An electrochemical aptasensor using coaxial capillary with magnetic nanoparticle, urease catalysis and PCB electrode for rapid and sensitive detection of pathogenic bacteria

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ABSTRACT

In this study, a novel electrochemical aptasensor was developed for rapid and sensitive detection of pathogenic bacteria using the coaxial capillary with immune magnetic nanoparticles (MNPs) for specific separation of the target bacteria, the urease for effective amplification of the impedance signals, and the PCB gold electrode for sensitive measurement of the impedance change. The impedance change of the catalysate had a good linear relationship with the concentration of the bacteria. This aptasensor was able to detect *E. coli* (used as research model) as low as 10^1 CFU/mL in 3 h, and the mean recovery of target bacteria in the spiked pasteurized milk was ~99%.

HIGHLIGHTS

- **Coaxial capillary**
  Separate and concentrate target bacteria from large-volume sample
- **PCB electrode**
  Measure the impedance change at much lower cost
- **Urease**
  Catalyze the hydrolysis of urea to amplify biological signals

INTRODUCTION

- The key to control the outbreaks of foodborne diseases is rapid screening of pathogenic bacteria in food supply chain.
- Immunomagnetic separation is not suitable to separate target bacteria from large-volume sample.
- Interdigitated microelectrodes are often used as transducer but fabricated at very high cost.
- Biological signals are often very weak since only few target bacteria are present at food samples, resulting in false negatives.

PRINCIPLE

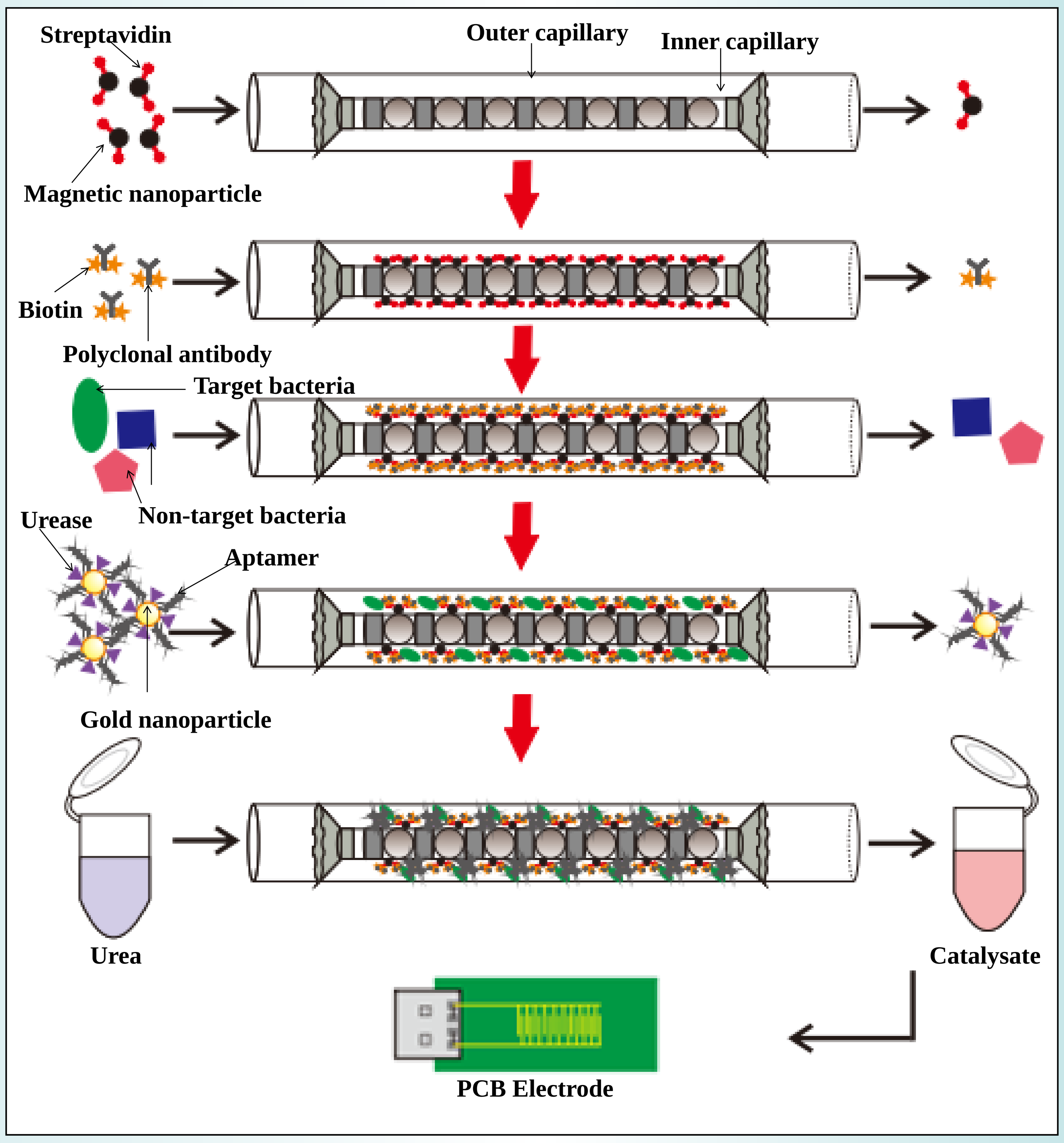

Fig. 1. Schematic of the electrochemical aptasensor for rapid and sensitive detection of pathogenic bacteria.

RESULTS AND DISCUSSION

Magnetic Separation

The magnetic field had a intensity of 0.45 T and a gradient of 350 T/m. The MNPs were distributed uniformly in a larger area of ~520 mm^2, leading to a high separation efficiency of ~85%.

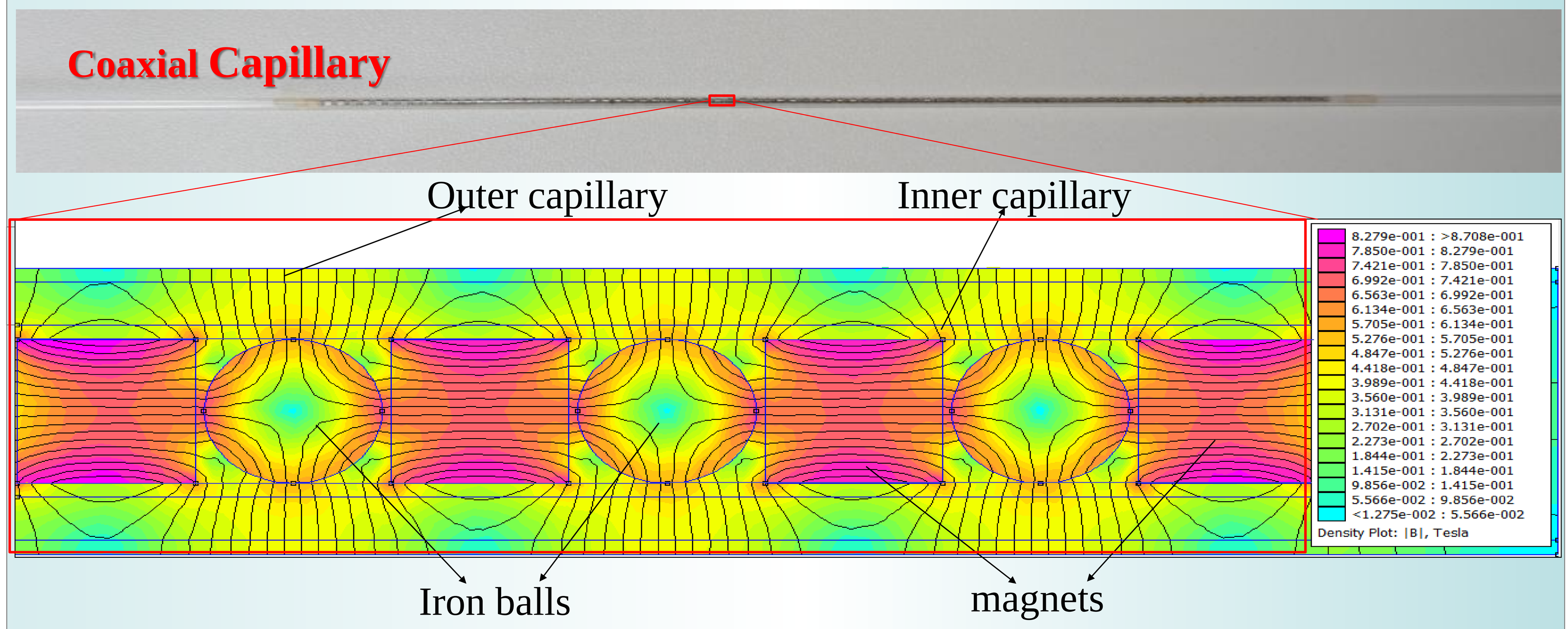

Fig. 2. The simulation on the distribution of the magnetic field.

Impedance Measurement

The PCB electrode was able to quantitatively measure the impedance of ammonium carbonate with higher sensitivity than the microelectrode, but it was fabricated at much lower cost (~10 RMB).

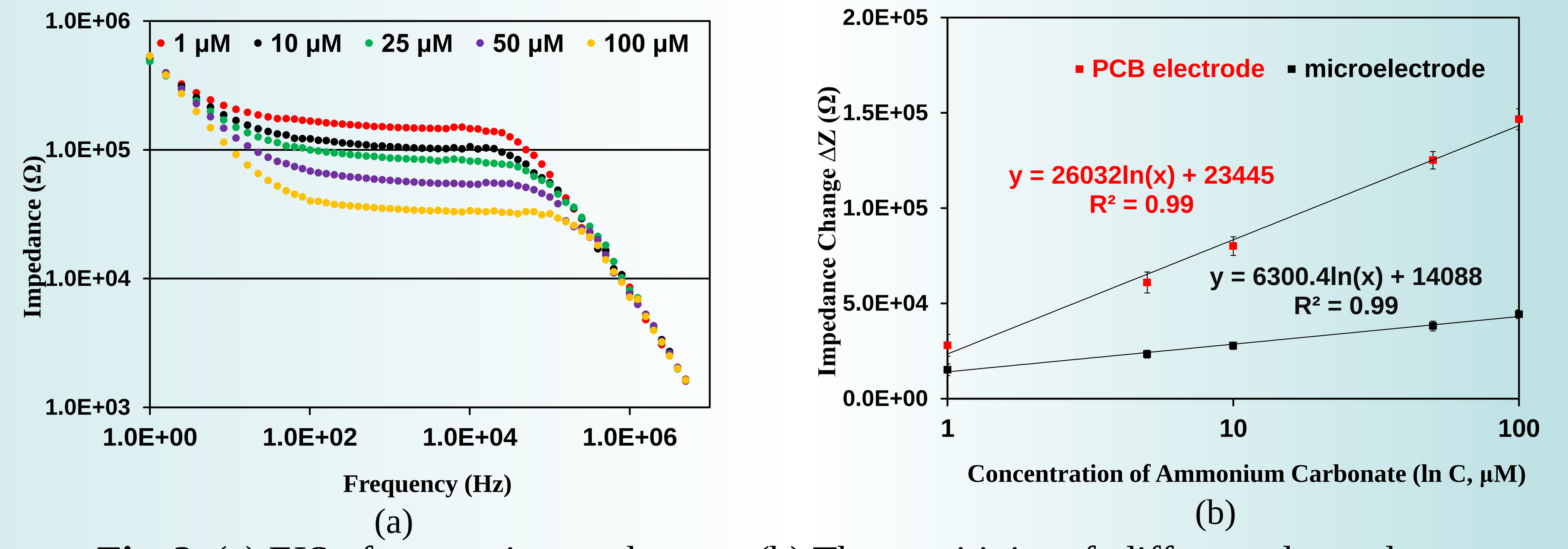

Fig. 3. (a) EIS of ammonium carbonate; (b) The sensitivity of different electrodes.

Bacteria Detection

The impedance change had a good linear relationship with bacteria concentration. The detection limit was 10^1 CFU/mL and this aptasensor had shown a good specificity to target bacteria.

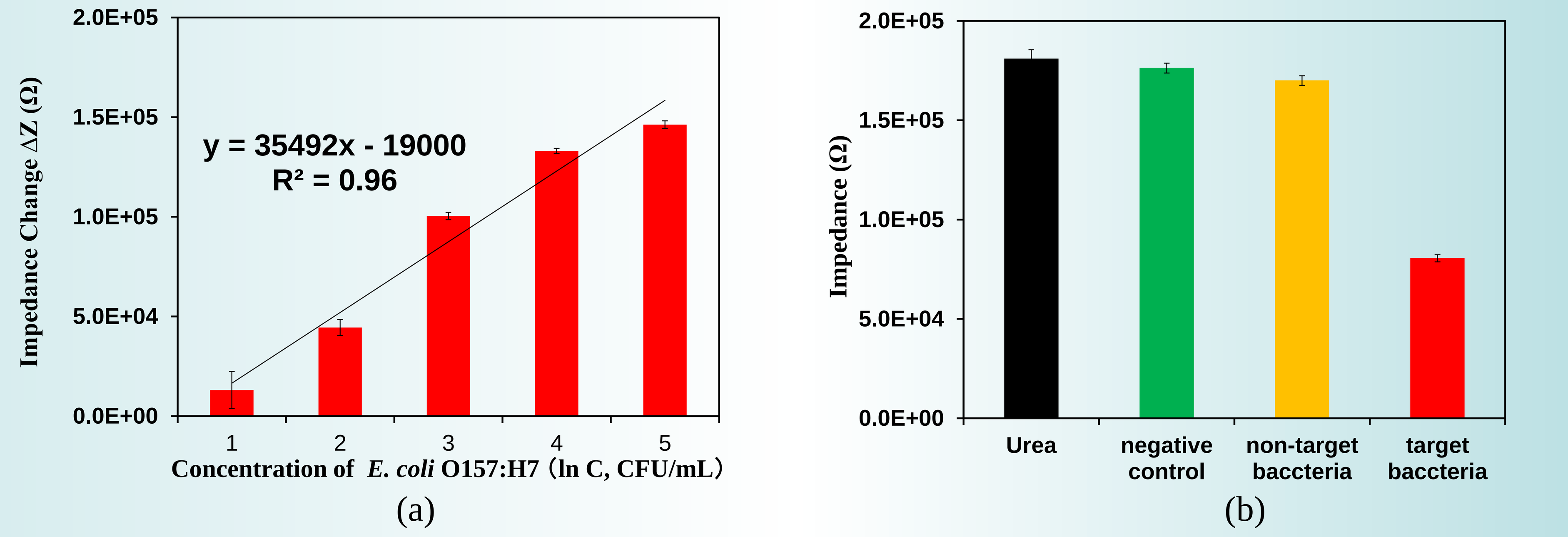

Fig. 4. (a) Linear relationship between the impedance change and bacteria concentration; (b) The specificity of the electrochemical aptasensor.

CONCLUSIONS

- The coaxial capillary was able to efficiently capture, separate and concentrate the target bacteria from a large volume (10 mL) of sample.
- The low-cost PCB electrode could accurately measurement the impedance change.
- The aptasensor was able to detect target bacteria as low as 10^1 CFU/mL.

ACKNOWLEDGMENT

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