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Abstract

Colorimetric Detection of Bacteria Using Au Nanoparticles †

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Abstract: Colorimetric detection, a technique that observes changes in colour as a signal, has been employed in the identification of bacterial presence using gold nanoparticles (Au-NPs). Au-NPs exhibit unique optical properties, changing their colour in response to bacterial interactions. This straightforward and rapid method offers potential for early diagnosis and monitoring of bacterial infections. The sensitivity and specificity of Au-NPs provide a promising tool for the next-generation point-of-care diagnostics, streamlining bacterial detection without the need for complex instrumentation.

Keywords: gold nanoparticles; colorimetric detection; food contamination; paper analytical device; bacteria

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1. Introduction

The threat of bacterial contamination to people's health and food represents a global concern. Thus, their detection in a fast and accurate manner is essential. Moreover, the access to portable, practical, and affordable devices that permit fast and precise live bacteria detection is still a challenging issue nowadays. Here, we introduce the bacterial inhibition of Au nanoparticles (AuNP) by a colorimetric approach. These nanoparticles produce a noticeable colour shift without the use of sophisticated equipment and facilitate the quick and broad-spectrum detection of living bacteria. Four typical foodborne pathogens—*Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimurium*, and *Candida albicans*—were detected using colorimetric detection based on paper analytical devices (PADs) and UV-Vis spectroscopy [1,2]. Our findings imply that this technique is useful for the quick identification of studied bacteria in food products.

2. Materials and Methods

Several cruciferous plants were evaluated for the phytosynthesis of gold nanoparticle. The hydroalcoholic extracts were obtained through the two extraction methods (temperature (T) and microwave (MW)). For the phytosynthesis of the metallic nanoparticles, each extract was mixed with prepared 1 mM aqueous solutions of $HAuCl_4$ in an Erlenmeyer flask and incubated at room temperature for 30 min [3].

PADs have been prepared using filter paper Whatman no. 1 with computer-designed circular areas (diameter of 0.7 cm) followed by wax printing. Then, a hydrophobic barrier was created by placing the wax-printed paper for 20 s on a hot plate at 170 °C. The immobilization of AuNP on PADs hydrophilic surface was performed by three successive

additions of 7.5 µL 0.5 mM solution of AuNP in methanol with 10 min drying between the additions. Then, the PADs containing AuNP (AuNP-PADs) were exposed for 30 min to bacteria culture. After drying, the test zone of AuNP-PADs was digitalized using a flatbed scanner to keep constant lighting across all images. The JPEG format image was then imported to ImageJ software (https://imagej.net/ij/) (National Institute of Health, USA) for analysis in RGB colour space (the range of each channel is from 0 to 255) after exposure to analytes. The colour change in AuNP in presence of bacteria caused a maximum change in the intensity of the blue channel and less changes in the intensity of the red and green channels. Therefore, the differences in the blue channel mean intensity values (ΔI) from the inner 75% of the spot (in terms of the radius) between AuNP-PAD without and with bacteria were calculated and used as the sensor response. Spectroscopic measurements were performed in methanol. Spectral changes of 0.5 mM AuNP solution were noticed after the addition of different amounts of bacteria.

3. Results

The results show the colour change in the filter paper from white to light yellow after adding AuNP. The observed differences in the mean colour RGB channels intensity before and after adding AuNP reveal a decrease in the colour which confirms Au nanoparticles immobilisation onto paper. Further, in the presence of bacteria (e.g., *E. coli*), the colour of AuNP-PAD fades. The highest change was noticed for the blue channel when comparing the mean colour intensity variation (ΔI) of RGB channels in the absence and in the presence of bacteria. This channel was further considered in bacteria sensing experiments. These experiments were confirmed by UV-Vis spectrometry experiments.

4. Conclusions

By using AuNP, colorimetric (paper based and UV-Vis spectrometry) sensors were obtained in a very simple manner and displayed recognition properties towards bacteria. Further, these sensors could be used to detect the presence of envisaged bacteria from food products.

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References

1. Ungureanu, C.; Fierascu, I.; Fierascu, R.C. Sustainable Use of Cruciferous Wastes in Nanotechnological Applications. *Coatings* **2022**, *12*, 769. [CrossRef]
2. Chen, Q.; Li, H.; Ouyang, Q.; Zhao, J. Identification of spoilage bacteria using a simple colorimetric sensor array. *Sens. Actuators B Chem.* **2014**, *205*, 1–8. [CrossRef]
3. Su, H.; Ma, Q.; Shang, K.; Liu, T.; Yin, H.; Ai, S. Gold nanoparticles as colorimetric sensor: A case study on *E. coli* O157:H7 as a model for Gram-negative bacteria. *Sens. Actuators B Chem.* **2012**, *161*, 298–303. [CrossRef]