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AUTOMATIC DOOR KNOB/HANDLE SANITIZATION USING UV-C LIGHT

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Abstract - *In these difficult times it is an extreme need to save ourselves from various harmful bacteria and viruses which are a threat to mankind. Due to this COVID-19 situation people have become more aware of the importance of cleanliness & hygiene and have started giving importance to personal and environmental sanitation. Cleaning and disinfection helps to reduce the incidences of healthcare-associated infections. In the coming years there will be a major need for various methods of eliminating biological organisms that are harmful to health and we will need different methods of sanitation to do so. In our daily lives we come across various contact surfaces such as door knobs which have great possibility of containing harmful bacteria. Thus we have come up with a new door knob sanitizing device which can be installed in various public places which treats the door knobs/handles to make it bacteria free.*

Key Words: UV-C Light, Disinfection, Door Knob/Handle, Automation, IOT Device.

1. INTRODUCTION

Environmental cleaning and disinfection are important factors of a comprehensive strategy in order to control healthcare-associated infections, especially in crowded places where there is a continuous contact with door knobs/handles. However, studies evaluating the effectiveness of improved cleaning interventions have shown that approximately 5–30% of surfaces remain contaminated, due to the lack of existing disinfectant methods.

There has been a lot of interest in the development of effective and more comprehensive environmental disinfection strategies. One of the most widely used methods for killing harmful bacteria is exposing them to Ultraviolet radiations typically between 200 to 280nm range using UV-C light. The germicidal effects of UV-C irradiation results in cellular damage by photohydration, photosplitting, photodimerization, and photocrosslinking, thereby inhibiting cellular replication.

We have used similar technology in building our device which will disinfect the door knobs/handles & effectively stop the spread of bacteria through door knobs/handles. This device will help us to reduce the spread of health-care associated infections to a good extent.

2. LITERATURE REVIEW

Ultraviolet light is a form of electromagnetic radiation which is transmitted in the form of waves or particles at different wavelengths and frequencies. UV light falls in the range of the EM spectrum between visible light and x-rays. It has frequencies of about 8×10^{14} to 3×10^{16} cycles per second, or hertz (Hz), and wavelengths of about 380nm to about 10nm.

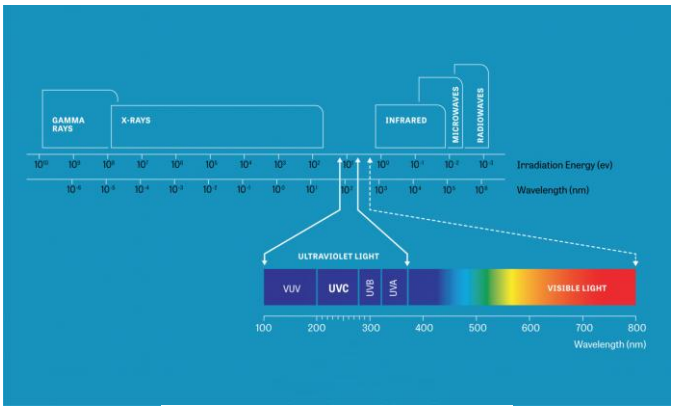

Fig-1: Classification of UV light

UV is generally divided into three sub-brands:
UV-A, or near UV (315-400 nm)
UV-B, or middle UV (280-315 nm)
UV-C, or far UV (180-280 nm)

UV-C light is a short wavelength light which is used for sanitization purposes. UV-C light deactivates the DNA of bacteria, virus and other pathogens so that it is unable to function or reproduce. When the organism tries to reproduce, it dies. Many research studies & reports say that when any biological organisms are exposed under a deep UV light in the range of 200nm to 300nm they are absorbed by DNA, RNA, and proteins. Absorption by proteins results in bursting or breaking of cell walls and hence results in death of the organism while absorption by DNA or RNA causes inactivation of the DNA or RNA and hence the replication process is disrupted.

3. COMPONENT

3.1 UV-C Light:

We have used 4 UV-C LEDs in this device. Function of UV-C LED Light is to disinfect the door knob/handle by projecting the light on the surface to be disinfected. UV-C LED that can be used for this device has following specifications:

Table -1: UV-C LED specification

Wavelength (nm)		275±2	
Model		TY-UV275nm SMD	
Encapsulation mode		SMD	
Optical power [mW]	**IF = 20mA**	**Min**	1.0
		Max	1.5
Forward Voltage V_F[V]		**Min**	5.50
		Max	6.00
Beam Angle		120-140	

3.2 IR Sensor:

We have used IR Proximity Sensor for this device. The function of an IR sensor is to detect the motion on the door knob/handle. It has a range of 10-15 cm with input supply voltage of 5V DC. It is operated at 6.5V and has output voltage for logic one(+3.5V) & logic Zero (0.0V).

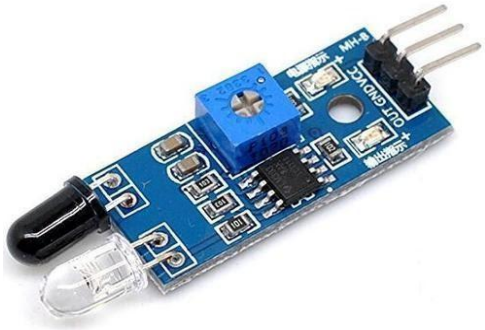

Fig-2: IR Proximity Sensor

3.3 Microcontroller:

We have used Arduino Uno as our microcontroller. This microcontroller will help the device to control all the necessary functions as per the instructions given. The microcontroller which can be used have following specifications:

Table -2: Microcontroller specification

Microcontroller	Atmel ATmega328 SMD Package
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	32 KB (of which 2KB used by bootloader)
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Dimensions	0.70” x 1.70”

Fig-3: Arduino UNO

3.4 Battery:

We have used a 9V battery. It will provide the necessary power supply to all the components of the device.

Fig-4: 9V Hi-Watt Battery

4. MATERIAL AND MANUFACTURING PROCESS

Looking at the use and purpose of this device and also mounting of the device on the door we have found out that this device does not undergo any major forces. Hence it would not be practical to use stronger materials but at the same time the material should be long lasting, durable, vulnerable and also cost-effective. We have chosen **Polypropylene** as our material for this device. Polypropylene (PP) is a thermoplastic polymer and due to its properties it is used in various applications. PP has good resistance to environmental stress cracking which helps it for its longer life. PP is also used widely in medical industries because it exhibits high chemical and bacterial resistance. Also, PP exhibits good resistance to steam sterilization. These properties of PP are highly suitable for our need as our sole purpose is to make the door knob/handle bacteria free. PP can be processed virtually by many processing methods such as Injection molding, Extrusion, Blow Molding and General-Purpose Extrusion. For our application Injection molding suites our requirements the best. Hence, we have selected injection molding method for manufacturing our product.

Injection Molding

- Melt temperature: 200-300°C
- Mold temperature: 10-80°C
- Drying is not necessary if stored properly
- High mold temperature helps to improve brilliance and make the product aesthetically good
- Mold shrinkage lies between 1.5 and 3%, which depends upon the processing conditions, rheology of the polymer and thickness of the final product.

PP costs around Rs 90-100/ kg as of now in the domestic market. Hence it is also cost effective. Considering all the properties of PP it is best suited as compared to other materials and fulfills all the requirements needed for our device. Hence, we have chosen polypropylene as our material.

5. DESIGN

Designing is one of the most important aspects while developing any new product. Various factors were considered while designing this device such as safety, aesthetics, ergonomics etc. Design of this device is such that the UV-C LEDs are placed at a distance which can disinfect the door knob/handle very efficiently and also the UV-C LED light can cover the overall surface of the door knob/handle. UV-C LED lights are directly projected on to the door knob/handle and there is minimal exposure anywhere outside the targeted surface as it can have minor ill effects to human skin. The device is adjustable and can be adjusted as per the size of the door knob/handle and hence can be installed on any door knob/handle. The design of the device is also aesthetically pleasing.

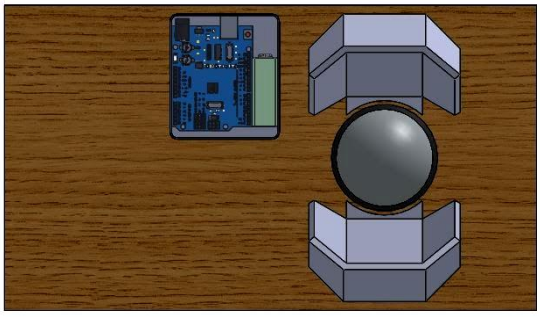

Fig-5: Front View of Disinfectant

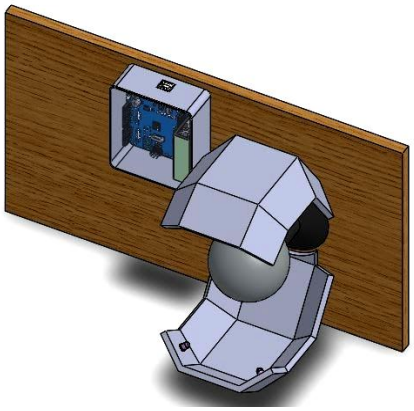

Fig-6: Isometric View of Disinfectant

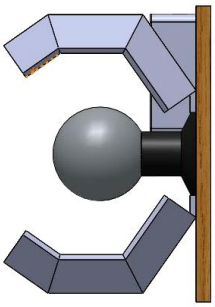

Fig-7: Side view of Disinfectant

6. WORKING

This project comes under the domain of IoT. The Automatic Door Knob/Handle sanitizer uses UV-C LED lights (210-280nm) to generate broad spectrum ultraviolet light, and Infrared Proximity Sensors. Automatic UV technology is dependent on the distance between the light source and the surface to be disinfected. According to the Inverse Square Law, the doubling of distance between the light and the surface to be disinfected will quadruple the time required for disinfection of frequently touched surfaces ie: door knobs and handles, this device uses a 1 minute disinfection cycle with light approaching the knob from multiple angles in order to cover maximum surface area to achieve optimal disinfection. It is recommended that the device be placed properly and can at max can be 15 centimetres away from the knob/handle surface. When a subject uses the door knob/handle, the movement is detected by the IR sensors and the circuit is triggered, as soon as the subject retracts

their hand the one-minute sanitation cycle begins, it is recommended that the door knob is unused during the sanitation process, if motion is detected the sanitation cycle is stopped and started again once no motion is detected. When the UV-C light is projected on the door knob/handle it breaks apart the DNA bacteria which stops bacteria so that the bacteria is unable to function or reproduce. Apart from this the sanitation cycle is triggered automatically irrespective of anyone using the door knob 20 minutes from the last time it was used and every 20 minutes after that. The device itself has been fitted with hinges to ensure proper adjustment.

7. CIRCUIT DIAGRAM

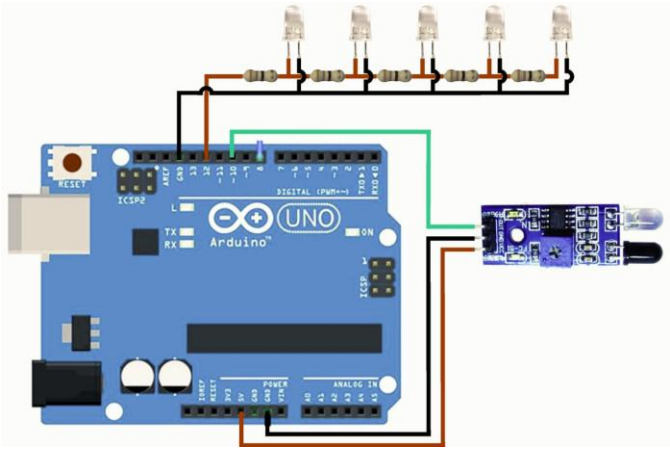

Fig-8: Circuit Diagram

8. CONCLUSION

The device we have built will be able to work efficiently to disinfect door knobs/handles and can improve the results of reducing germicidal issues. This device will help in reduce health-care associated infections rates to a good extent.

Hence, this device can be used in places like hospitals where there is a need to disinfect the surfaces and also in public places like railway stations, airports, offices etc to eliminate the surface bioburden and hence resulting in improved hygiene and reduction in infections.

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