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STUDIES ON THE DISINFECTANT ACTIVITY OF TITANIUM OXIDE NANOPARTICLES

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Abstract

In recent years, nanotechnology has experienced explosive growth. Because of their potential for attaining targeted processes and selectivity, nano-structured materials are garnering a lot of interest, particularly in the fields of biology and medicine. Nanotechnology has become one of the most practical technologies, because of unique physical and chemical features of nanoparticles. With their dazzling and intriguing optical, dielectric, and photo-catalytic features resulting from size quantization, nanomaterials like titanium dioxide nanoparticles (TiO_2-NPs) have become a new generation of sophisticated materials. Applying Nanoparticle-based formulations to their media prevents the growth of resistant bacteria. The ability of some nanoparticles to inhibit the growth of bacteria makes them promising candidates for use as antimicrobial agents. Disk diffusion technique is used to analyze the antibiotic resistance pattern of E. coli and can be performed with both liquid and agar nutritional media. The bactericidal efficacy of 0.01, 0.5, 1, and 1.5% nano-TiO_2 was determined using the optical density (OD) and the Kirby-Bauer disc diffusion test. Antibiotic resistance was observed for this strain across the board. Optical density decrease was detected with nano-TiO_2 concentration increase (0.225, 0.218, 0.158, 0.075, 0.031respectively). This was also seen in measurements of the inhibition zone. It was found that 1.5% nano- TiO_2 produced the largest inhibitory zone (5 mm). Nanomaterials are notorious for their ability to bind to electron-donating groups, such as carboxylates, amides, indoles, hydroxyls, thiols, and phosphates, and so render cellular enzymes and DNA inactive. The tiny pores they create in the cell walls of bacteria make it easier for molecules to pass through and ultimately kills the bacteria. This research shows that nano-TiO_2 acts as an effective antibacterial agent and could be put to a variety of uses.

Keywords: Antibacterial effect, TiO_2 nanoparticles, Escherichia coli, Disk diffusion technique.

Introduction

Nanotechnology has experienced explosive growth in recent years. Building blocks for progress in nanotechnology are nanomaterials research and development. Those materials whose geometric dimensions are on the nanoscale are called nanomaterials, and they have unique features. Nano oxide has received a lot of attention as a promising Nano-material [1, 2, 3]. The potential for particular procedures and selectivity in nano-structured materials, especially in biological and pharmaceutical applications [4, 5, 6], is garnering a lot of interest. Nanomaterials are hailed as a medical miracle of the 21st century. It has been reported that antibiotics are only effective against a handful of disease-causing organisms, but Nano-materials can eliminate as many as 650 cell types.

If we use Nanoparticle-based formulations in their media, resistant strains won't be able to evolve. Lab tests have shown that nanoparticles may effectively eradicate germs, viruses, and fungi within minutes of contact. As the first link in the ecosystem's food chain, bacteria are particularly sensitive to the effects of nanoparticles [8, 9]. The unique and fascinating optical, dielectric, and photo-catalytic properties of TiO2 nanoparticles (Tio2-NPs) resulting from size quantization have made them a new generation of sophisticated materials. [10] Because of its nontoxicity, photo induced super-hydrophobicity, and antifogging effect [11], titanium dioxide (TiO2) is widely used as a self-cleaning and self-disinfecting material for surface coating in many applications. These qualities have been used in self-cleaning or self-sterilizing surfaces for use in locations like hospitals [12-15], as well as in the removal of germs and hazardous organic compounds from water and air.

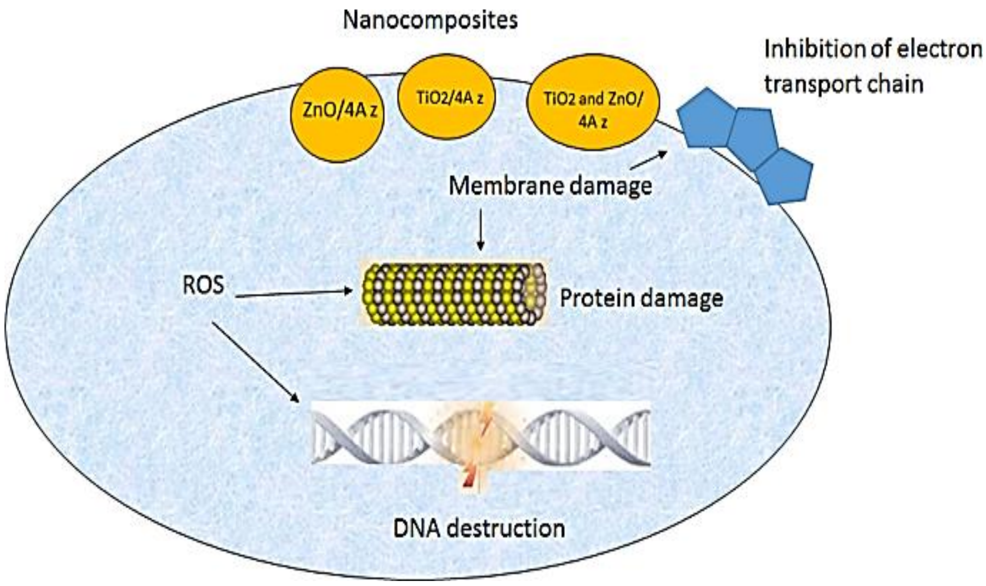

Figure 1: Antimicrobial activity of Titanium dioxide nanoparticles

Materials and Methods

This study utilized an antibiotic-resistant strain of *E. coli* that was isolated from a healthcare facility. Commercially available TiO_2 nanoparticles (particle size: 60 nm) were suspended in distilled water and sonicated for 15 minutes before to use (7). Various concentrations were made, from 0.1% to 1.5%. The same was taken for bactericidal efficacy.

Antibiotic resistance pattern of *E.coli*

The Kirby-Bauer Disk Diffusion Method was used to analyze the resistance pattern of bacteria cultured in Muller-Hinton Media to Tetracycline (TE), Penicillin (G), Amoxicillin (AMY), Ceftriaxone (CRO), Chloramphenicol (C), and Tobramycin (Tob).

Antimicrobial Effect of TiO_2 in Liquid media

100 ml of nutritional broth containing 0.01%, 0.5%, 1%, and 1.5% TiO_2 was inoculated with E. coli overnight and then left to grow at 37°C. The bacterial concentration was analyzed by measuring the optical density at 600 nm.

Antimicrobial effect of the TiO_2 in solid Media

Kirby Bauer disk diffusion technique was used to generate antibiogram disks containing 0.01, 0.5, 1.0, and 1.5 percent TiO_2 and then inoculated with bacteria cultivated in Muller-Hinton Medium. The disks were incubated at 37°C for 18 hours after being placed on the media.

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Results

In this investigation, antibiotic resistance was observed in *E. Coli* across the board. Increasing concentrations of nano- TiO_2 resulted in decreasing Optical Density (OD) (0.225, 0.218, 0.158, 0.075, 0.031). Measuring the size of the inhibition zone, it was found that as the concentration of TiO_2 was raised, so too was the size of the inhibition zone. (0, 0.2, 2.5, 3.0, 5.0) accordingly (figure 2 &3).

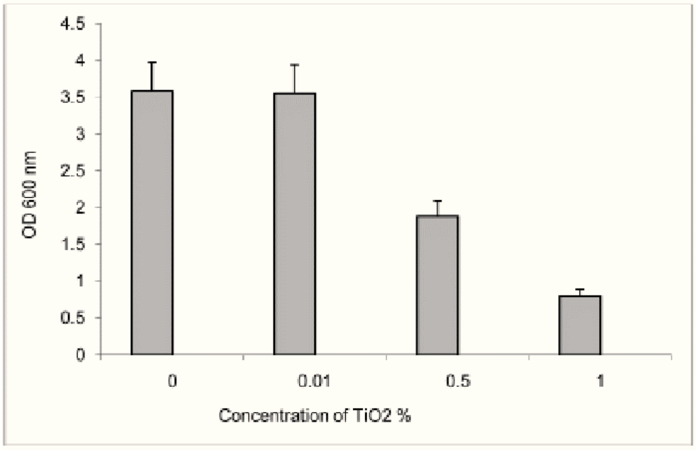

Figure 2: *E. coli* Density in different TiO_2 concentrations.

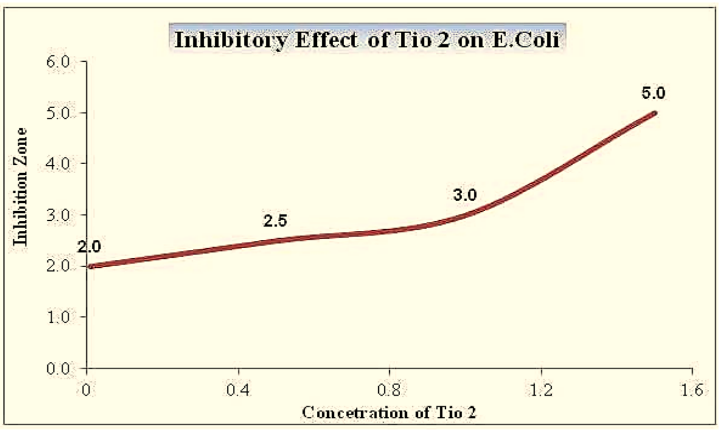

Figure 3: Inhibition Zone of different concentrations of TiO_2

Discussion

Different concentrations of TiO_2 were tested for their antibacterial effects in this investigation. Most broad-spectrum antibiotics are ineffective against E. coli, which is a major cause of nosocomial infections. Due to over usage of the antibiotics, Antibiotic resistance of bacteria is dramatically enhanced. To reduce the toll that infectious diseases have on human

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life, [16] researchers have found that introducing new antibacterial medicines is effective. Inhibitory effects of Nano-Materials against a wide variety of bacterial strains are well documented.

Conclusions:

The electromagnetic attraction between the microbes and the metal oxides is thought to be what causes the oxidation and eventual death of the bacteria, and various investigations support this theory. [17] By coordinating to electron-donating groups like thiols, carboxyls, amines, indoles, hydroxyls, etc., nanomaterials may also inactivate biological enzymes and DNA. Due to the pits, they create in bacterial cell walls, bacteria are more easily damaged or killed. [18] Using an antibiotic-resistant E. coli strain, we demonstrated that varying doses of Tio2 might stunt its development. TiO_2 could be utilized as an effective disinfectant in hospitals, which is especially important because resistant strains can spread quickly and infect surgical incisions and burn victims. Nano materials, such as TiO_2, are being used in the textile industry to create cotton fabrics with an antibacterial effect [19], which suggests that employing such fabrics in the production of sutures or wound bands could help reduce the incidence of infection in patients.

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