Host pathogen interaction and pathogen detection methods

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ABSTRACT
Identification and detection of pathogens are the strategies towards the elucidation of infectious disease. There are growth and significance in the field of Nanomedicine. Present circumstance here is a need in research surrounding the topic of nanoparticle (NP) properties, mainly concerned with mechanisms of action with the bacterial cell. Metal NPs are now showing strong antibacterial activity. The bacterial cells have more resistance towards the antibiotics, which has met the research community to innovate novel antibiotic agents. The ability to detect micro-organisms has become an essential requirement in food-processing technology for clinical and environmental monitoring. In keeping with traditional methods of detection, those are time taking and develop the result solitary has to wait for long hours. Nowadays, there are many rapid and sensitive methods developed by the effort of researchers and inventors. Nanoparticles act as the alternative to pathogen detection. The size, shape and morphology of nanoparticles play a role for the pathogen nanoparticle communication. Here, in this review article, we discuss the nanoparticle and bacterial cell interaction. The different methods based on culture-based, optical sensing-based and nanoparticle-based methods all discussed in this chapter.

INTRODUCTION
The nanotechnology is the main active research areas in the present study. It expresses different characteristics like size, shape and morphology. For the specific use of nanoparticles, it needs to prepare a specific size and shape of nanomaterial (Havel, 2016; Lam et al., 2017). The fundamental properties and characteristics of all nanoparticles are committed on its size, shape, composition, crystallinity and morphology. There are many uses of Nanoparticles in the playing field of biosensors, biomedicine, and bionanotechnology (Fakrudin et al., 2012). Apart from this, there is also the use of Nanotechnology in case of medicine for diagnosis of disease, therapeutic drugs delivery for disease treatment and treatments for several diseases and disorders. Nowadays, Nanotechnology is a powerful technology, which has potential medical applications on early disease detection, treatment, and prevention. For bacterial as the alternative to antibiotics Nanoparticles (NPs) are progressively used (Patra et al., 2018), and also use in advantageous in treating bacterial infections (Wang et al., 2017). In case of antibacterial activity, there
is the application of NPs practice as antiseptic layers for implant devices and medicinal resources to avoid microbial pollution and help in twisting curative course fast, also now in case of antibiotic transfer schemes to delict infection, in bacteriological target schemes toward convince microbial diagnostics and in bactericidal serums to manage infective impurities (Escárcega-González et al., 2018). How nanoparticles act as a sterile agent is not understood correctly, but the mechanisms include oxidative stress induction, metal ion release, and non-oxidative mechanisms. Nanoparticle research is presently a component of important research, has the potential applications in various field such as biomedical, optical, and electronic fields. All the application of nanoparticles depends on the size of nanoparticles as per example in case of semiconductor particles we consider quantum confinement, in some metal nanoparticles surface plasmon resonance and superparamagnetism in magnetic materials (Yin et al., 2015). Currently, nanotechnology is one of the foremost promising and takes a significant role in scientific application and technology development toward human use (D’Agata et al., 2008). The synthesis and characterization of nanoparticles (NPs) is an expanding research area because of the possible applications for the event of bio-medical use.

In case of bacterial study, one of the bacteria; E. coli (Escherichia coli), maybe a range of gram-negative bacteria, resides within the intestine. Most varieties of E. coli are harmless and even help keep healthy (Zhu et al., 2014). Some strains cause disease like diarrhoeas, sickness, pneumonia, breathing problems, and tract infections with E. coli. Infections often associated short for “Shiga toxin-producing E. coli has one especially bad strain, O157: H. It causes acute nephropathy in children. In relevance to the current fact, it has been identified that identifying the pathogenic strain differ from healthy strain and to destroy the pathogenic strain (Peterson and Pathogenesis, 1996). The aim is to research antibacterial activities of metal nanoparticles and their mode of action against pathogenic bacteria on the whole cell. Here in this review, we discuss the Nanoparticle interaction with the bacterial cell. Here we discuss the detection methods of nanoparticle bacterial interaction.

**BACTERIAL PATHOGENS**

Disease-causing bacteria are the pathogenic microorganisms (Sánchez-López et al., 2009). Most bacteria are harmless; some are pathogenic, cause diseases in humans. There are thousands of species that exist within the human gastrointestinal system. Some of the infected bacterial disease such as tuberculosis, caused by mycobacterium bacteria, which kills about a million people in a year. Pathogenic bacteria also cause important diseases, like pneumonia, which produced by bacteria like Streptococcus (Patterson and Streptococcus, 1996) and Pseudomonas (Iglewski, 1996), and foodborne infections, which may well be produced by bacteria like Shigella, Campylobacter, and Salmonella (Gianella, 1996). E.coli bacteria are pathogenic, meaning causing disease, or able to cause disease, whichever diarrhoea or disorder external of the intestinal tract. E.coli, which might cause diarrhoea, is communicated through polluted water or food, or interaction with animals or persons. E. coli consists of various group of bacteria (Katouli, 2010). Enteric Escherichia coli (E. coli) central pathogens are instigating significant morbidity and mortality worldwide. Two adhesins (mannone sensitive (type-1) and mannoses resistant (type p) produce by Fimbria in the bacterial cell. Through these adhesins, bacteria attach to the particular receptors host cell on Uroepithelial cells.

**PATHOGEN DETECTION METHODS**

Exact and absolute way for pathogen or microorganism documentation, including bacteriological documentation besides pathogen finding, imperative aimed at appropriate infection analysis, cure from contamination then eradication of sickness related to bacteriological toxicities. Bacterial credentials are working a varied cutting-edge variety of presentations including bacteriological forensics, criminal surveys, bio-terrorism extortions and environmental readings—Scheme 1. Represent different types of detection methods; here, we discuss several studies.

**Culture-based method**

Bacterial population growth within the laboratory is called a bacterial culture (Vartoukian et al., 2010). There are mainly two culture types; a pure culture contains only one single form of bacteria, and a mixed culture contains two or more diverse bacteriological segregates. For the growth of bacterial culture, bacteria need nutrients and proper environment. Thus, there is a necessity for infectious cultures to be regularly moved or subcultured, to new mass media with nutrient to stay the microbial population increasing. Growing of bacterial culture in pure culture as single bacterial culture is one of the best broadly used procedures in microbiology. Several micro-organisms depend upon biological composites in place of nutrients, toward yield drive
and carbon compound. Some bacteria also require added nutritive constituents like vitamins in their nourishment for growth. For the growth of germs, a suitable physical atmosphere needs to create where significant aspects related to hotness, pH, and also attentiveness of atmospheric air (particularly oxygen) are well-ordered and preserved (Tanaka and Benno, 2015). Dietary wants for microbes found over media that indeed contain proteins extracts, mineral salts like potassium phosphate or sulfate, and in selected cases, carbohydrates like glucose or lactose.

Scheme 1: Schematic representation of bacterial detection process

Optical sensing based method

In Optical based method, Plasmons are generated by coupling photons and electrons near a surface of an electrically conductive material, and it called surface plasmon polaritons (SPPs) (Raizman et al., 2019). In the case of conventional methods, it’s a time-consuming process for the detection and characterization of pathogenic micro-organisms. Immunosensing based or macromolecule based optical detection of pathogens now a day’s most active method. There’s collaboration sandwiched between antigens existing on the board cells and antibodies restrained on planes just in case of Immunosensors founded recognition. There are many optical sensing methods for pathogen detection including fluorescence-based, electrical or electrochemical impedance which involved in or involving the application of electricity in technology, quartz crystalline microbalance (QCM), surface plasmon resonance (SPR) (Mocan et al., 2017). In the fluorescence detection method, quantitative chemical analysis is typically performed by measuring the fluorescence of a search—intensity of the spectrum changes in response to the analyte of interest. Nanoparticles based devices are representative examples used as functional probes for detecting pathogens. Surface plasmon resonance sensors are constructed for biological and chemical sensing.

Nanoparticle-based method

Pathogenic bacteria are responsible for causing various globally significant diseases and affecting by causing diseases to human beings. A disease-related biome is quickly and straight spotted by using nanostructures; resembling nanowires, nanotubes, nanoparticles, cantilevers, microarrays, and nanoarrays. These nanostructures are component of clear progression characterized by lesser sample ingesting and significantly advanced specificity and compassion. There is a requirement for using exact methods for pathogenic microbes documentation and discovery to permit the anticipation and running pathogenic infections then promise nutrition contamination and security. Nanoparticles remain dissimilar since majority supplies of identical configuration which help them overwhelmed style of constraints of old-style beneficial and analytical representatives (Zhang et al., 2019).

In the case of silver NPs research carried out this work indicating that Nanocrystalline silver gauzes might decrease infectious points, lessening the lingering provocative response, and indorse coiled curative. A discriminatory electrochemical device maintained carbon dot (CD)/ZnO Nanorod Nano assembly has been established to the exposure of cadmium (II) pollution existing inside the ecofriendly tasters. The nanocomposites CDs/ZnO/PANI nanocomposites were categorized by Fourier transform infrared spectroscopy, UV-Vis spectroscopy, Scanning microscopy (SEM) and electrochemical analyzer (Sun et al., 2019). NPs with the specific properties of visual, electrochemical or magnetic properties increase the speed and the detectability of the analytical approaches. There are different detection methods of pathogens such as nanoparticle conjugate with antibody readily and precisely classify a diversity of bacterium, for example, Escherichia coli O157: H7; over antibody-antigen communication then gratitude (Yoo and Lee, 2016).

For the finding of solitary-bacterium in fewer periods established through the plate-counting technique then understood through spending two self-governing visual methods. Additionally, we were capable of spotting multiple microbial sections through from top to bottom amount by using a 384-well microplate system (Xie et al., 2007; Zhang et al., 2016) for food and water shield essential aimed at precise methods for pathogenic micro-organisms documentation and finding to permit the anticipation then organization of pathogenic syndromes.

In the case of medicine and drug delivery cases currently assistance from the procedure of nanotech-
nology presentations, in which there is increasing attention and a treasured resolution for disease management. The extent then belongings of nanoparticles makes them excellent stages for the finding and empathy of pathogens in living biotic models. Magnetic nanoparticles are recycled for noticing micro-organisms, which can be more considered through nuclear magnetic resonance imaging (Wei et al., 2013). There is also bacteriological recognition using silver nanoparticles, gold nanoparticles, silica and many other magnetic nanoparticles. Many bio-conjugated nanoparticles could be committed to a solitary bacterium cell for exposure method. Nanoparticle constructed recognition is the quick and delicate mode of pathogen finding.

CONCLUSION

Herein book chapter, we offered an aspect outline about Nanoparticles, NPs interaction with the host cell and the detection methods. Nanoparticles have a small size, NPs have a large surface area, this property makes them suitable contestant for binding to the host cell. NPs stand possible substitute toward antibiotics, besides seem to have great budding towards resolve delinquent of the advent of super microbial strain. Mechanism of antibacterial activity was found to be size and concentration-dependent.

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Conflict of Interest

The authors declare no conflict of interest.

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