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The establishment of sensitive and rapid pathogenic bacteria detection method using magnetic nanoparticle clusters and optical nanoparticle probes

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INTRODUCTION

The increasing incidence of food poisoning from pesticides, microorganisms, pharmaceuticals, and toxins is a vital public health concern. The early detection of pathogenic microorganisms at the lowest possible concentrations is, in particular, critical because microorganism populations increase rapidly over time.

In this study, we developed a simple, rapid, and cost-effective method for the detection of pathogenic bacteria in foods using magnetic (superparamagnetic) nanoparticles (MNPs) and TiO_2 nanocrystals (TNs). The MNPs enabled the rapid extraction of pathogenic target bacteria under an external magnetic field, and TNs were used as optical nanoprobes for spectroscopic detection. TNs are less expensive and exhibit more stable absorption spectra than gold nanoparticles over a range of pH, temperature, and salt concentration. The detection limit of our assay for *Salmonella* bacteria was found to be better than 100 cfu mL^{-1} in milk. To the best of our knowledge, this study describes the first demonstration of an assay based on MNPs and TNs for the detection of hazardous bacteria in foods.

RESULT

UV-Vis absorption spectra were collected for the buffer solutions containing unbound TNs or the MNP–*Salmonella*–TN complexes. The results obtained from the unbound TN solution were found to be more sensitive because of the absence of interferents such as MNPs and *Salmonella* bacteria. Fig. 2(a) shows the UV-Vis absorbance spectra for various concentrations of *Salmonella* ranging from 10^2 to 10^8 cfu mL^{-1}. Because the absorption intensity of the unbound TN solution was reversely proportional to the *Salmonella* concentration, the absorption intensity decreased with increasing *Salmonella* concentration.

CONCLUSION

In summary, a simple, rapid, and cost-effective assay was developed by combining immuno-magnetic separation and optical sensing techniques for the detection of Salmonella in a buffer solution or in milk matrix. Salmonella bacteria were selectively captured by antibody-immobilized magnetic nanoparticles and separated from solution by applying an external magnetic field. Our detection scheme possesses many advantages over conventional methods; the measurement is rapid because it does not require cell culturing processes; immuno-sensing based on the light absorption of TNs is more economic and less hazardous than conventional sensing methods based on fluorescence nanoparticles or gold nanoparticles; and the low sensitivity of conventional light absorption methods is overcome by measuring the light absorption intensity of free TN solutions rather than Salmonella-containing solutions. The TN-based immunoassay described here provides an elegant alternative to conventional methods based on cell culture or PCR-based assays.

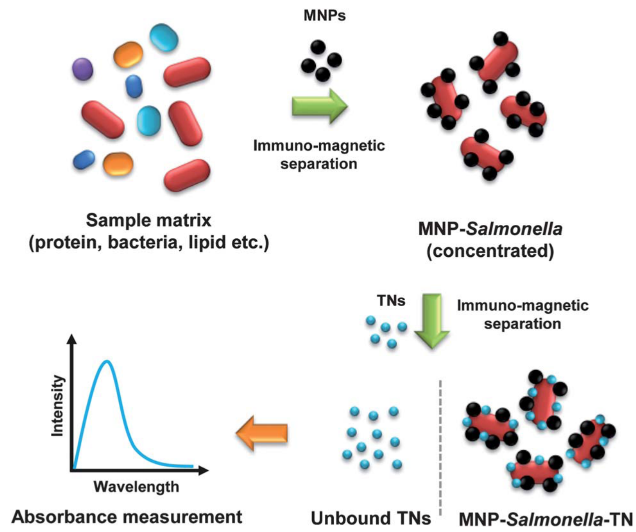

Fig 1. A schematic illustration of the pathogenic bacteria detection method using magnetic nanoparticles and optical nanoprobes

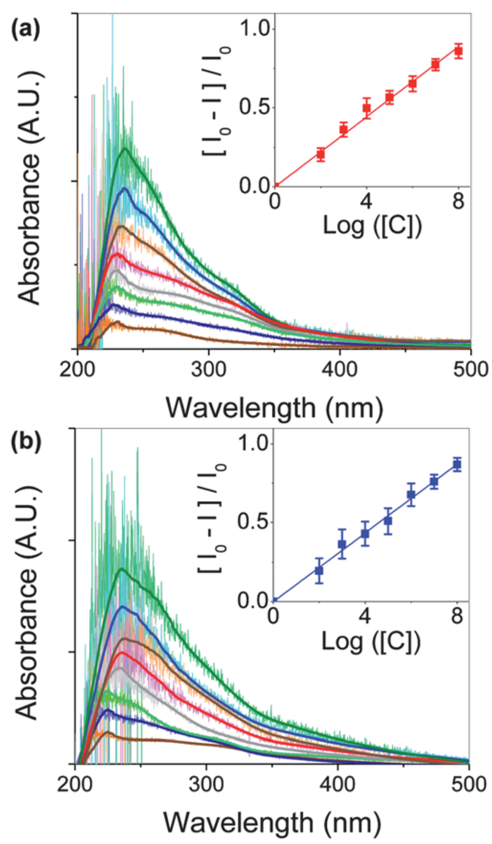

Fig 2. The absorption spectra of unbound TiO_2 nanocrystals in a buffer solution (a) or in milk (b) as a function of the *Salmonella* concentration. The inset shows that the normalized relative intensity at 230 nm is proportional to the logarithmic concentration of *Salmonella*.

REFERENCE

[1] J. Joo, C. Yim, D. Kwon, J. Lee, H. Shin, H. Cha and S. Jeon, *Analyst*, **137**, 3609-3612 (2012)

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