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Short Communication

Nanoparticle-based Optical Sensors for Pathogenic Bacterial Identification and Detection

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Pathogenic bacteria are contributing to various diseases and responsible for worldwide mortality annually. This necessitates the accurate techniques for detection and identification of pathogenic bacteria for the prevention and treatment of pathogenic diseases. Nanotechnology applications are benefitting a variety of fields of medicine in which there is an increasing inclination in the recent times. The nanostructures such as nanowires, nanotubes, nanoparticles, cantilevers, microarrays, and nanoarrays have the capability to detect disease-related biomarkers rapidly and directly. These techniques are a have unique advantages of very low quantity of samples consumption and remarkably higher sensitivity [1].

There is a mounting evidence of use of nanotechnology in different fields of medicine which may potentially benefit from the use of these applications [2-4]. For example, for an effective cancer –specific therapy, conjugation of cancer cell-directed targeting agents to gold nanoparticles is a potential approach to treat numerous types of human malignant disease using noninvasive RF hyperthermia [2]. Similarly, development new generation cardiovascular implants such as bypass grafts, heart valve prostheses, and coronary stents by application of polyhedral oligomeric silsesquioxane (POSS) containing polymers is under thorough investigation with hopeful outcomes. 3 In preclinical studies, carbon nanotubes has shown positive results for use as transplanting scaffolds containing stem cells into the injured areas of the neural cells and brain tissues [4].

Conventional techniques for detecting pathogenic microorganisms, such as microbial cultures and bacterial growth, are complex and lengthy processes entailing 6–24 hours for the culture growth process followed by 1–3 days for the morphological and biochemical identification of bacterial isolates [1].

Nanoparticles (NPs) are a brilliant option for the detecting pathogens in biological samples owing to their ultra-fine size and and high surface-to-volume ratio properties [5,6]. Amongst nanoparticles, gold nanoparticles (AuNP) have been widely used in the development of various bio-and nanosensors due to their unique properties such as the surface Plasmon band localization in the visible spectrum, simplicity of synthesis, of particles with specific size and shape (including spherical nanoparticles, nawires, nanoshells, nanorods, nanodisks, nanocubes, nanotriangles, nanooctahedrons etc.), long time stability, easy surface functionality, biocompatibility, unique optical properties and high catalytic action [5].

Type of nanoparticle	Size (nm)	Bacteria detected/ Detection limit (CFU/ml)	Method	Advantages
Superparamagnetic Fe_3O_4 nanoparticles	120	*Salmonella* (functionalized with monoclonal antibodies for *Salmonella*)/100	Immuno-magnetic separation	Fast, and cost-effective
Molecular beacon–Aunanoparticle	15	*Escherichia coli/100*	Real-time PCR	10^3 times more sensitive than traditional beacon probes
Cadmium sulfide (CdS) nanoparticles	40–50	*Desulforibrio caledoiensis/25.8*	Fluorescence microscopy	Short detection time
FePt@Van magnetic nanoparticles	<10	*Escherichia coli* *Coagulase-negative Staphylococcus (CNS)/4*	Fluorescence microscopy	Bacteria detection in less than 2h

Cysteine gold nanoparticles (CAuNPs)	20 ± 2	*Escherichia coli/100*	Colorimetric method	Rapid and visual detection
Streptavidin coated magnetic nanoparticles	36	*Escherichia coli, Salmonella Vibrio cholera, Campylobacter jejuni/100*	Multiplex PCR	Concurrent detection of four pathogens
Silver NPs (AgNPs)	90.4 ± 3.6	*Escherichia coli/Single detection*	Anodic particle coulometry technique	Single bacteria detection
Polyethylenimine (PEI)-modified Au-coated magnetic microspheres (Fe3O4@Au@PEI) and concentrated Au@Ag nanoparticles (NPs),	300	*Escherichia coli Staphylococcus aureus/100*	SERS detection method	Simple operating procedure, total assay time 10 min.
Au-coated magnetic nanoparticles (AuMNPs) conjugated with Staphylococcus aureus (S.aureus) antibody	190	*Staphylococcus aureus/10*	SERS detection method	Low limit of detection

Table 1: The important properties of some nanoparticles based technology for pathogenic bacterial detection.

Conclusion

Nanotechnology is transforming the development of biosensors in recent years. Nanobiosensor research focusing on developing innovative technologies to make significant developments in the areas of pathogenic marker detection for both human and animal diseases. These technologies are based on nanometrically engineered, liquid-solid interfaces or biologically active surfaces, A s result, new prospects are being opened up for the development of nanosensorss with submicron-sized dimensions, which are ideal for intracellular measurements [6].

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