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MULTICENTRIC STUDY CONDUCTED BY INDIAN MEDICAL ASSOCIATION TO TEST THE ANTI-MICROBIAL EFFICACY OF PHOTOCATALYSTS IN INDIAN SCENARIO

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Abstract- Earlier advancements in nanotechnology have brought to the development of photocatalysts, which offer hope in the regulation of infectious microorganisms through advanced disinfection methods. This study reports the antimicrobial efficiency of photocatalysts in a general office indoor and in a hospital scenario. The antimicrobial efficacy of visible light based photocatalytic devices was tested against bacteria from air and various surfaces from three rooms, one on each ground floor, first floor and second floor in the Indian Medical Association (IMA) premises before the installation of the devices and at intervals of 24, 48 and 168 hours after the installation. Another similar study was conducted by IMA in National Heart Institute (NHI) to test the photocatalyst efficacy in a hospital scenario. In NHI three locations were selected for this study, isolation room in Intensive Critical Care Unit (ICCU)-3, deluxe room-205, washroom of deluxe room-205. Sterile conditions were recorded following the installation, which proved beyond reasonable doubt that photocatalytic devices were capable of excellent disinfection.

I. INTRODUCTION

According to Rekha et al, the prevention of infectious diseases largely depends on maintaining a sterile environment through environmental disinfection. Lately, opportunistic bacteria found in the environment have led to the outbreak of diseases in different settings. In addition, the rising cases of microbial resistance to the available chemotherapeutic agents and disinfectants hamper the creation of novel disinfectants. As a result, the ability to control and get rid of infectious microorganisms is of paramount importance to many establishments such as healthcare facilities, food and beverage industries and water treatment plants. The ability of photocatalytic substances, for example, titanium dioxide (TiO2) to disintegrate organic contaminants in the air and water has been established by Verdier et al[4].

Studies by Bonetta et al. have shown that the rutile and anatase forms of TiO2 have photocatalytic activity and are active against various Gram-positive bacteria, Gram-negative bacteria, yeast and green algae such as Lactobacillus acidophilus, Escherichia coli, Saccharomyces cerevisiae and Chlorella Vulgaris[5]. There are two key traits that make TiO2 ideal in the manufacture of building materials. They include photo-stimulated redox reactions of adsorbed materials and the photo-generated hydrophilic exchange of TiO2. Motta, Strini, & Carraro said Titanium dioxide is deemed as an inactive and safe material and has been used in many functions including the manufacture of several products such as paint, used as a food additive, nutritional supplements, sunscreens and other cosmetics such as Baby Blanket Sunblock LotionTM for babies as well as in ArbonneTM and MaybellineTM products. However, Matafonova, Batoev & Linden, said that the use of titanium dioxide as a color additive in food is under the regulation of the USFDA. The weight of TiO2 should not surpass 1% by weight of the food. In addition, foods containing such colorant should state so explicitly on their labels.

Based on various observations by Bonetta et al, IMA (Indian Medical Association) has conducted a pilot study in their own office and National Heart Institute to test the antimicrobial efficacy of photocatalysts. The authors of this paper report that the product under testing is certified as safe for use by National Toxicology Center (NTC) Pune. The safety of the product has been established through oral, dermal and intranasal (inhalation) and routes of exposure. This paper reports the finding of Lifeline laboratories about antimicrobial efficacy of photocatalysts in inhibiting the growth of microorganisms in Indian Medical Association premises and National Heart Institute.

II. METHODOLOGY

A. In Indian Medical Association premises:

The room air cultures as well as door handle and table top swabs were taken in three rooms on ground, first and second floors of Indian Medical Association premises before the treatment to assay the total viable count of bacteria. The surface swabs were taken by moistening swabs in normal saline followed by streaking on culture plates to determine total viable count on the different surfaces in the three rooms. Photo-catalytic devices based on visible-light illumination, which were procured by Indian Medical Association after conducting an extensive market research, were then installed in the three rooms. Thereafter, air cultures, door handle swabs, and table top swabs were taken from the three rooms after 24 hours, 48 hours, and 168 hours following the installation of the photocatalytic devices. The swabs were plated to determine the viable counts of bacteria.

B. In National Heart Institute:

The air cultures were taken from all the three areas under investigation: Isolation room (ICCU-3), Deluxe room—205 and washroom of deluxe room-205. The surface samples were

taken from: bed railing, tabletop and door handle of the isolation room and deluxe room-205. From washroom of deluxe room samples were taken from door handle and washroom tap before the treatment to assay the total viable count of microorganisms. The surface samples were taken by moistening swabs with normal saline followed by streaking on culture plates to determine total viable count on the different surfaces in the three areas. Photo-catalytic devices based on visible-light illumination, which were procured by Indian Medical Association after conducting an extensive market research and the same were provided to National Heart Institute for study. These photocatalytic devices were then installed in the three areas under study. After that, air cultures and surface samples were taken from all the three rooms after 24 hours, 48 hours, and 168 hours following the installation of the photocatalytic devices. The swabs were plated to determine the viable counts of bacteria.

III. RESULTS

It was observed that the air samples had more than 10^4 cfu (colony forming units) of bacteria before the installation of the photocatalytic devices. The door handle and table top cultures, on the other hand, had more than 10^5 cfu of the same bacteria. However, 24 hours after the initiation of treatment, the surfaces were found to be sterile with no traces of bacteria. The sterile conditions were also recorded at 48 hours and 168 hours following the installation of the devices in all the rooms. The findings are summarized below (Table 1).

Table 1: Total Viable bacterial count (CFU) in three rooms before and after the installation of visible light based photocatalytic devices

Time	Ground Floor			First Floor			Second Floor		
	AC	DH	TT	AC	DH	TT	AC	DH	TT
0 hours	$>10^4$ cfu	$>10^5$ cfu	$>10^5$ cfu	$>10^4$ cfu	$>10^5$ cfu	$>10^5$ cfu	$>10^4$ cfu	$>10^5$ cfu	$>10^5$ cfu
24 hours	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
48 hours	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile
168 hours	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile	Sterile

A. Observations in National Heart institute:

It was observed that in deluxe room-205 the air samples had more than 10^5 cfu (colony forming units) of bacteria before the installation of the photocatalytic devices. The door handle had more than 10^5 cfu and the table top cultures had more than 10^2, on the other hand, had more than 10^3 cfu of the bacteria on the bed rail. The wash room showed more than 10^4 colonies in the air culture, more than 10^2 cultures in the door handle and more than 10^3 for the washroom tap. However, 24 hours after the initiation of treatment, the surfaces were found to be sterile with no traces of bacteria in **Deluxe room-205 and washroom room.** The hygienic conditions were also recorded at 48 hours and 168 hours following the installation of the devices in all the rooms and the result showed that they were still sterile. The observation for the **isolation room,** bed rail showed more than 10^4 cfu. Moreover, the door handle maintained the same cfu after 24 hours while the bed rail showed an increase to 10^5 cfu after 24 hours. Later treatment in the two cultures showed sterility. The air culture and the table top were sterile for the rest of treatment after 24 hours. The findings are summarized below

Appendices Observations

Appendix 1: Observations in Deluxe room-205, National Heart Institute

Sr. no.	**Area**	**Microbial load Before Hygia treatment (in cfu)**	**Microbial load After 24hours (in cfu)**	**Microbial load After 48hours (in cfu)**	**Microbial load After 168hours (in cfu)**
1.	Air culture	>10^5 colonies of contaminants	sterile	sterile	sterile
2.	Door handle	>10^5	sterile	sterile	sterile
3.	Table top	10^2	sterile	sterile	sterile
4	Bed railing	10^3	sterile	sterile	sterile

Appendix 2: Observations in washroom room, Deluxe room-205 in National Heart Institute

Sr. no.	**Area**	**Microbial load Before Hygia treatment (in cfu)**	**Microbial load After 24hours (in cfu)**	**Microbial load After 48hours (in cfu)**	**Microbial load After 168hours (in cfu)**
1.	Air culture	>10^4 colonies of contaminants	sterile	sterile	sterile
2.	Door handle	10^2	sterile	sterile	sterile
3.	Washroom tap	10^3	sterile	sterile	sterile

Source. National Heart Institute

Appendix 3: Observations in isolation room, ICCU-3 in National Heart Institute

Sr. no.	Area	Microbial load Before Hygia treatment (in cfu)	Microbial load After 24hours (in cfu)	Microbial load After 48hours (in cfu)
1.	Air culture	>10^5	Sterile	sterile
2.	Door handle	>10^5	10^5	sterile
3.	Table top	>10^5	Sterile	sterile
4	Bed railing	>10^4	10^5	sterile

Source. National Heart Institute

IV. CONCLUSION

In this study, the efficiency of visible light based photo-catalytic devices in the elimination of bacteria and maintaining sterile conditions was tested in multiple locations including a general office scenario and in a healthcare setting. Previous studies have confirmed the antimicrobial activity of photo catalytic particles in solution form. In addition, previous studies have used ultra-violet based photo catalytic devices while others have used solar light irradiation this is according to Rekha et al [1], Gamage & Zhang[2], Hajipour et al[3] and Hashimoto et al[4]. However, in this study, it was shown that the antimicrobial activity is demonstrated by installing visible-light based photo catalytic devices. Shanga et al[5], sunada et al[6], Evans & Sheel[7] and Foster et al[8] have conducted several studies that demonstrate this , it is proposed that the nanoparticles from the devices disrupted the integrity of the bacterial membranes as proposed by Sunday[9], Wanatabe[10], and Hashioto[11]. This is in accordance with a study conducted by According to Indian Standard[12], U. S. FDA[13] and GoodGuide[14]

From this study it can be concluded that the devices demonstrated their ability to sterilize the air and all surfaces coated with the same photo catalytic formulation in areas under the illumination of the devices. This study shows that the visible light based photocatalytic devices are able to maintain sterile conditions in all locations under test and these findings offer promising solutions to disinfection techniques, which may see to it that incidences of infectious diseases are under control.

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