AUTOMATIC ANTIBACTERIAL CLOTHES DRYER SYSTEM UTILIZING ULTRAVIOLET (UV) LAMP

Khin Mar Win[1], Tun Soe[1] & Nan Thazin[2]

Abstract

The antibacterial clothes dryer system is designed and constructed for killing the bacteria which make the bad smell in clothes. The system contains the clothes holder attached with motor dryer and ultraviolet (UV) lamp with a keypad lock. It is also designed to control the bacterial killing time and drying time of the wet clothes. The hardware of the lock system is designed and simulated by the Proteus 8.6 software and it is constructed by using PIC16F887 microcontroller, an 8 MHz crystal oscillator, 4×4 keypad, 16×2 LCD module, ultraviolet (UV) antibacterial Lamp, piezo sounder, relay, some active and passive components. The firmware for the lock system is written by Mikro Basic Pro programming language. The system permits to operate the UV antibacterial lamp for twenty minutes and motor dryer for thirty minutes as the instruction of the controlled program as soon as the keypad lock is unlocked. The presence of bacteria in clothes is observed by EC-1001-P-HLED Eco Blue microscope. The observation results show the antibacterial process in clothes is very effective by using ZW30S19W UV lamp.

Keywords: PIC16F887, 8 MHz crystal oscillator, Ultraviolet (UV) antibacterial Lamp, 16×2 LCD, Mikro Basic Pro programming language

Introduction

A clothes dryer is a well known appliance intended to be dried the clothes. The internal temperature of the clothes dryer is above the room temperature and it dries the wet clothes in a short time interval. Ultraviolet (UV) light has been known, to kill the bacteria by destroying some of the bacterial organisms. UV light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays, in the range 10 nm to 400 nm, and energies from 3 eV to 124 eV. A UV lamp is a source of germicidal ultraviolet radiation. A cylindrical instant start UV lamp emitting a wavelength of 253.7 nm is considered suitable for use in the present research work. Although literature on UVC damage is scarce since it is relatively benign in the natural form, it is the most dangerous form industrially. It can cause damage to eyes in as little as 3 seconds and DNA damage to all biological surfaces. The UV light created by human is very dangerous when it directly deposits on the eye or skin, especially child. The most common injuries of UVC are corneal burns and erythema or severe skin burns and excessive exposure to UVC causes skin cancers as UVA and UVB. Chronic exposures to acute intense UVC can lead to cataract formation and retinal damage [Mofidi, A. A. (2001)]. The UV hazards are listed in Table (1).

UV light is preferably housed within an impact resistant housing which includes a UV reflecting surface that functions to protect the light and to direct the UV light generally downward, e.g. to cast the light outside the cabinet [Katara G. (2008)]. By providing UV lamp to be full and complete distribution of UV light throughout the clothes dryer makes the efficient bacteria killing process. There is also a control system which controls the specified period of the illumination of the UV light and automatically turn off the function of the system. The system is used in killing bacteria in clothes that make the bad smell in clothes. The basic idea of

[1] Dr, Associate Professor, Department of Engineering Physics, Mandalay Technological University
[2] Dr, Professor, Department of Engineering Physics, Mandalay Technological University

microcontroller is to collect all the input and output peripheral in one single circuit and it is suitable for this research work. The system design is to construct a clothes dryer with antibacterial system and to kill the bacteria from clothes with ultraviolet (UV) antibacterial lamp. The block diagram of the automatic antibacterial clothes dryer system is as shown in Figure (1).

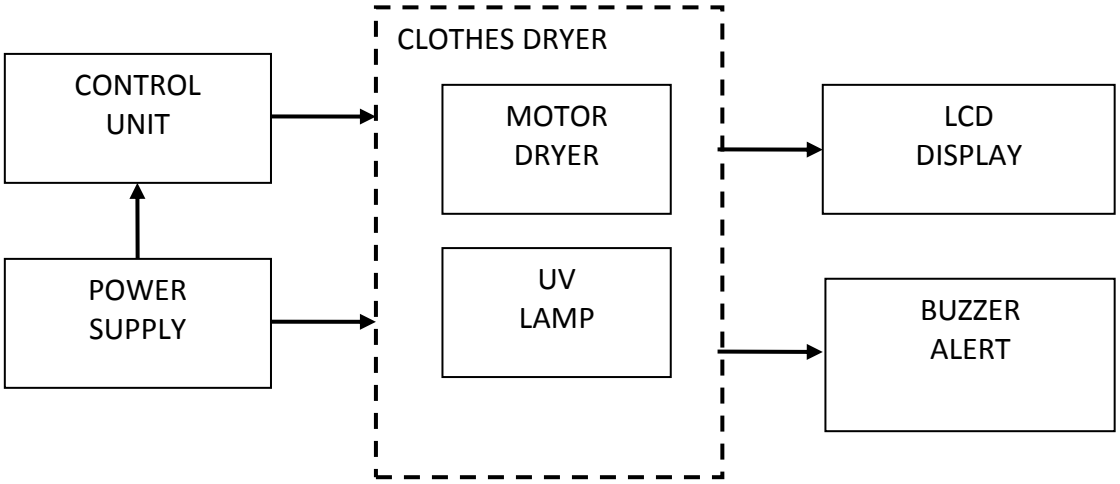

Figure 1 Block diagram of automatic antibacterial clothes dryer system

Table 1 UV hazards

Band	Wavelength	Primary Visual Hazard	Other Visual Hazards	Other Hazards
UV-A	315-400nm	cataracts of lens	skin cancer, retinal burns	
UV-B	280-315nm	corneal injuries	cataracts of lens, photokeratitis	erythema, skin cancer
UV-C	100-280nm	corneal injuries	photokeratitis	erythema, skin cancer

Materials and Method

UVC lamp

Mercury UVC devices use low-pressure mercury gas bulbs that primarily emit a strong narrow band of the UVC spectrum at 253.7 nm. The UVC lamp can be applied in disinfection kitchen cabinet, microwave oven and air condition etc. They are also used in hospital, school, hotel, home and office to disinfect. In this research work, ZW30S19W UV lamp is used according to the technical parameters as shown in Table (2). The photograph of the ZW30S19W UV lamp is as shown in Figure (2) and it is made up of pure quart glass materials filled with mercury.

Table 2 Technical parameters of ZW30S19W UV lamp

Parameters	**Specifications**	**Parameters**	**Specifications**
Diameter	19 mm	Power	30 W
Length	894.6 mm	UV intensity	107 μW/cm^2
Voltage	129 V	Wavelength	253.7 nm
Current	300 mA	Life span	8000 h

Ultraviolet Disinfection Testing

Antibacterial agents inhibit the growth of bacteria and may rapidly kill them by disrupting one or more of their essential cellular functions. Depending on the type of antibacterial agent, the mechanism of activity may result in: inhibition of the production of proteins or cell wall materials, inhibition of DNA replication, and disruption of cell membrane activities that maintain chemical balance. In bacteria killing process, the UV light penetrates the cell walls of bacteria, virus and protozoa as shown in Figure (3). The UV energy permanently alters the DNA of the microorganism. Microorganisms are inactivated and unable to reproduce or infect after depositing the UV light.

Design and Construction of the System

The constructed keypad based secure ultraviolet (UV) antibacterial lamp system comprises the control unit, the input unlock unit, and the ultraviolet (UV) antibacterial lamp unit including clothes holder with UV reflection system. The clothes dryer holder is designed to make cabinet based on foldable metal frame and the waterproof cloth in dimension (90×48×48) cubic centimeter. The inner waterproof walls are covered with silvery UV reflecting clothes with the purpose of reflecting the UV light inside the cabinet. The photograph of the constructed antibacterial clothes dryer is as shown in Figure (4).

The UV light created by human is very dangerous when it directly deposits on the eye or skin, especially child. Because of this fact, it needs to operate by an authorized person who can handle it safely. Only this authorized person know the input password of this system can prevent the unnecessary danger from harmful UV light. The controlled circuit connection of PIC16F887 microcontroller is tabulated in Table (3).

Table 3 Controlled circuit connection of PIC16F887 microcontroller

PIC16F887	**Controlled Circuit**	**PIC16F887**	**Controlled Circuit**
pin#1($\overline{MCLR}$)	LCD VDD	pin#27(RD4)	Keypad R0
pin#8 (RE0)	speaker	pin#28(RD5)	Keypad R1
pin#19 (RD0)	Keypad C0	pin#29 (RD6)	Keypad R2
pin#20 (RD1)	Keypad C1	pin#30 (RD7)	Keypad R4
pin#21 (RD2)	Keypad C2	pin#33 (RB0)	LCD D4
pin#22 (RD3)	Keypad C3	pin#34(RB1)	LCD D5
pin#25 (RC6)	Motor dryer	pin#35(RB2)	LCD D6
pin#26 (RA7)	UV lamp	pin#36(RB3)	LCD D7
pin#12, 31 (VSS)	Ground	pin#37(RB4)	LCD RS
pin#11,32 (VDD)	Power	pin#38(RB5)	LCD EN

The Operation of the Lock Circuit

The hardware of the lock circuit operates according to the instruction sets of the controlled program. The program starts with blinking "Hello!" word three times and asking for “Enter Password". Enter the password and press "OK" key. If the user can enter correct password, the Green LED will ON and LCD will display "Correct". If the entered password is incorrect, LCD will display “Incorrect..." "Try Again" and the Red LED will ON.

User can press "Undo" key to delete the entered error key. If password is correct, LCD will show Port pins in first row as 1 2 3 4 5 6 7 8 and in second row as 0 0 0 0 0 0 0 0. The user can press any key if he wants to open and/or close. The password is 12345678. If the entered password is wrong 3 times, and then the alarm will activate. The printed circuit design for antibacterial clothes dryer is as shown in Figure (5). The simulation screen capture and the lock circuit are shown in Figure (6). The program flow is as shown in Figure (7).

Discussion

The American Conference of Governmental Industrial Hygienists (ACGIH) recommended exposure limits 1.0 J/cm^2 for periods lasting less than 1000 seconds, and 1.0 mW/cm^2 for periods lasting greater than 1000 seconds. For UVC, threshold limit values are 250 mJ/cm^2 at 180 nm and 3.1 mJ/cm^2 at 275 nm. At certain wavelengths, UV is mutagenic to bacteria, viruses and other microorganisms. Particularly at wavelengths around 260-270 nm, UV breaks molecular bonds within microorganism DNA, producing thymine dimers that can kill or disable the organisms.

Mercury-based lamp, ZW30S19W emits UV light at the 253.7 nm line and we choose it for antibacterial agent. The design and implementation of Ultraviolet (UV) antibacterial lamp control system is presented practically with photos and demonstration circuit. The circuit can provide effective bacteria killing system for the clothes by using ZW30S19W UV antibacterial lamp. The disinfection process on napkin by ZW30S19W UV lamp for twenty minutes (1200 seconds) is as shown in Figure (7). The results are observed by Eco Blue microscope (EC-1001-P-HLED) of set up arrangement with (1000×) magnification as shown in Figure (8). According to the observation and results as shown in Figure 9 (a-d), it is found that the constructed UV antibacterial system is very effective in killing bacteria.

The UVC is dangerous for skin so that all exposed skin should be covered with opaque material including face, neck, head, hands, and arms when the system is operate. It is difficult to do so, to overcome this difficulty, the UV lamp is installed in a fully covered or envelope cabinet. The inner walls of the cabinet are designed by UV reflecting surfaces. The application of UVC in this research work follows the UVC guidelines and information for the safe use of Ultraviolet Radiation.

Conclusion

The purpose of this research work is just want to kill the bacteria in clothes and don’t want to get any harmful effect. But the ultraviolet light, UVC is danger for human when it exposed to eye and skin. The constructed system is designed that the UV light is not allowed to reach the outside of clothes holder and it can just reflect inside the clothes holder. The clothes holder is foldable and it contains a heater beneath floor. It takes thirty minutes to dry the wet clothes and twenty minutes (1200 seconds) to kill the bacteria inside the clothes holder.

Therefore, the time to dry the clothes is sufficient time to kill the bacteria in clothes. The clothes holder has three clothes hangers in it and it can kill bacteria in three clothes simultaneously. This clothes holder can operate only by the use of correct password to open the lock switch. Thus it can be used effectively and safely.

Future Work

The observation and analysis of the presence of the bacteria, viruses, dust mites, fungus, mold and other pathogens in clothes will carry on by the use of scanning electron microscope for more detailed purpose.

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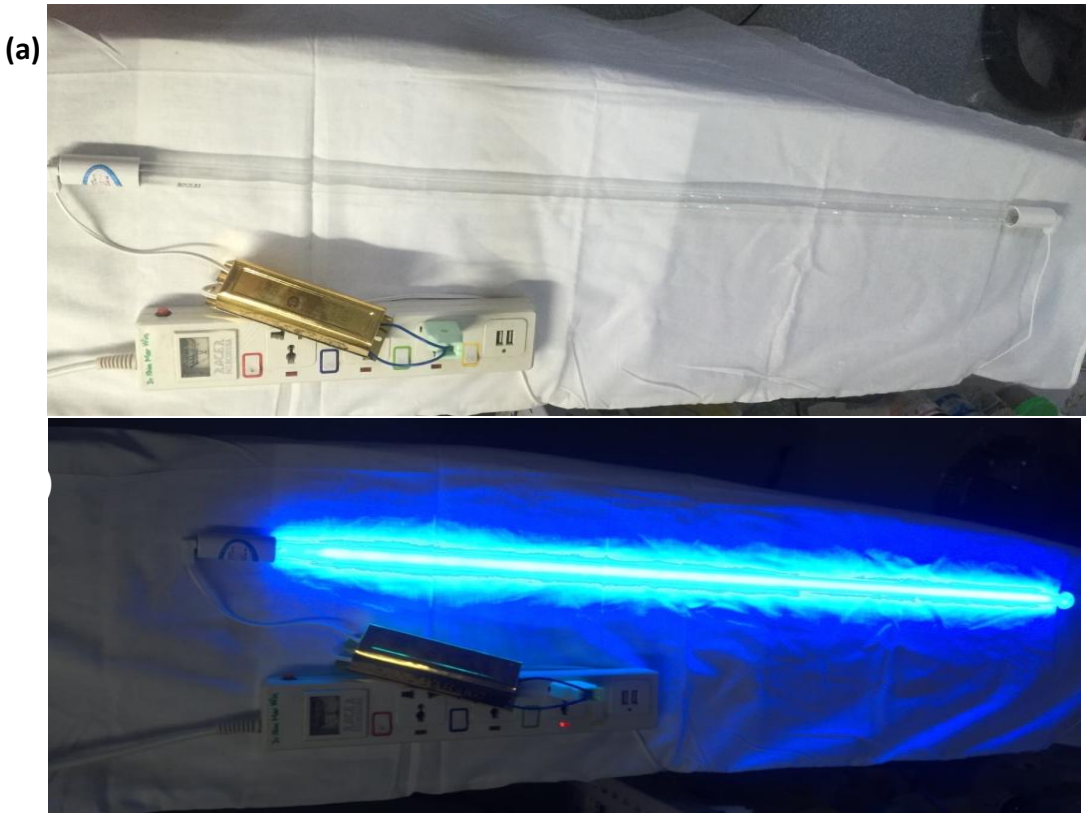

Figure 2 Photograph of the ZW30S19W UV lamp (a) testing circuit connection (b) emitting UV radiation in 253.7 nm wavelength and 107 μW/cm^2 intensity

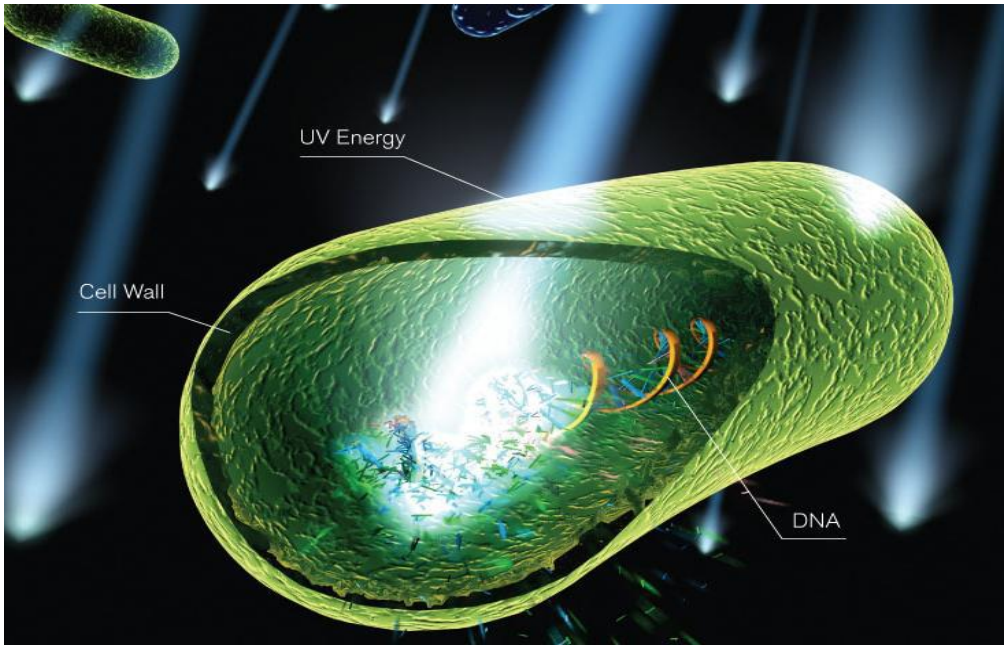

Figure 3: The UV light penetrates the cell walls of bacteria and breaks molecular bonds within microorganism DNA [www.trojanuv.com]

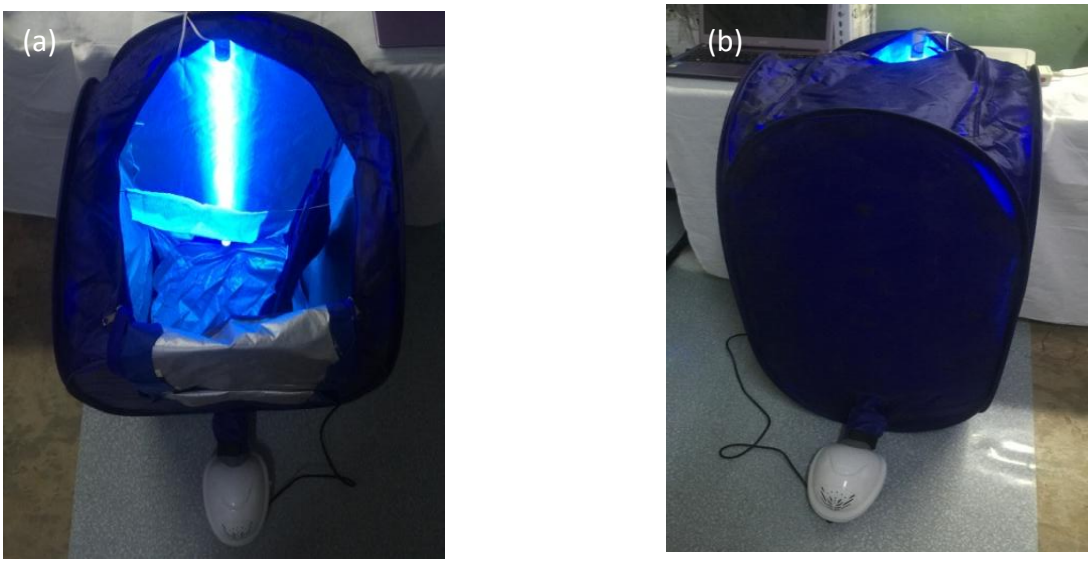

Figure 4 Photograph of (a) inner view and (b) outer view of antibacterial clothes dryer

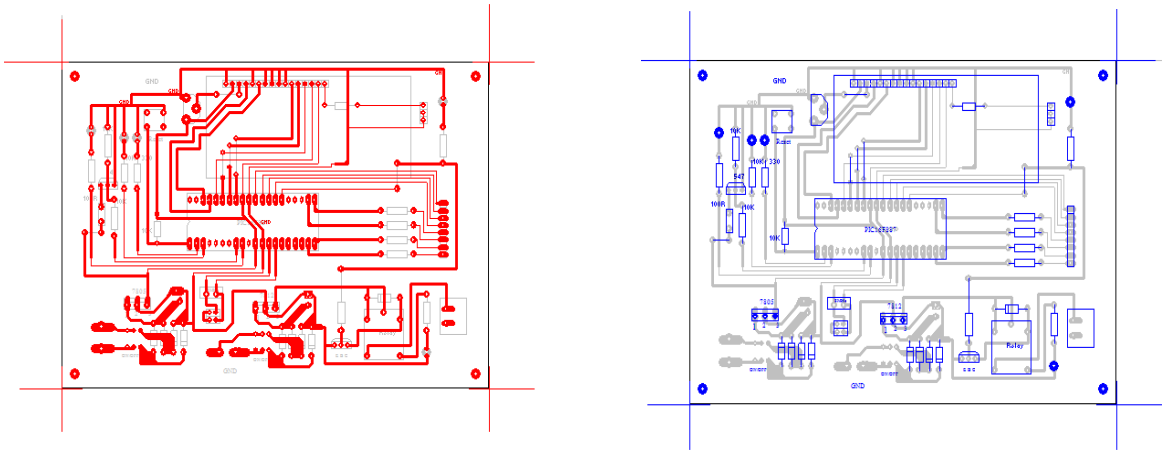

Figure 5 Printed circuit design of (a) soldering side view (b) component side view of the control lock for antibacterial clothes dryer

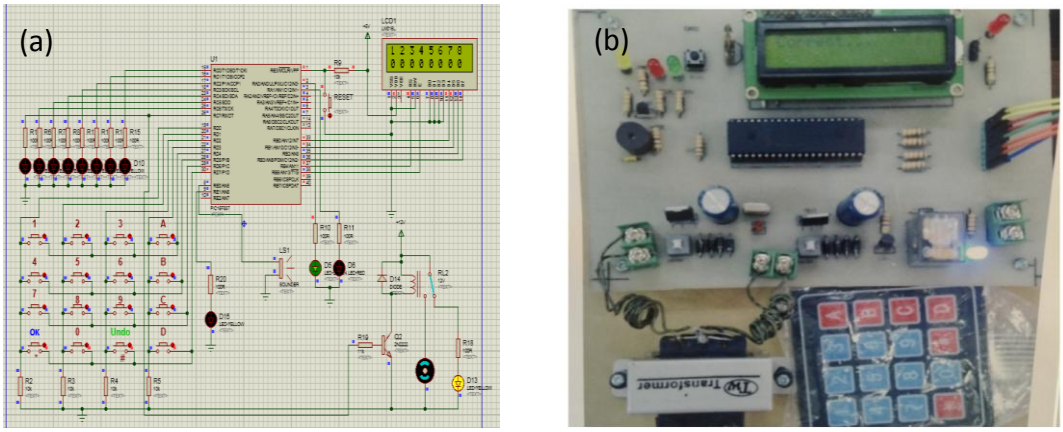

Figure 6 Antibacterial clothes dryer system (a) simulation screen capture and (b) control lock circuit

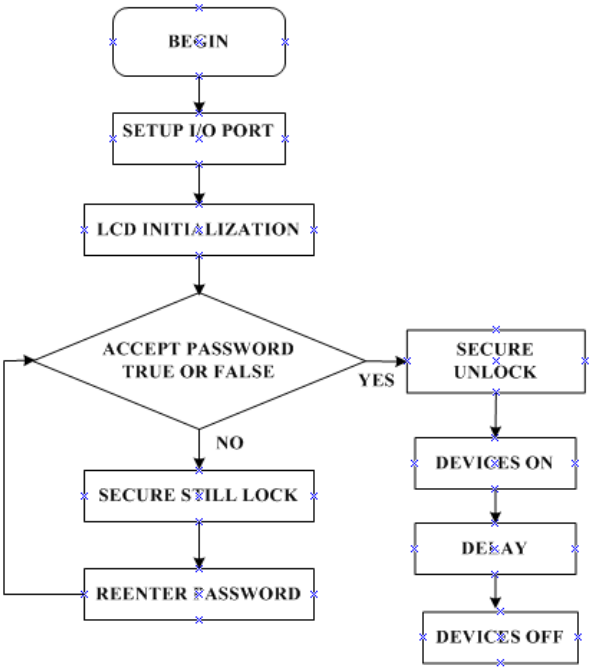

Figure 7 Flowchart diagram of the source code

Figure 8 Disinfection process on napkin by ZW30S19W UV lamp for twenty minutes (1200 seconds)

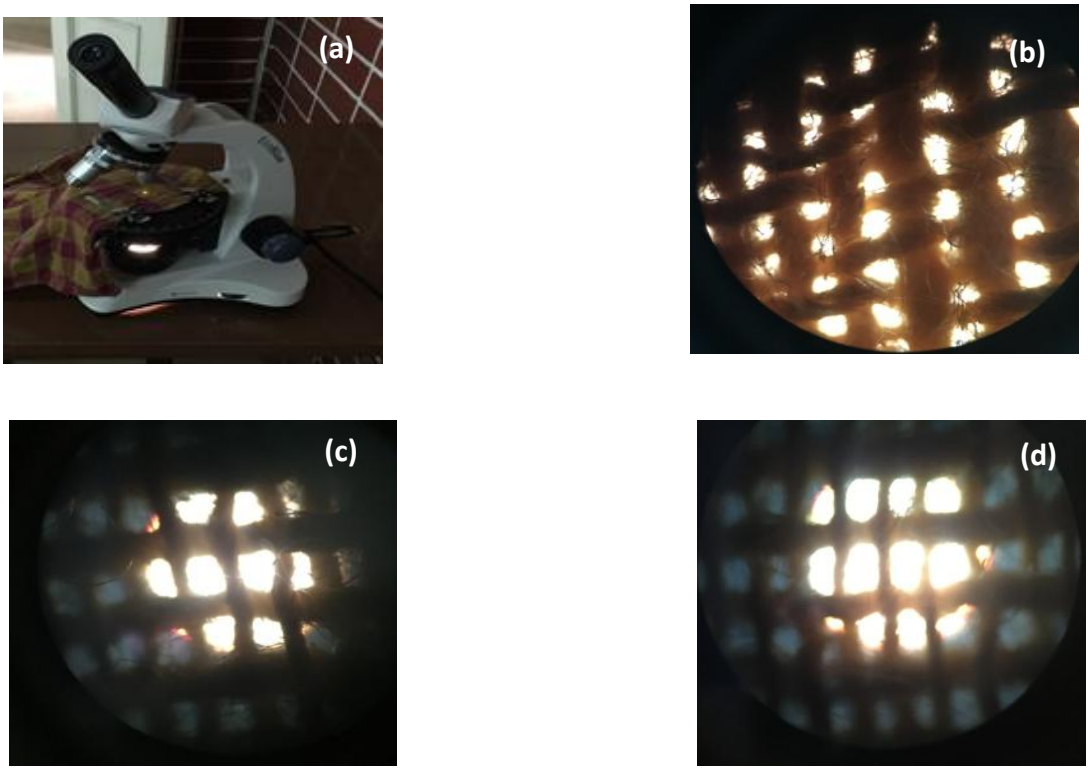

Figure 9: (a) Observation on presence of bacteria (mite dust) under EC-1001-P-HLED Eco Blue microscope (b) on dirty napkin fabric before wash (c) on clean napkin fabric after wash (d) after 1200 seconds disinfection process by ZW30S19W UV lamp

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