A sensitive biosensor using double-layer capillary based immunomagnetic separation and invertase-nanocluster based signal amplification for rapid detection of foodborne pathogen

Fengchun Huang[1], Weihua Lai[2], Jianhan Lin[1*]

[1]China Agricultural University; [2]Nanchang University

Abstract

Foodborne pathogen have resulted in many serious public health issues and numerous economic losses, and the key to control the outbreaks of foodborne diseases is rapid screening of pathogenic bacteria. In this study, a novel biosensor was proposed for sensitive and rapid detection of target bacteria combining double-layer capillary based high gradient immunomagnetic separation, invertase-nanocluster based signal amplification and glucose meter based signal detection. A linear relationship between the readout of the glucose meter and the concentration of the target bacteria (from 10^2 to 10^7 CFU/mL) was found and the lower detection limit of *E. coli* O157:H7 in this proposed biosensor was 79 CFU/mL.
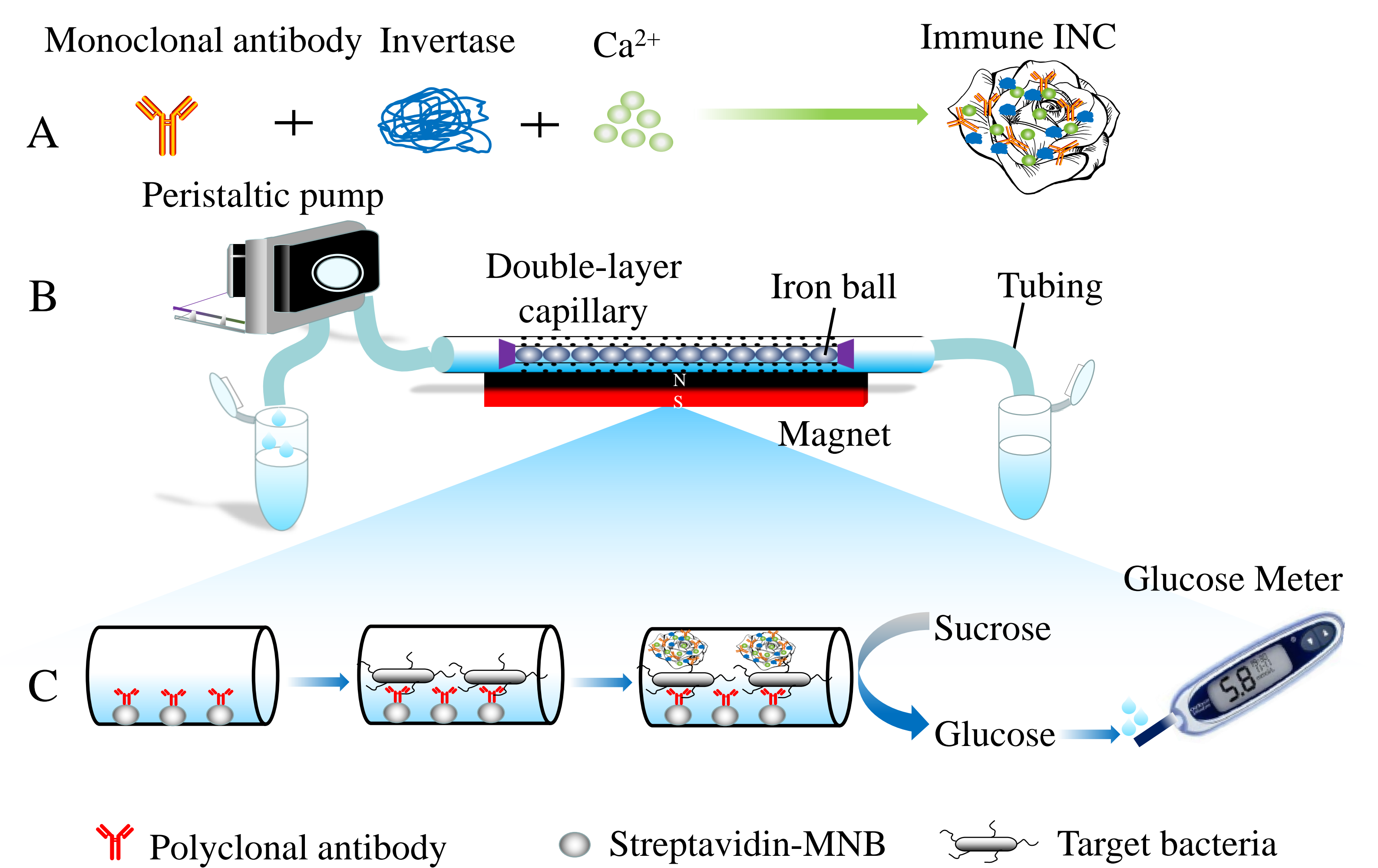
Principle

Fig.1. *Schematic of this proposed biosensor*

Results and Discussion

1. Modeling of this biosensor for detection of target bacteria

(a) $y = 1.07\ln(x) + 11.78$, $R^2 = 0.97$; Lower Detection Limit: 79 CFU/mL

(b) Average size: 1~2 µm; 500 nm
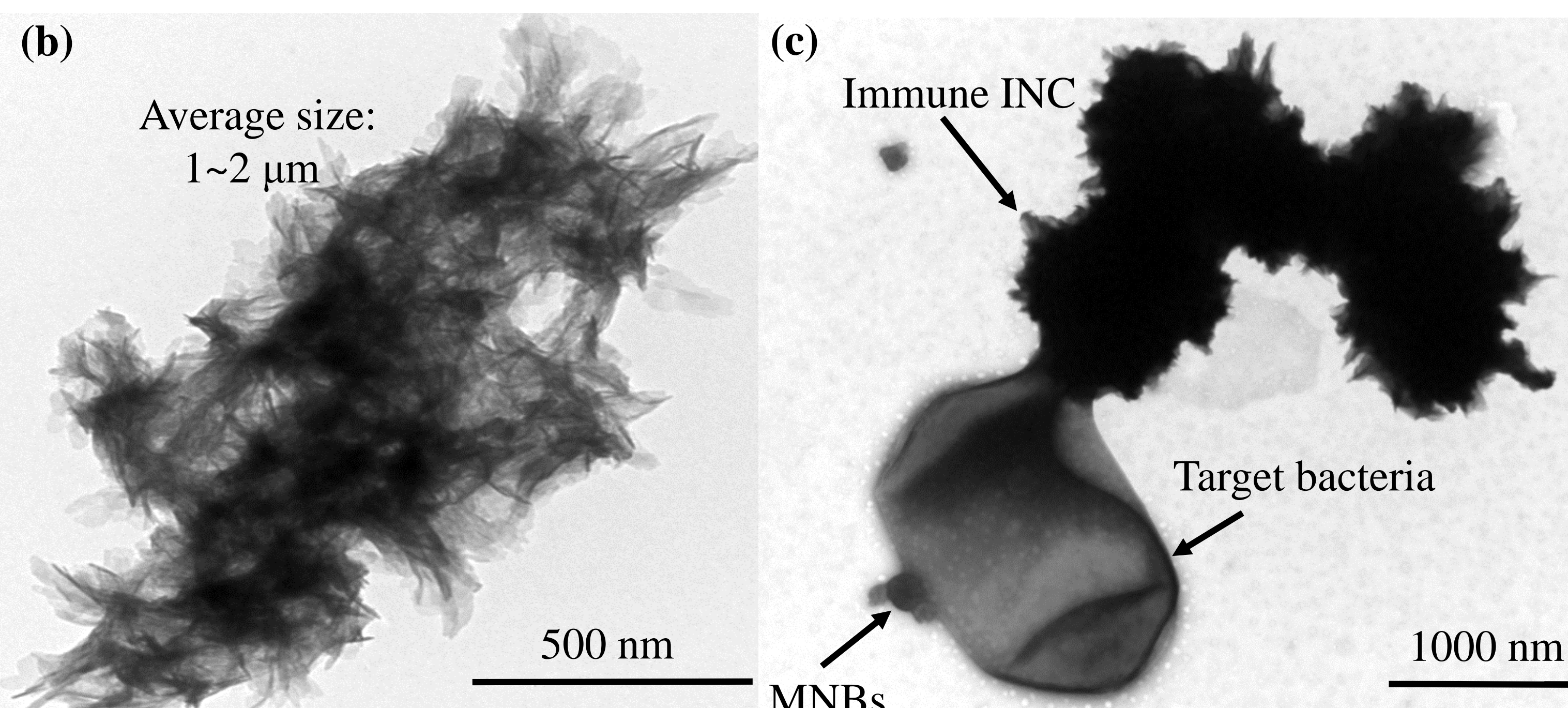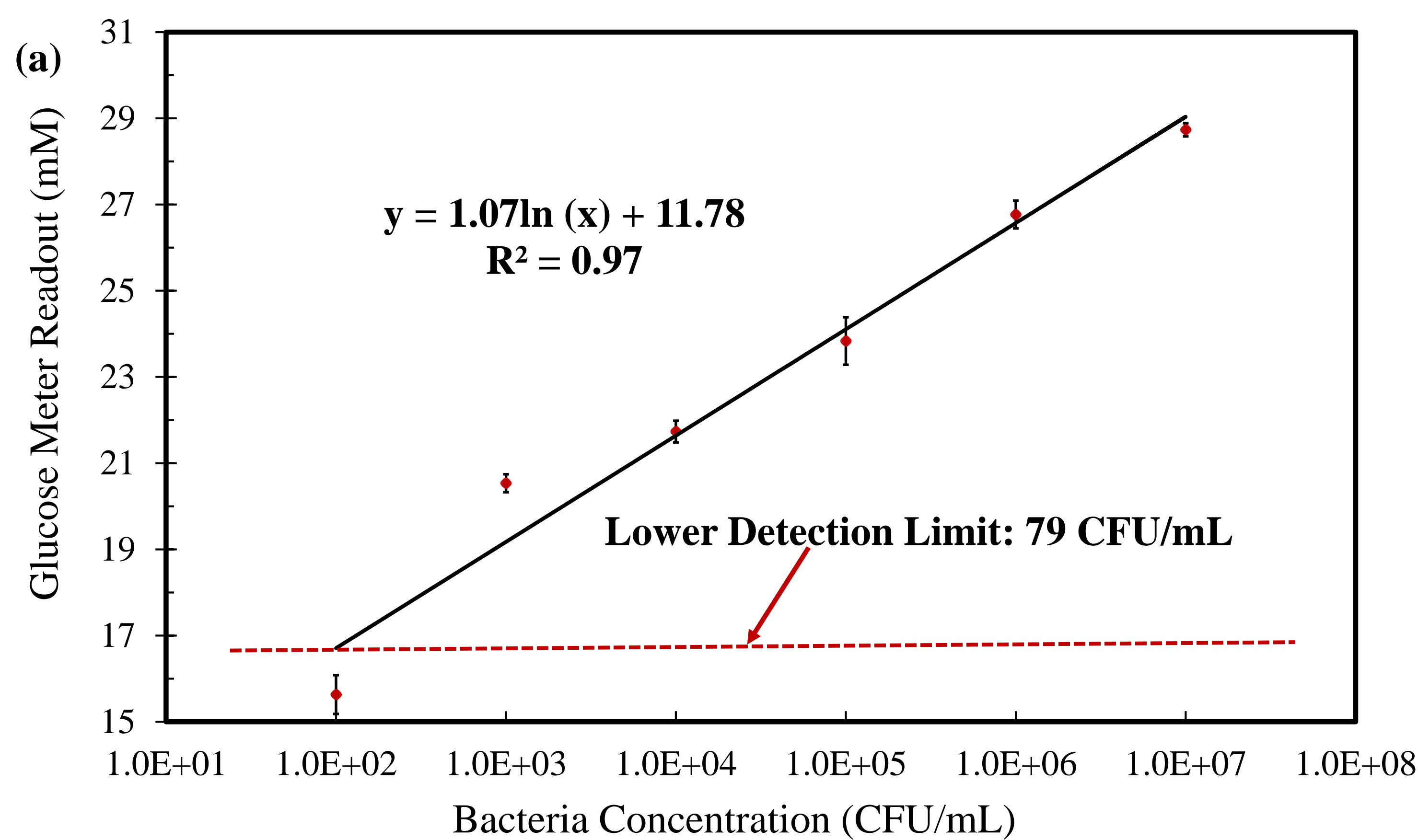
(c) Immune INC; Target bacteria; MNBs; 1000 nm

Fig.2. *Calibration curve of this proposed biosensor(a) ; TEM image of the immune INC(b) and the MNB-E. coli-INC complex(c).*

2. Simulation of the magnetic field in the double-layer capillary

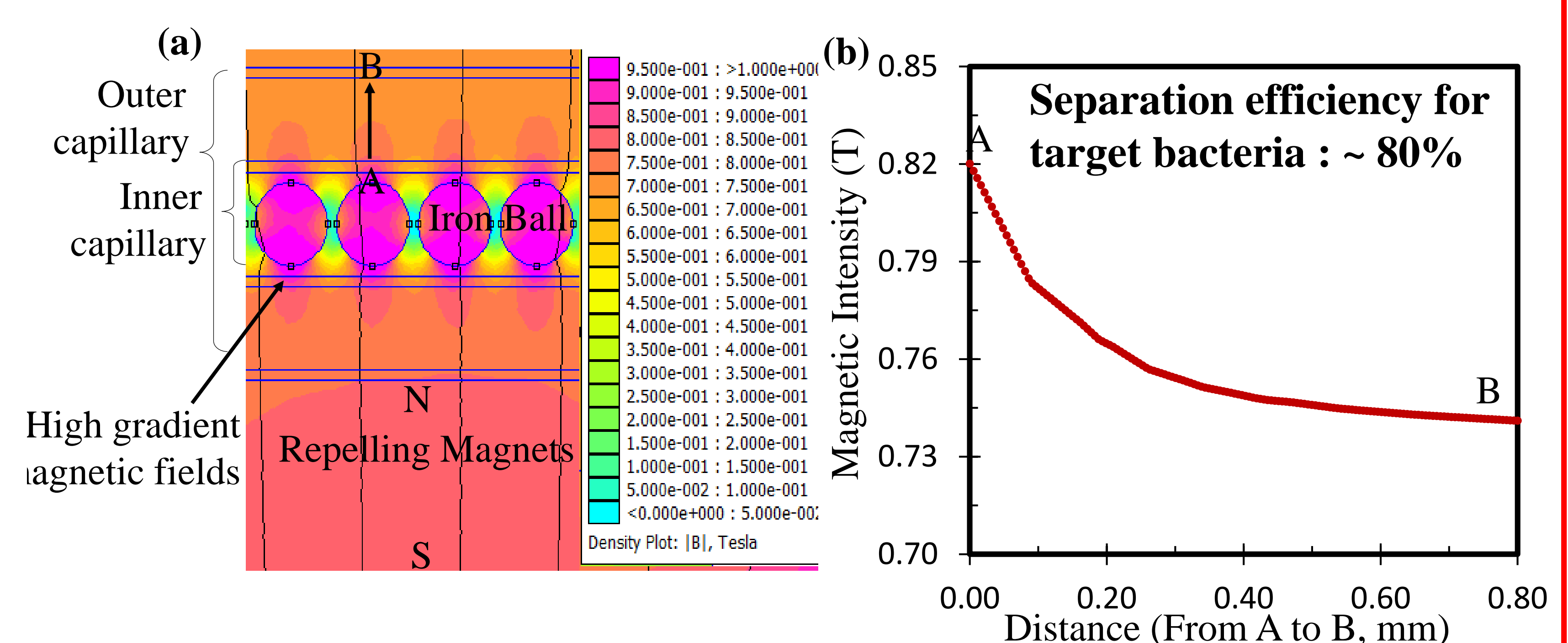(b) Separation efficiency for target bacteria : ~ 80%

Fig. 3. *(a) The simulation on the distribution of the magnetic field in the double-layer capillary; (b) The intensity of the high gradient magnetic field at different distances from the outer wall of the inner capillary.*

3. Detection of target bacteria in spiked milk

(a) Pure Cultures; Milk Samples; log[*E.coli* O157:H7(CFU/mL)]
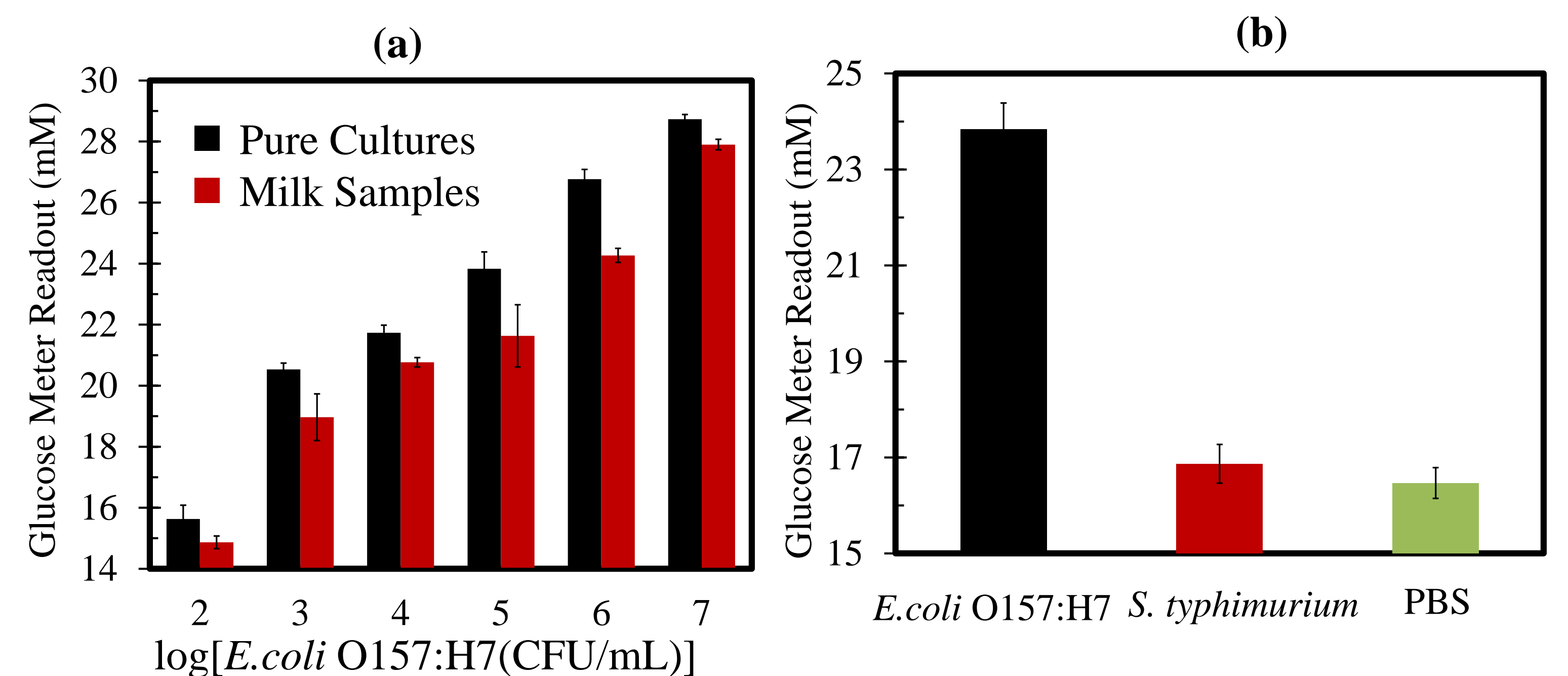
(b) *E.coli* O157:H7; *S. typhimurium*; PBS

Fig. 4. *(a) Detection of the spiked milk containing the E. coli O157:H7; (b) Detection of the S. typhimurium and E. coli O157:H7 at the same concentration of 1.0×10^5 CFU/mL, and the negative control.*

Conclusions

1. Double-layer capillary based high gradient magnetic separation was effective for bacteria separation and enrichment.
2. The mean recovery of the target bacteria in the spiked milk was ~ 87.5% verifying the applicability of this proposed biosensor for detection of target bacteria in the food samples.

Acknowledgment