Antimicrobial Activity of TiO_2 Nanoparticles against Pathogenic Strains That Cause Wound Infections

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ABSTRACT

The first civilization dealt with disorders and provided detailed information about wound management was ancient Egyptians. Wound infections evidently appeared in times of World War I that accounted a significant mortality and morbidity rate among injured soldiers. Currently, around 11 million people worldwide requires medical treatment for wound infections, 300,000 as die every year. Scientists highlighted the concept of introducing micro-organisms into wounds resulting in an infection. The infected wound was successfully treated with wide-spectrum antibiotics that can eradicate the pathogenic micro-organisms. Due to extensive use of antimicrobial drugs such as β-lactam, methicillin, vancomycin, etc., new strains with high resistance have been emerged. During the past few decades, nanotechnology has arisen with new promising technology for synthesis of nanobiomaterials. Researchers focused on using nanobiotechnology to employee several nanoparticles as antimicrobial agent. Metallic nanoparticles such as zinc, copper, titanium and silver have demonstrated antibacterial activity. Metallic nanoparticles, especially TiO_2, will be considered as a new alternative treatment, which replaces the existing antibiotics. Antibacterial activity of these nanoparticles will enhance the future of the therapeutic strategies against the resistant pathogenic strains that cause wound infections

INTRODUCTION

Infections of the wound are considered as a common life-threatening world-wide problem resulting in 300,000 death every year (Song *et al.*, 2016). Wounds are vulnerable to be contaminated with different microbes, which capable of causing infection (Singh *et al.*, 2014). For the past several decades, clinicians used to prescribe antibiotics for wound treatment (Friães *et al.*, 2015). Thus, improper using of antibiotics leads to the emergence and dissemination of drugs-resistant bacteria and becomes a global health challenge (Chudobova *et al.*, 2015a).

In this era, researchers start to look for alternative treatments and replaced the conventional antibiotics (Beyth *et al.*, 2015). Metallic nanoparticles (NPs) such as titanium (Ti) turn out to be a key component in different area (Pereira *et al.*, 2015). Recently, nanobiotechnology has offered great possibilities of these nanomaterials and their potential as alternative antimicrobial agents (Joost *et al.*, 2015). Titanium dioxide (TiO_2) NPs are a promising semiconductor with photocatalytic activities widely used in photocatalytic, antimicrobial activity and many applications (Gopinath *et al.*, 2016).

We produced a performance photocatalysts TiO_2 NPs via green synthesis technology and investigated their antibacterial activity on many antibiotic-resistance strains that cause wound infections. Regarding to their antimicrobial activity, they can be applied in many ways, such as cream, ointment, gel and wound dressings.

The aim of this project is to investigate the antimicrobial activity of TiO_2 nanoparticles against the most common multi-drug resistant pathogenic strains that cause wound infections. Thereby, determine which concentration of TiO_2 nanoparticles can affect these pathogenic strains at a specific time.

METHODS AND MATERIALS

TiO_2 synthesis

We synthesized our nanoparticles via green chemistry with different structures in a novel way.

Microorganisms

In this research, we used 3 strains obtained from the American Type Culture Collection (ATCC) org. They were *Staphylococcus aureus* (MRSA), *Escherichia coli and Pseudomonas aeruginosa,* which commonly caused wound infections and they are multi-drug resistance.

Assessment of TiO_2 Nanoparticles Antimicrobial Activity

We had 7 samples and studied the time-dependent growth curves of bacterial cells that exposed to these samples. The experimental procedures were achieved for negative-control and for each treatment sample in parallel.. Then, we determined the minimum exposure time for the efficient antimicrobial activity of each TiO_2 nanoparticles sample at different concentrations.

RESULTS

TiO_2 Nanoparticles Antimicrobial Activity

In the present study, we tested the 7 samples of TiO2 nanoparticles with different structures.

The results revealed that these samples exhibited antimicrobial activity against the 3 bacterial strains at specific concentrations (µg/ml-CFUs/ml) at specific time. Figure.1 illustrates the effect of TiO_2 NPS (sample FW12) against *Pseudomonas aeruginosa* at different time and different concentrations

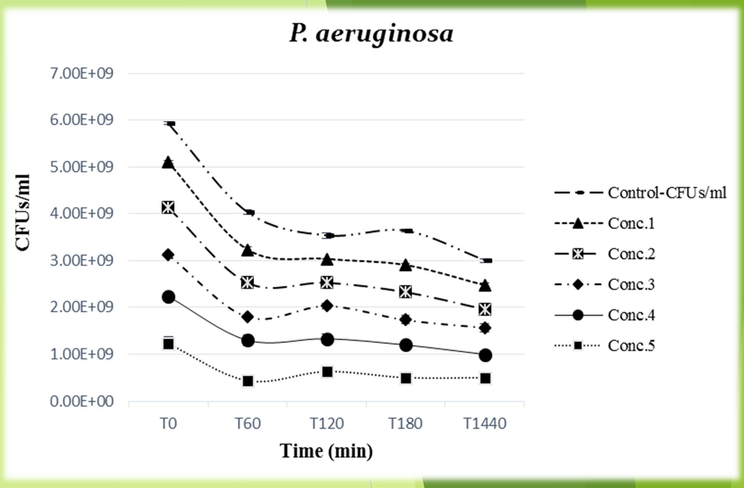

Figure.1 Effect of TiO_2 NPs (sample FW12) against *P. aeruginosa*

DISCUSSION

In this research, the ATCC strains were selected as a models to evaluate the effects of our nanoparticles. Recently, these microorganisms have been developed constitutive resistance to several classes of broad spectrum antibiotics, which became a global health problem. They did not respond to any of the available antimicrobial agents and showed actively increasing resistance to the antibiotics by a various mechanisms. Titanium dioxide (TiO_2) NPs was prepared via green synthesis technology. They are potent antimicrobial agents, which can be considered as an alternative to antibiotics for the treatment of wound infections caused by MDR bacteria. The incidence, cost, morbidity, and mortality associated with non-healing wounds are dramatic. TiO_2 NPs have unique properties resulting in the optimal possible interaction with bacterial surfaces leading to a significant antimicrobial activity.

Our finding from this project demonstrated the enhanced activity of TiO_2 NPs via studying the antimicrobial activity of the bacterial suspension with various samples at different concentrations and time.

CONCLUSIONS

Nanosized TiO_2 is finding an increasing attention in medical applications as a promising biocide against a wide range of infections. Furthermore, the possibility to tailor the antibacterial activities of the TiO_2 nanoparticles make them interesting materials for potential applications as efficient alternative therapeutic agents for multidrug resistance strains including MRSA, *E. coli* and *P. aeruginosa* that cause wound infections.

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