Rapid and Sensitive Detection of *Salmonella* Typhimurium using a LSPR Sensor Based on Polydopamine Surface Imprinted Recognition Polymer

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ABSTRACT

Due to its good reproducibility, label-free feature and real-time analysis, the plasmonic nanoparticle-based localized surface plasmon resonance (LSPR) biosensor has attracted a great attention in biodetection. However, the poor chemical/physical stability of the recognition biomaterials, such as antibodies or enzymes, limits its use in harsh environments for in-field applications. We reported here a simple and inexpensive method to address this issue in LSPR by improving the sensing chip with a polydopamine surface imprinted recognition polymer (PDA-SIRP). *Salmonella* Typhimurium was used as a model target of foodborne pathogens. The PDA-SIRP was designed and fabricated by self-polymerization of dopamine (DA) and *S.* Typhimurium on the surface of a LSPR sensor chip. After removal of the *S.* Typhimurium template, the developed PDA-SIRP can selectively recognize and capture target bacteria, resulting in an increase in signal. The results showed that the PDA-SIRP based LSPR biosensor could dramatically reduce detection time down to 5 min using a label-free assay. The detection range of 1.16×10^2 to 1.16×10^8 CFU/mL was obtained and the detection limit was achieved at 116 CFU/mL for *S.* Typhimurium in pure culture without any pre-enrichment procedures. When compared to the LSPR immunosensor for detection of *S.* Typhimurium, the developed PDA-SIRP based LSPR biosensor not only extended life-time, but also reduced detection time and enhanced detection sensitivity. Although the developed PDA-SIRP showed some cross interaction with other non-target bacteria, the signal generated from *S.* Typhimurium can be distinguished from the signal of non-target bacteria. We are currently investigating different blocking agents to minimize the non-specific binding. The PDA-SIRP could be adopted for detection of other bacteria if their target template is available. It is potentially a simple, rapid, sensitive and label-free technique for bacteria detection. Ongoing research focuses on the validation of the PDA-SIRP based LSPR biosensor with food samples.

INTRODUCTION

- *Salmonella* Typhimurium is the most commonly identified foodborne pathogens for humans and animals, and responsible for numerous hospitalizations and deaths every year, which pose a threat to human health and cause substantial economic cost to society.
- It is estimated that *S.* Typhimurium is responsible for 1821 illnesses and 197 hospitalizations, resulting in $8 million economic costs each year in the United States.
- Currently used detection techniques (i.e., culture, ELISA, and molecular methods) are either poor in specificity, low in sensitivity, time consuming, too expensive, or require a laboratory and a highly trained technician.
- There is an urgent need for development of a rapid, specific and sensitive method to detect *S.* Typhimurium for food safety.

MATERIALS & METHODS

Apparatus

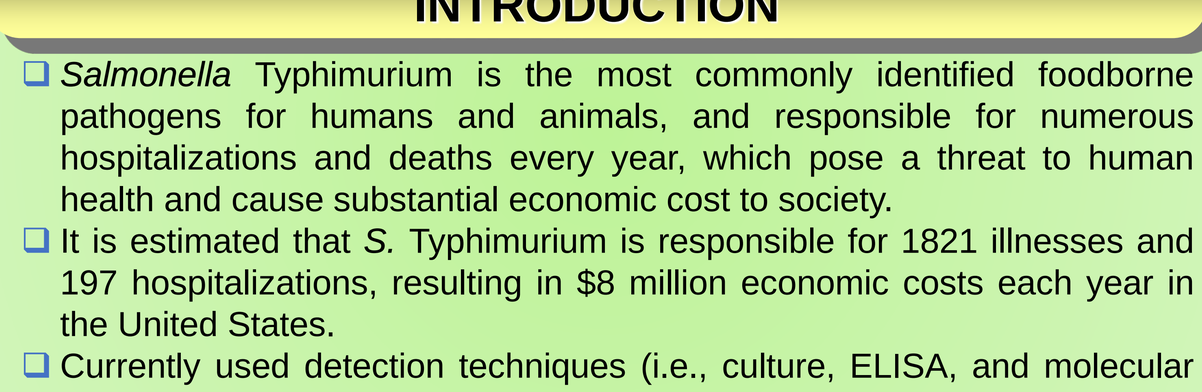


Fig. 1. Nicoya OpenSPR (a) Sensor chip; (b) Internal structure; and (3) Whole system

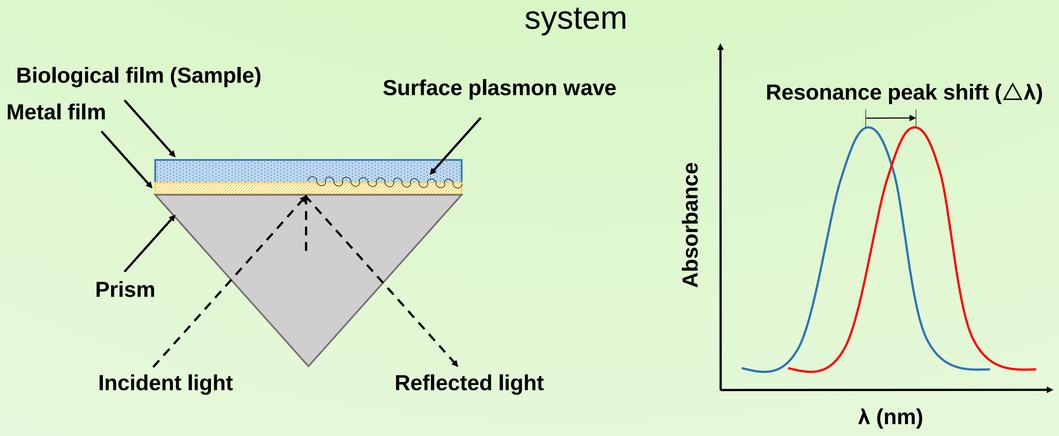


Fig. 2. Principle of LSPR

MATERIALS & METHODS (CONT'D)

Principle

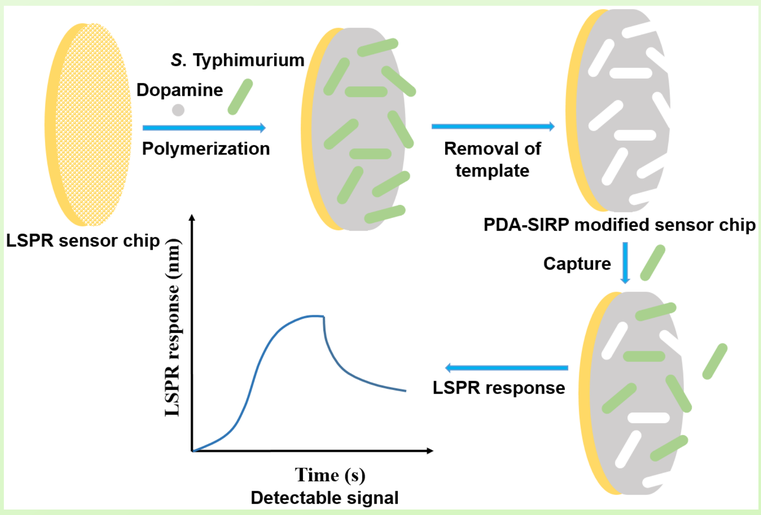
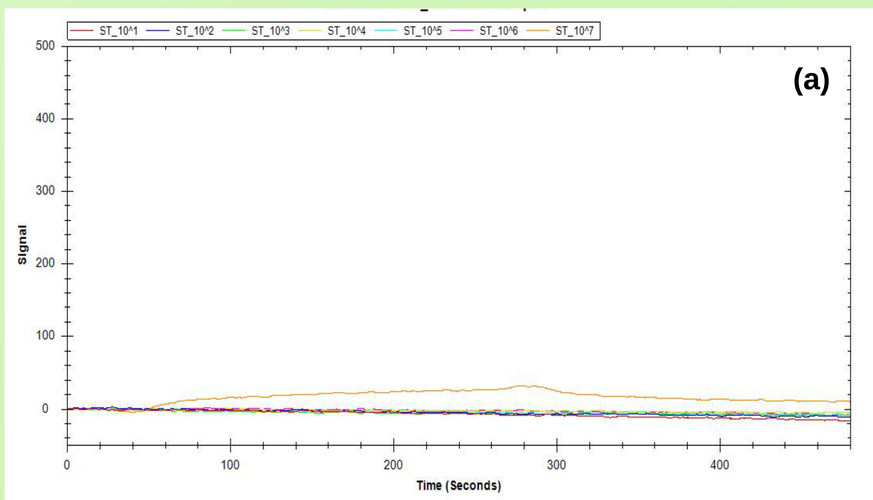


Fig. 3. Principle of the PDA-SIRP based LSPR biosensor

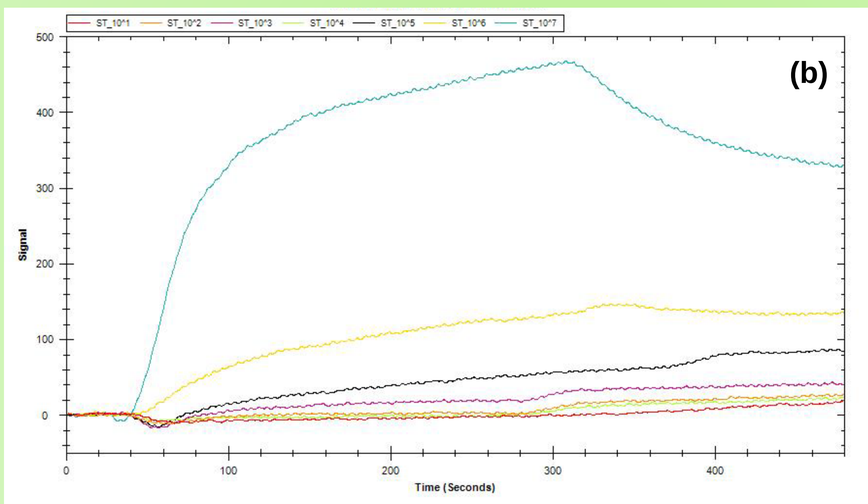
Materials

- ***Bacteria:*** *Salmonella* Typhimurium (ATCC 14028)
- ***Reagents:*** Biotin labeled rabbit anti-S. Typhimurium antibodies (4-5 mg/ml), Streptavidin, Bovine serum albumin (BSA), Dopamine hydrochloride (DA), 16-mercaptohexadecanoic acid (MHDA), 20 mM, N-(3-Dimethylaminopropyl)-N'-ethylcarbodiimide hydrochloride (EDC)/ N-hydroxysuccinimide (NHS), 70 mM/30 mM 1:1 (Sigma).

RESULTS



E. coli (CFU/mL)	LSPR signal (pm)
10^1	-18
10^2	-11
10^3	-10
10^4	-6
10^5	-9
10^6	-8
10^7	10



E. coli (CFU/mL)	LSPR signal (pm)
10^1	22
10^2	27
10^3	43
10^4	28
10^5	86
10^6	135
10^7	325

Fig. 4. A typical response curve of the LSPR biosensor for detection of *S.* Typhimurium (10^1 to 10^7 CFU/mL) within 5 min using: (a) anti-*S.* Typhimurium antibody immobilized sensor chip; and (b) PDA-SIRP modified sensor chip.

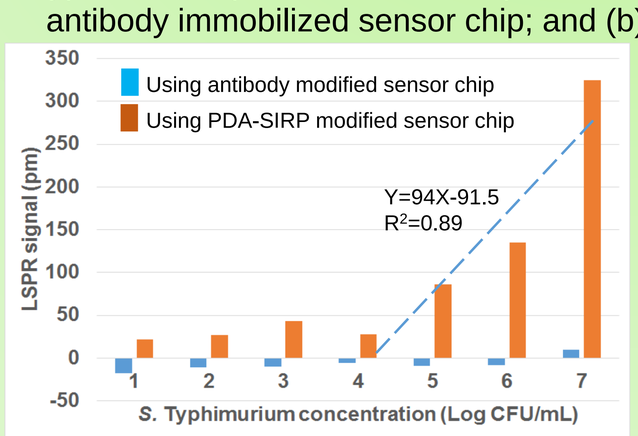


Fig. 5. Comparison of LSPR signal versus bacteria concentration using both anti-*S.* Typhimurium antibody immobilized sensor chip and PDA-SIRP modified sensor chip. A linear relationship was obtained in the bacteria range of 10^4 to 10^7 CFU/mL .

CONCLUSIONS

- A PDA-SIRP based LSPR biosensor was developed in this study for detection of *S.* Typhimurium.
- The results showed that the PDA-SIRP based LSPR biosensor could dramatically reduce detection time down to 5 min using a label-free assay.
- When compared to the LSPR immunosensor for detection of *S.* Typhimurium, the developed PDA-SIRP based LSPR biosensor showed an enhanced detection sensitivity.

ACKNOWLEDGMENTS

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