polymers as sensing elements, several methods such as colorimetry(Chen et al., 2014), fluorimetry(Saleem et al., 2017), electrochemistry(Maria et al., 2015), raman spectrometry(Song et al., 2016) for $Hg^{2+}$ detection were proposed. However, most of these methods resulted in limitations of poor specificity to the interference ions, inadequate sensitivity, labelling requirement and high-cost instruments.

Localized surface plasmon resonance (LSPR) phenomenon has its unique advantages in measuring chemical and biological reactions, because of its high sensitivity, label-free, short response time(Mayer et al., 2011). LSPR sensor is based on the phenomenon of the enhanced local electromagnetic fields near the surface of the metal nanoparticles excited by incident light. The LSPR phenomenon, compared to SPP(Surface Plasmon polaritons), has much shorter electromagnetic field decay length, the less influence by temperature fluctuation, the simpler design and the similar detecting sensitivity for the biochemical interaction on the surface of metal nanoparticles(Haes et al., 2004).

$Hg^{2+}$ detection based on LSPR sensors have been developed in the past decade. Currently, the most popular method named colorimetry was based on the aggregate statement of metal nanoparticles in aqueous solution(Du et al., 2013). However, the color-varied method was mainly used for semi-quantitative test since it has the disadvantage of low sensitivity. There are some researches for $Hg^{2+}$ detection using solid phase nanoparticle film. Based on Au/Hg amalgamation, Au nanorods were utilized to detect the concentration of $Hg^{2+}$(Heider et al., 2012). The LSPR spectroscopy of Au nanorods was