Abstract No: MO-15

Visible light sensitized antibacterial paint using copper doped TiO_2 nanoparticles

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Bacteria can survive on surfaces increasing the possibility of transmission of diseases. Places such as food-processing facilities, restrooms, and hospitals have a high risk and require some additional protection against bacteria. Paints can be an attractive antibacterial method boosting their value as a coating and eliminating the need for additional antibacterial methods on surfaces. Titanium dioxide (TiO_2) nanoparticles would be the ideal antibacterial material to be incorporated to produce antibacterial paints, due to their photocatalytic, chemically stable, non-toxic properties and low cost. The antibacterial activity of TiO_2 results from its photocatalytic activity. However, due to its wide bandgap (3.2 eV) and fast recombination rate of photogenerated species, TiO_2 is activated only under high energy radiation such as ultraviolet radiation. The ultraviolet radiation accounts for nearly 3% and visible light for 45% of the solar radiation at ground level of the Earth. Modifying TiO_2 nanoparticles into a visible-light sensitive material, would make TiO_2 nanoparticles and the paint a self-activating antibacterial material. Reducing the bandgap is the best way to do this modification and, in this project, copper has been doped into the TiO_2 nanoparticles to reduce the bandgap (the band gap was reduced to 2.5 eV). Sol-gel technique was used to synthesize and dope the nanoparticles. Pure and 3%wt Cu-TiO_2 nanoparticles were synthesized. X-ray fluorescent (XRF) data was used to confirm the doping concentrations of the synthesized Cu-TiO_2 nanoparticles as 3%wt. X-ray diffraction (XRD) data was used to identify the phase of the nanoparticles as anatase. Using UV-visible spectroscopic data, the radiation absorption of the nanoparticles was observed to be shifted from 190×10^{-9} m to 350×10^{-9} m with the copper doping. The scanning electron microscopic (SEM) data confirmed that the particle sizes were in nanometer range both for pure and doped samples. Antibacterial activity of the paints was tested using agar well diffusion method with the visible light and without the visible light against the bacteria *Escherichia coli* (Gram-negative) and Methicillin-resistant *Staphylococcus aureus* (Gram-positive). The inhibition zones (clear circular area in which bacteria are unable to grow, around antimicrobial wells) of Ciprofloxacin (C17H18FN3O3) (a well-known antibiotic) was compared with the inhibition zones of paints. The unmodified paint showed 0.2 and 0.1 of the antibiotics' effect against Gram-positive and Gram-negative bacteria, respectively. Addition of TiO_2 increased it up to 0.27 and 0.27. Exposure to the visible light increased it further up to 0.3 and 0.3. Addition of Cu-TiO_2 increased it to 0.47 and 0.5. Exposure to visible light has increased it further to 0.57 and 0.63. The standard deviation of these values was 0.18. Copper doped TiO_2 has significantly increased the antibacterial activity of the paint against both types of bacteria. A better effect was observed in the visible light as compared to the condition without the visible light.

Keywords: Antibacterial, Bandgap, Solar radiation, Titanium dioxide