An ultrasensitive fluorescent biosensor using high gradient magnetic separation and quantum dots for in-field detection of pathogenic bacteria

Li Xue[1], Lingyan Zheng[1], Huilin Zhang[1], Weihua Lai[2], Jianhan Lin[1*]
[1] China Agricultural University, Beijing, China
[2] Nanchang University, Nanchang, China
*corresponding author's email：jianhan@cau.edu.cn

Abstract

A novel fluorescent biosensor, using immune magnetic nanoparticles for high gradient magnetic separation and concentration of the target bacteria in a double-layer channel and quantum dots for quantitative detection of the bacteria with a portable optical detector, was developed for ultrasensitive and in-field detection of pathogenic bacteria. This biosensor was able to detect target bacteria as low as 14 CFU/mL within 2 h and the recovery of *E. coli* O157:H7 (used as research model) in the spiked milk ranged from 96% to 108%.

Introduction

- Rapid screening of contaminated foods is the key to prevent and control the outbreaks of foodborne diseases.
- It is crucial to develop effective methods for separating few target bacteria from a large volume of sample to increase the sensitivity.
- Fluorescent biosensor is a very promising alternative for sensitive and in-field detection of pathogenic bacteria.

Principle

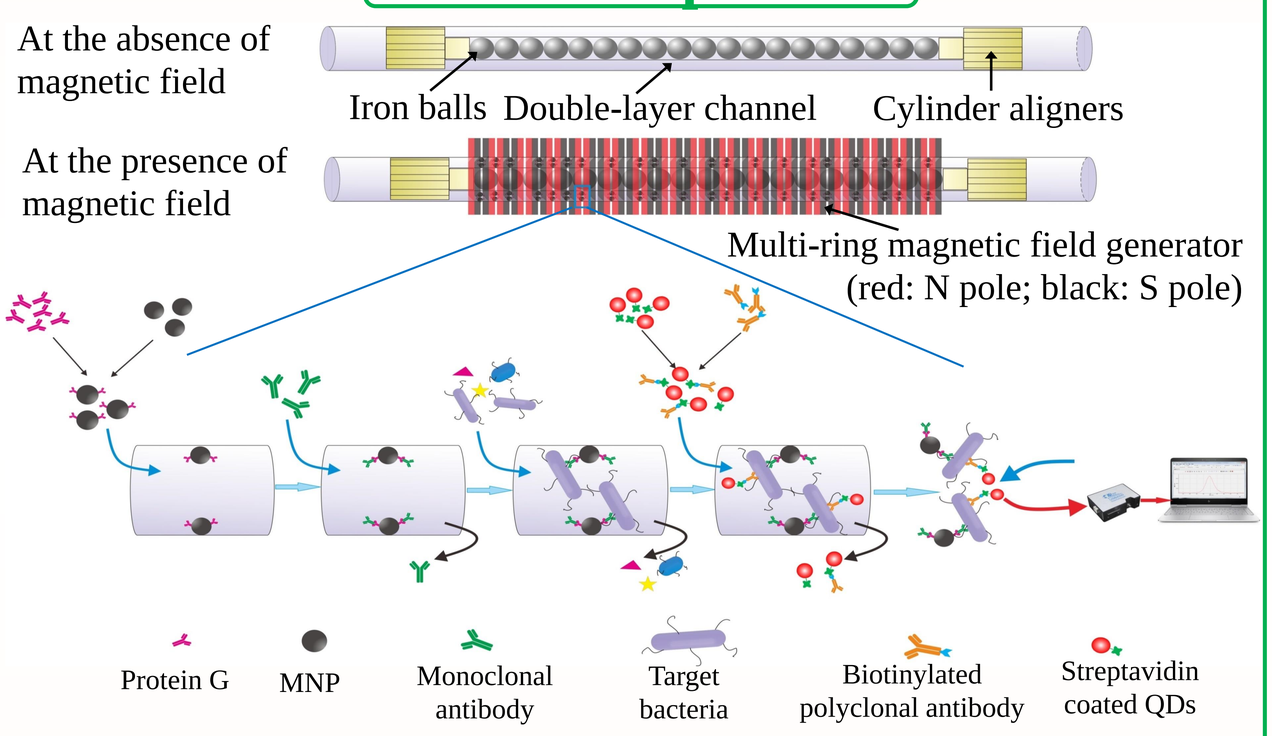


Fig. 1. Schematic of the ultrasensitive fluorescent biosensor using double-layer channel with magnetic nanoparticles (MNPs) and quantum dots (QDs)

Results and Discussion

1. Parameter optimization

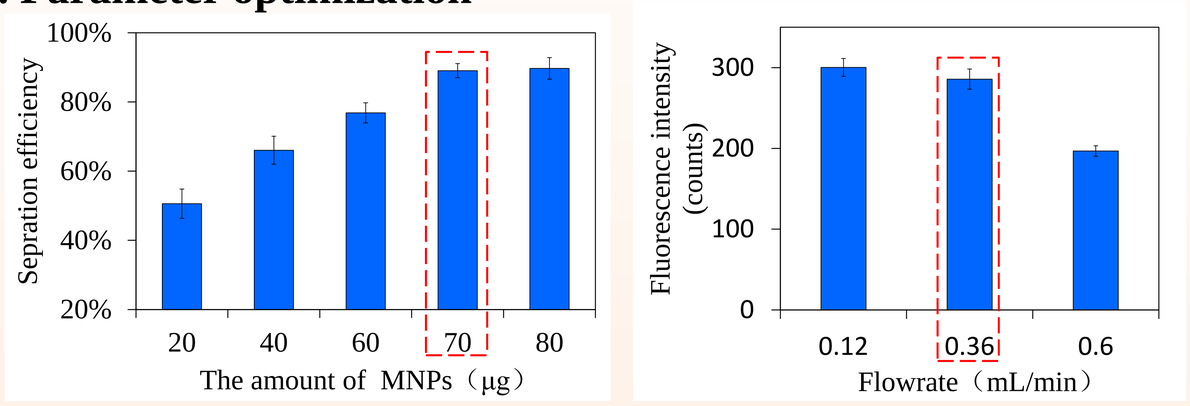
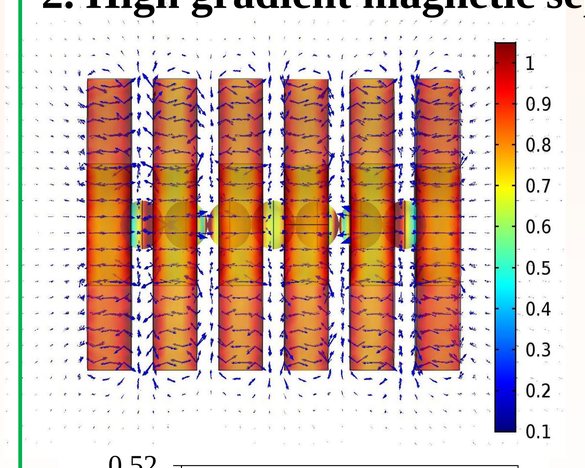
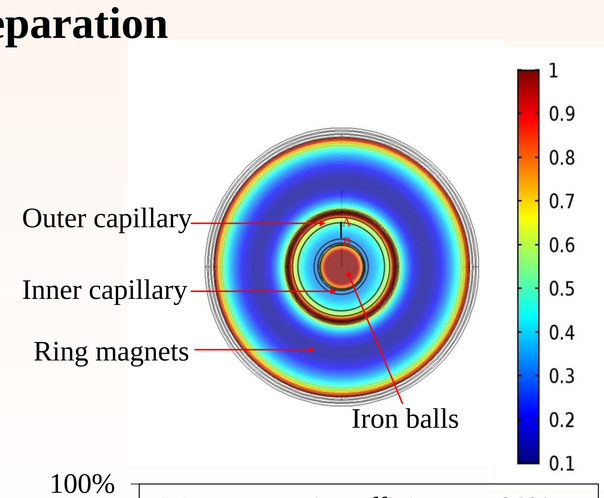
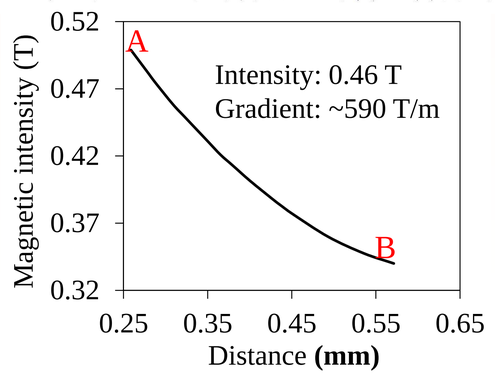


Fig. 2. Optimization of the amount of the MNPs and the flowrate of the fluids

2. High gradient magnetic separation







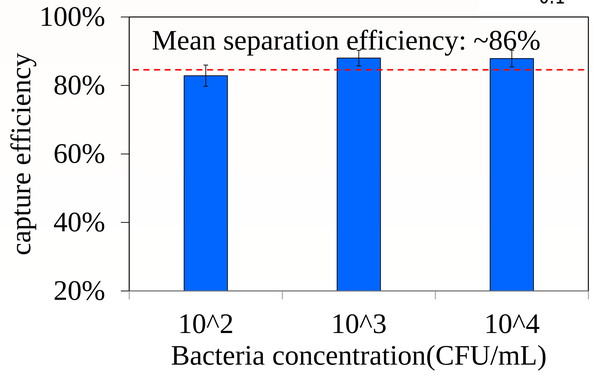


Fig. 3. Simulation and evaluation on the high gradient magnetic separation of target bacteria in the double-layer channel

3. Bacteria detection

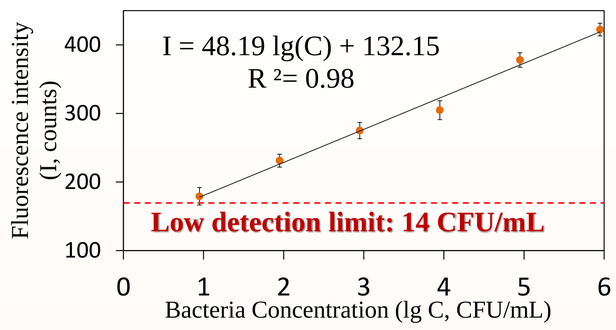


Fig. 4. The linear relationship between the fluorescence intensity and the bacteria concentration

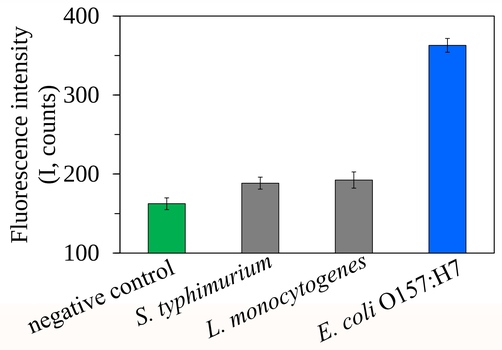


Fig. 5. The specificity of the fluorescent biosensor

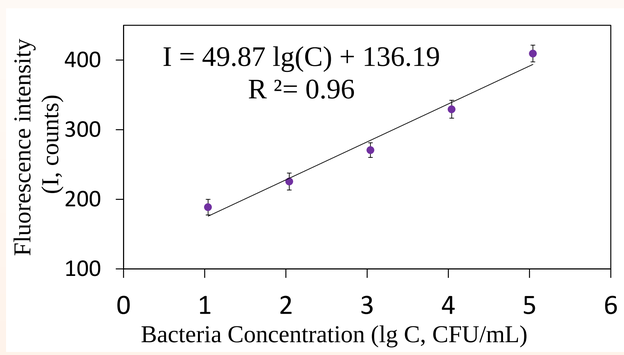


Fig.6. Detection of different concentrations of target bacteria in spiked milk

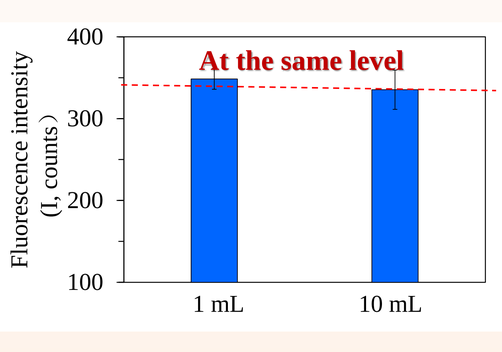


Fig.7. Comparison on the intensity for same amount of bacteria in different volumes

Conclusions

1. The high gradient magnetic separation in the double-layer channel had a bacteria separation efficiency of 86%.
2. This fluorescent biosensor was able to detect target bacteria as low as 14 CFU/mL in a large volume up to 10 mL.
3. The mean recovery in the spiked milk was 101%, indicating this biosensor might be suitable for practical application.
4. A smartphone APP will be developed to analyze the data and transmit the result to the food safety monitoring platform.

Acknowledgment

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