Antibacterial Activity of Quantum Dots for Treatment of Wound Infection

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ABSTRACT

Antibiotics are one of the most important drugs in fighting bacterial infection and have a significant role in the maintenance of public health. Wound infection is responsible for a higher percentage of morbidity and contributes to aggravate in health care costs. In recent decades, these drugs become less effective against many bacteria such as Methicillin Resistant *Staphylococcus aureus* (MRSA), *E. coli* and *Pseudomonas aeruginosa*. Therefore, to overcome the major disadvantages related to antibiotics resistance pathogenic microorganisms, developments in nanotechnology have opened new areas in nanomedicine that allow for synthesis of nanoparticles, which can be assembled into complex architectures. Using of nanoparticles with novel synthesis has economic and eco-friendly benefits and may give new source of antibacterial agent with the possible novel mechanism of action. In addition to that, inorganic antibacterial agent such as titanium and zinc have advantages over organic compound due to their stability and safety. In this study, quantum dots were synthesized, chemically and physically characterized, and their antibacterial activity were investigated. The nanoparticles were tested in a dose response strategy against three of the most common pathogenic bacteria, Methicillin Resistance *Staphylococcus aureus* (MRSA), *E. coli* and *Pseudomonas aeruginosa* that cause wound infection. The main finding of this result revealed that the synthesized quantum dots were not only are capable to kill the pathogenic bacteria in a short period of time but, they are strain specific in some cases. The impact of this project will give new strategies in treatment of wound infection.

INTRODUCTION

Wound is define as disruption of the structure and function of normal anatomy of the skin which leads to loss of protective function (Amit Kumar Gupta *et al.*, 2015). Wound can be either chronic or acute (Marja N Storm-Versloot *et al.*, 2010). It occurs due to arterial or Venus insufficiency, burn, diabetes, trauma and surgery (Marja N Storm-Versloot *et al.*, 2010). During normal homeostasis, our skin provides physical barrier that prevents bacteria from entering into the skin (Marja N Storm-Versloot *et al.*, 2010). In the same time may promote growth of commensals and beneficial bacteria that prevents over population of pathogens (Rachel Crompton *et al.*, 2016). Antibiotics are essential treatment of wound infection (Abdul R. Siddiqui and Jack M. Bernstein, 2010). Although antibiotics are effective in treating infection, human population exhibit high level of antibiotic resistance (Aydin *et al.*, 2016). Increase prevalence of antibiotic resistance with less development in antibiotic field resulting in shortage of novel classes of antibiotics that fight resistance pathogens (Kumari *et al.*, 2010). In recent years, researchers focus on using nanoparticles as antibacterial activity which can be an alternative treatment of wound infection (Kim *et al.*, 2011). There are several types of nanoparticles that can be employed as antibacterial such as: metallic nanoparticles (zinc, copper, titanium and silver) (Kim *et al.*, 2011). Introducing novel quantum dots (especially TiO_2) as antibacterial activity can control the mortality and morbidity rate of the infectious diseases (Morteza Haghi *et al.*, 2012).

The aim of this project is to investigate the antibacterial activity of TiO_2 quantum dots that synthesize with a novel way against three of the most common pathogenic strains that cause wound infection, to determine at which concentration and time TiO_2 quantum dots can inhibit growth of pathogenic strains. The impact of this project will give new strategies in the treatment of wound infection.

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*, *Escherichia coli* and *Pseudomonas aeruginosa*, which commonly caused wounds infection 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 efficient antimicrobial activity of each TiO_2 nanoparticles sample at different concentrations.

RESULTS

In this project, we were used TiO_2 quantum dot that's synthesized with novel method, seven samples were produced with different contents. Experiment was performed with different concentrations at different times to determine best effect. From our experiments, we demonstrate that, all of them showed antibacterial activity with specific concentration (µg/ml-CFUs/ml) at specific time, figure. 1 illustrates the effect of sample FW1 on *Pseudomonas aeruginosa.*

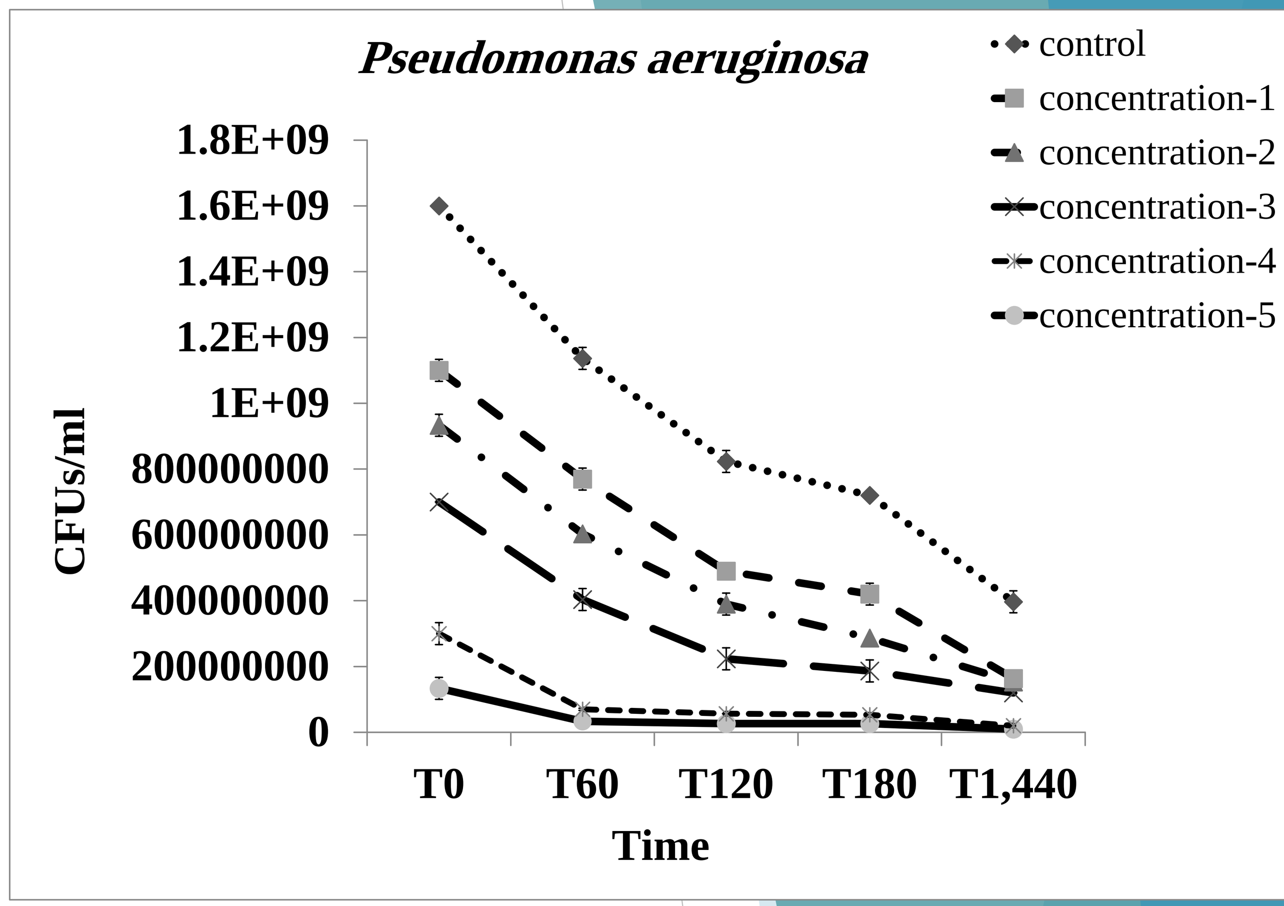

Figure1. Effect of sample FW1 TiO_2 quantum dots on *Pseudomonas aeruginosa*

DISCUSSION

During the present study, different concentrations of TiO_2 quantum dots were tested to find out the best concentration that can have the most effective antibacterial property against MRSA, *Pseudomonas aeruginosa* and *E. coli* at specific time. Good growth-inhibition results were observed when the bacterial cells were incubated with nanoparticles. These bacteria considered as most common organisms cause wound infection and nosocomial infection. Nevertheless, resistance to most of broad spectrum antibiotics. Excessive use of antibiotics has resulted in emergence highly resistant bacteria. Introducing TiO_2 quantum dots with novel synthesis can control morbidity and mortality rate of infectious disease.

CONCLUSIONS

We have developed a biosynthesis method for TiO_2 quantum dots using novel way and evaluated their antibacterial activity. This method is cost-effective and eco-friendly because no toxic chemicals were employed. There is highly desirable for the development of antibacterial material and their application in medicine, food, hygiene and the biomedical industry. These nanoparticles exhibit broad spectrum activity against bacteria and considered as a powerful antibacterial compounds. In the present study, we observed that different concentrations of TiO_2 quantum dots can inhibit growth of MRSA, *Pseudomonas aeruginosa* and *E. coli.*

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