Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 132 (2014) 1–5

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

Portable evanescent wave fiber biosensor for highly sensitive detection of *Shigella*

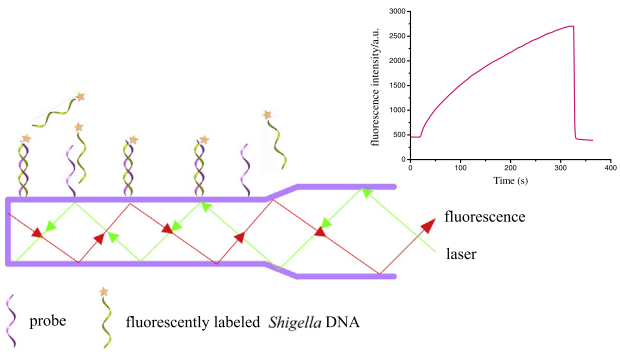
Rui Xiao [a,*], Zhen Rong [a], Feng Long [b], Qiqi Liu [a]

[a] Beijing Institute of Radiation Medicine, Beijing 100850, PR China
[b] School of Environment and Natural Resources, Renmin University of China, Beijing 100872, PR China

HIGHLIGHTS

- A portable evanescent wave fiber biosensor is developed to achieve the rapid and highly sensitive detection of *Shigella*.
- The sensor probe is home-made and can be used repeatedly.
- The fiber biosensor can be used in high-sensitivity online detection in fields like medical, biological, and environmental.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 10 December 2013
Received in revised form 18 March 2014
Accepted 13 April 2014
Available online 9 May 2014

Keywords:
Fiber-optic biosensor
Biosensor
Evanescent wave
Fluorescence signal

ABSTRACT

A portable evanescent wave fiber biosensor was developed to achieve the rapid and highly sensitive detection of *Shigella*. In this study, a DNA probe was covalently immobilized onto fiber-optic biosensors that can hybridize with a fluorescently labeled complementary DNA. The sensitivity of detection for synthesized oligonucleotides can reach 10^{-10} M. The surface of the sensor can be regenerated with 0.5% sodium dodecyl sulfate solution (pH 1.9) for over 30 times without significant deterioration of performance. The total analysis time for a single sample, including the time for measurement and surface regeneration, was less than 6 min. We employed real-time polymerase chain reaction (PCR) and compared the results of both methods to investigate the actual *Shigella* DNA detection capability of the fiber-optic biosensor. The fiber-optic biosensor could detect as low as 10^2 colony-forming unit/mL *Shigella*. This finding was comparable with that by real-time PCR, which suggests that this method is a potential alternative to existing detection methods.

Introduction

Shigella is a species of enteric bacteria that causes disease in humans and other primates. Most people who are infected with *Shigella* develop various symptoms, such as diarrhea, fever, cramping, vomiting, and other serious complications and illnesses. According to the World Health Organization, the annual number of *Shigella* cases worldwide is estimated to be 164.7 million with 1.1 million deaths, most of which involve children under 5 years old. For adult patients, 10 colony-forming unit (CFU) to 100 CFU of *Shigella* can cause intestinal infections and severe inflammatory responses [1]. Developing countries have a high incidence of dysentery because of the insufficient supply of clean water, poor sanitation, overcrowding, and malnutrition. Thus, the fast and effective detection of *Shigella* is of particular importance.

* Corresponding author. Tel.: +86 01066930274.
E-mail address: ruixiao203@sina.com (R. Xiao).

http://dx.doi.org/10.1016/j.saa.2014.04.090
1386-1425/

Traditional analytical methods for *Shigella* detection include bacterial cultivation, serological methods, and polymerase chain reaction (PCR) [2–9]. However, bacterial cultivation is a labor-intensive and time-consuming process that requires professional skills. Serological methods are simple methods but suffer from low sensitivity and specificity. Despite being more precise than the other methods, PCR requires complex procedures and expensive equipment, thereby preventing online and real-time detection. Thus, a fast, sensitive, and specific method for *Shigella* detection must be urgently developed.

In this paper, we report a novel, highly sensitive evanescent wave fiber biosensor for *Shigella* detection in aqueous solution or food. The sensing time, sensitivity, specificity, and reusability of the biosensor were validated. We also compared the *Shigella* DNA detection sensitivity of the portable fiber-optic biosensor with that of real-time PCR.

Table 1
Oligonucleotides.[a]

Name	Sequence (5′–3′)
IPA probe	Biotin-TTTTTTTTTTTTAGTCTTTCGCTGTTGCTGCTGATGCC
FC TGT	Cy5.5-GGCATCAGCAGCAACAGCGAAAGACT
BPM TGT	Cy5.5-GGCATCAGCACCAACAGCGAAAGACT
NC TGT	Cy5.5-TGGCAGAGCGGGTACTAACATGATT
Forward primer	GGATTCCGTGAACAGGTCGC
Reverse primer	Cy5.5-GATGGACCAGGAGGGTTTTC

[a] TGT = target; FC = fully complementary; NC = non-complementary; BPM = base pair mismatched.

Experimental methods

Materials and reagents

Bovine serum albumin (BSA), (3-aminopropyl)triethoxysilane (APTES), and streptavidin (SA) were purchased from Sigma–Aldrich (Germany). The sequences of all DNA oligonucleotides used in experiments were purchased from Sangon Biotech (Shanghai) Co., Ltd. (China) (Table 1). All solutions were prepared with ultrapure water from a Millipore Milli-Q system. All other salts and reagents were purchased from Sinopharm Chemical Reagent Co.,

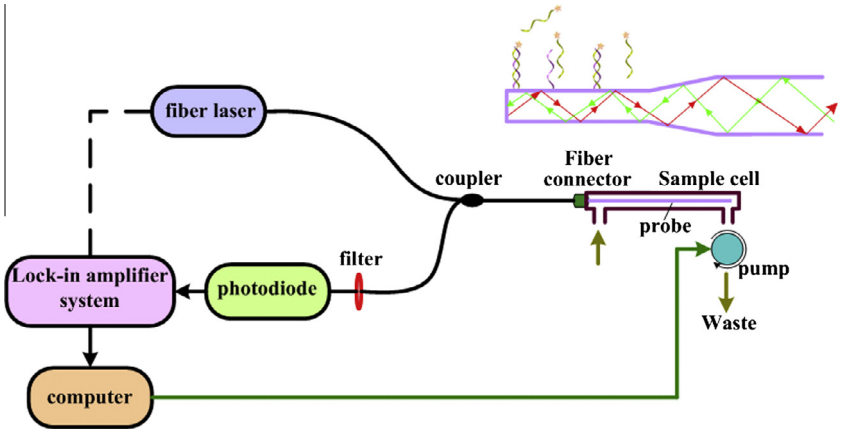


Fig. 1. Schematic of evanescent wave fiber biosensor system.

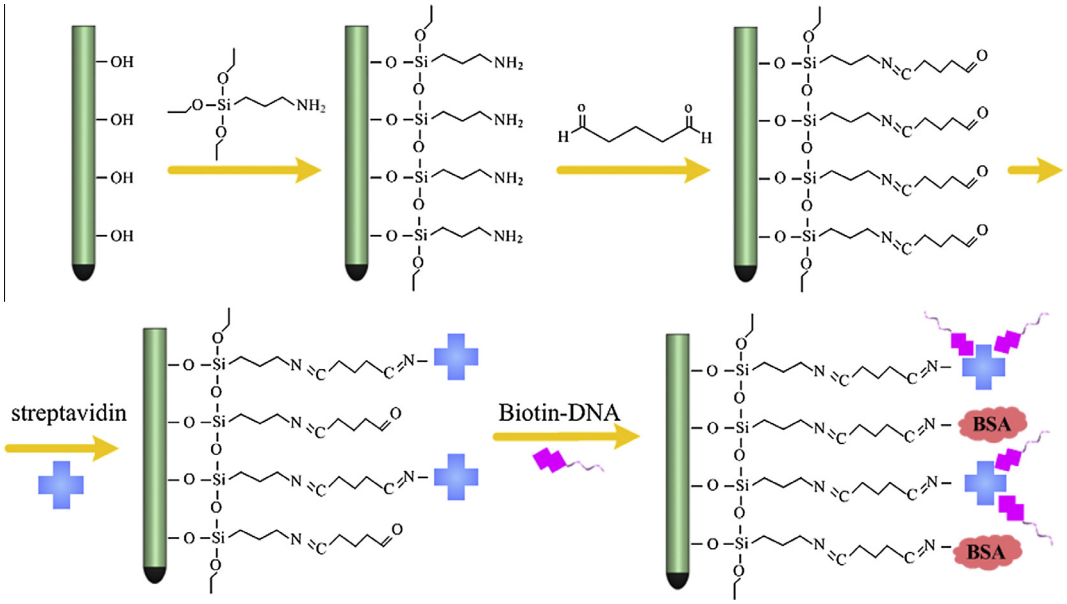


Fig. 2. Schematic of fiber probe modification.