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Synthesis and Antimicrobial Activity of Azobenzene Based Titania Nanoparticles Coated Cotton Fibers

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ABSTRACT

In this paper, we report the synthesis of a highly photocatalytic titanium dioxide nanoparticles bonded with azobenzene and cotton by simple sol-gel method. The synthesized azobenzene based titania nanoparticles coated cotton fibers were characterized using UV-visible and SEM and reported their antimicrobial activity. It was observed that the presence of titanium dioxide bonded with azobenzene effectively prevents both the cotton fibers from getting contaminated.

KEYWORDS

Azobenzene, Nanopatarticles, Band gap, Photocatalytic, Antimicrobial activity.

INTRODUCTION

Antimicrobial materials that are compatible with the biosystem of any being (human and animal alike) internally and externally (in contact within the body or over the body) could be used as a potential candidate for designing fabrics which in turn could be used to develop smart textile materials [1,2]. These smart textile materials are much needed in controlling infections which in turn prevent miniscule allergies to life threatening allergies in sensitive environment like hospitals, rescue camps, *etc*. The materials with such stability and multidimensional applications are feasible by incorporating or conjugating or embedding photocatalytic nanoparticles within the structures of the fabric used for producing the textile products; provided the nanoparticles are proven safe for the beings of the environment if they are to be leached out of the fabric due to any failures (induced or accidental). The prominent nanomaterials that possess sufficient and safe photocatalytic properties have been reported [3-6] and the same have been suggested for various smart textile applications. Most of the applications suggested and discussed were focused on medical, life science and baby care domains. Apart from the need of smart textile products for medical and health care environments, biomedical waste management requires the most needed attention. The management of biomedical waste is a problem that requires utmost care, inspection and technology; for, an outbreak or an abuse with respect to the same could cause havoc resulting in irreparable damages to lives and environment. Bacteria, viruses, fungi, arachea, protozoa's existence in the environment will affect an individual with common symptoms. Since all the infections begins (the on-set) with a similar set of symptoms, the delay in early diagnosis or a mislead diagnosis (zeroing on viral instead of fungal) followed by the treatment for the same (in form of antiviral drugs or antibacterial) would result in severe damage to liver or even cause a total shut down of the vital organs. Either way, the chances for the infection to spread is higher. Hence, necessary precautions to keep the environment safe from any dangerous microbes are must and most needed one. The best solution for the biomedical waste management could be using highly photocatalytic metal oxide nanoparticles to curb the infection as well as accelerate the degeneration of the waste. But a complete eradication of the microbes from the biomedical waste would result in a total absence of the most important/needed degradation process. Hence, the only solution is to use a material that has a tuned or programmed photocatalytic activity.

Azobenzene is widely regarded as the most versatile photochrome, whose isomerization could be fixed and exploited to achieve/induce a shape memory property within any other material. The translation of the nano level *cis* to *trans* isomerization can be enacted in the bulk too; with suitable engineering concepts [7,8]. Azobenzene have been reported for their advantageous role in developing photoresponsive gate materials for transistors [9,10]. These photochromes can also be used as a functionalizing agent to modify or program the properties of any metal oxide when they are treated/exposed to UV radiation. A similar work was attempted and the same have been communicated in this research communication. This paper deals with, the effect of azobenzene functionalized TiO_2 in preventing microbial growth as well as in treating biomedical waste.

EXPERIMENTAL

Individual TiO_2 nanoparticles were synthesized by the reported method [11]. Necessary modifications with respect to the stirring rpm, centrifuging, temperature, washing residue, drying overnight were modified due to the laboratory and equipment constraints.

The synthesized TiO_2 nanoparticles were soaked in 50 mL of ethanol solution with 0.1 M of azobenezene. The TiO_2 nanoparticles soaked in 50 mL ethanol solution with 0.1 M of azobenezene is incubated at 45 °C, till the ethanol is completely evaporated. The dry TiO_2 with reddish orange shade azobenzene is grinded using a mortar and pestle. The grinded TiO_2 was annealed at 450 °C to obtain anatase phase TiO_2 functionalize with azobenzene.

Electrospun PMMA nanofibers were placed over a cotton substrate and the TiO_2 functionalized with azobenzene was sprinkled over the PMMA nanofibers. The cotton with PMMA nanofiber layer and functionalized nanoparticles were hot pressed using a non-stick ceramic plate with a holding time of 10 sec at 60 °C. The cotton substrate was then dried and subjected to characterizations and antimicrobial activity tests.

Characterizations: UV-visible and SEM were performed to study the photocatalytic property and structural morphology, respectively followed by interaction of the synthesized material with bacterial colonies i) grown on a petri dish ii) grown on biomedical waste-tissue used to clean blood[#].

RESULTS AND DISCUSSION

UV-visible: UV-visible spectra (Fig. 1), it can be observed that the prepared functionalized material possess good photocatalytic property. From the obtained data, multiple absorptions could be noticed in azobenene functionalized TiO_2 nanoparticles when compared to pure TiO_2 nanoparticles. This is due to the presence of both $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ and their existence is proportional to the azobenzene func-tionalization. The band gap of the functionalized TiO_2 was found to 2.79 eV, using the formula: Energy (E) = h*C/λ.

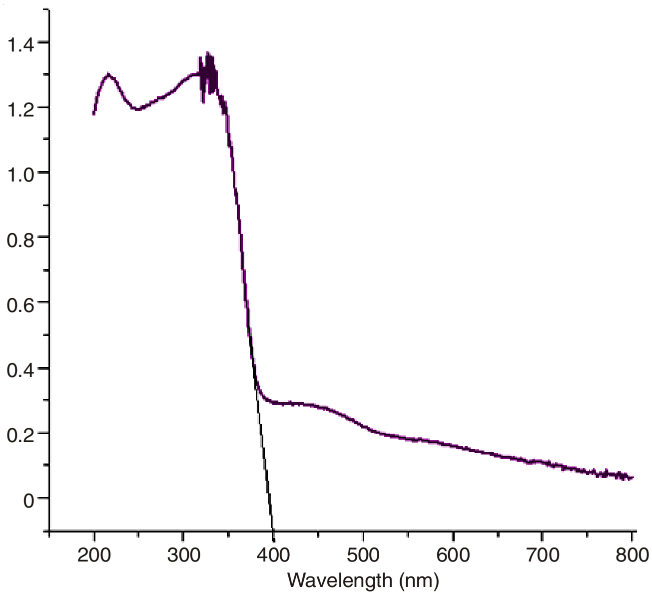

Fig. 1. UV-visible spectrum of azobenzene funcitonalized TiO_2

The UV-visible for the functionalized TiO_2 nanoparticles was repeated again for the same sample to record the loss of or drop in the photocatalytic activity for every 30+ h. No considerable change was noticed after 90+ h of shelf life. This could be due to the compact adsorption of azobenzene molecules towards the surface of TiO_2 nanoparticles.

SEM: Fig. 2 (SEM picture) showed that the particles were almost spherical and are of nearly uniform dimension. The dimensions of the particles were found to be around 200 nm.

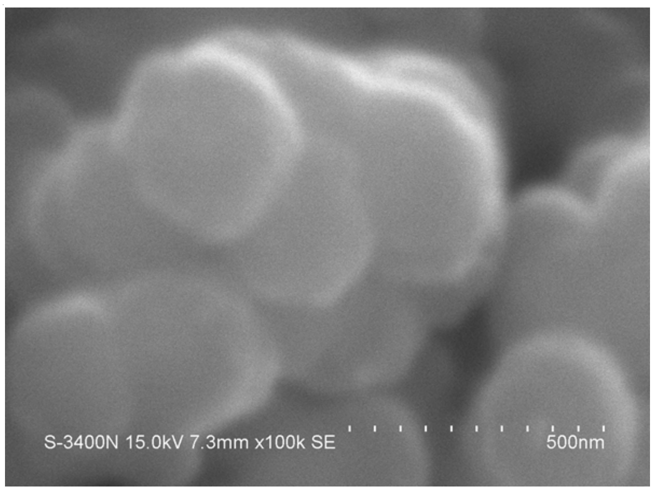

Fig. 2. Morphology of azobenzene functionalized TiO_2

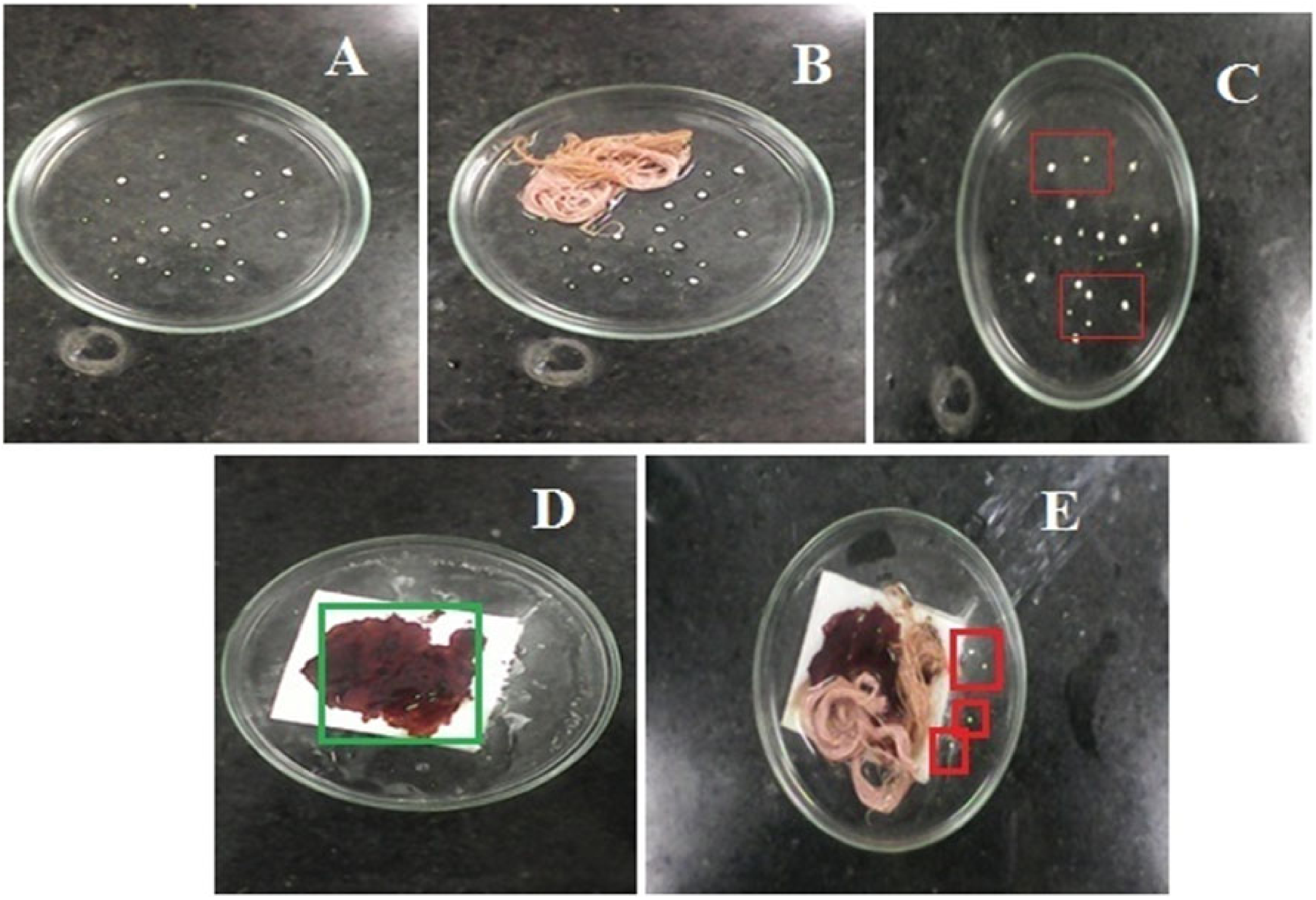

Fig. 3. (A) The bacteria, (B) azobenzene functionalized cotton fibers in interaction with the bacteria, (C) Absence of replication of the colonies, (D) a biomedical waste, blood on tissue with bacteria, (E) Absence of growth of bacteria on the waste but growth of bacterial colonies outside the reactive surface was noticed after 20 h

Antibacterial/antimicrobial tests: The prepared functionalized TiO_2 was adhered to a cotton substrate using freshly prepared PMMA nanofibers. The PMMA nanofibers, like a dye, will stay intact with the cotton fibers and will also prevent or slow down leaching of TiO_2 from cotton. Bacteria isolated from random environmental wastes were cultured in laboratory under laboratory temperature in a petri dish followed by culturing the same bacteria in another petri dish with biomedical waste. The cotton fibers coated with functionalized azobenzene TiO_2 nanoparticles were introduced into the petri dish with developed colonies of bacteria and the entire set up was positioned in a common environment where minimum to maximum sun rays would fall within a duration of 4 h.

The key results obtianed during the study are presented in Fig. 3.

After 4 h of exposure to minimum to maximum sun rays, the azobenzene functionalized TiO_2 nanoparticles coated cotton substrate was successful in destroying the bacterial colonies, in both the normal petri dish and in the petri dish with biomedical waste. The petri dishes were left untouched under a clean environment with a frequent monitoring only to prevent an outbreak of the bacteriae. It was noticed that, the petri dish did not contain any bacterial colonies after a day and there were no more new colonies for almost the next 48 h.

Conclusion

Thus, cotton substrates with antimicrobial activities were developed using simple sol gel methods and the same have been characterized to understand their optical band gap, morphology and antimicrobial activity. From the antimicrobial activity experiment and results, it can be concluded that the cotton coated with azobenzene functionalized TiO_2, can be used to control growth of bacteria in an environment. The same material could be further engineered into fabrics that can be used to make curtains, mattresses *etc*. in environment like hospitals and clean rooms. A detailed toxicological result can pave way for using the same material in developing antibacterial wearable textile materials.

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