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JIIICaS 2024
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"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

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Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh, Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

In the name of Allah, the Most Gracious, the Most Merciful.

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
Johor Branch

(A-PP009) DEVELOPMENT OF CARBON NITRIDE-MODIFIED AIR FILTERS FOR REMOVAL OF AIRBORNE BACTERIA AND VIRUSES

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ABSTRACT

A few years ago, millions of people died worldwide as a result of the fast-spreading coronavirus known as SARS-CoV-2 and the condition it caused, known as COVID-19. Additionally, another similar virus, influenza A, has also been reported to cause respiratory problems in healthy people. Because these diseases travel through the air, they are difficult to control. Since it is impossible to completely avoid these airborne diseases, the development of highly efficient antimicrobial air filters is required, as people cannot rely solely on protections such as social distancing and wearing masks. In the past few decades, nanotechnology has emerged as a promising field in the fight against infectious diseases. For example, various nanomaterials with outstanding physical and chemical properties have been extensively explored in biomedical applications such as the development of vaccines, drug delivery, and antibacterial treatments. Previous studies have shown that the application of metal-based and metal oxide nanoparticles, including copper oxide (CuO) and silver oxide (Ag_2O), as excellent antiviral and antibacterial filters, when coated on air filters. However, one of the limitations is that they cannot be simply disposed of, as they can be harmful to the environment. Therefore, in these studies, the use of sustainable nanomaterials that are environmentally friendly will be prioritized. Recently, graphitic carbon nitride (CN) has emerged as a prominent and sustainable photocatalyst, providing an innovative solution to address the environmental and energy challenges. However, since most of the reported CN absorbs light only up to 450 nm, it might not work well under solar light irradiation. Therefore, modification of CN with a dopant that can extend its light absorption to 700–800 nm is highly recommended. In this part, a red dopant (2,4,6-triaminopyrimidine) will be incorporated into the framework of CN, and the home air filters will be coated with the respective modified CN using nanospray drying. This product is expected to prevent the spread of a wide number of respiratory infections. Moreover, this study would also specifically investigate the effectiveness of the modified air filters to prevent the growth of two specific respiratory pathogens such as *Streptococcus pneumoniae* and *Pseudomonas aeruginosa.*

Keywords : Carbon Nitrides, Nanospray, Antimicrobial, Air-filter.

1.0 INTRODUCTION

The recent COVID-19 pandemic might have alerted people and made them more conscious about the air they breathe (Shah, 2021). The transmission of disease can occur in many ways; however, the most unpredictable way is airborne transmission. Airborne transmission can happen over long distances and time, leading to the spread of various diseases to a large number of people (Klompas et al., 2020). In general, airborne diseases contains bacteria or viruses that are usually spread via small respiratory droplets. These droplets are released when a person with the airborne disease sneezes, coughs, laughs, or exhales in any way (Gonzalez-Martin, 2019). It is said that the airborne transmission has different capabilities. For instance, airborne diseases can travel more than 6 feet and remain infectious in the air for minutes to hours. This largely depends on the building's ventilation and the preventative measures in such place. Moreover, the longer people spend time indoors, the more it significantly raises concerns about indoor air quality (Klompas et al., 2020). Therefore, addressing air quality concerns is crucial for safeguarding public health and ensuring a sustainable future for everyone.

Nanotechnology has played a key role in introducing innovative solutions to address airborne diseases through the development of air purifiers (Mahmoudi et al., 2023). A key application is the development of photocatalytic nanomaterials, which, when activated by UV or visible light, can destroy microorganisms by producing reactive oxygen species (ROS). Its mechanisms of action can be explained by oxidative damage resulting from the formation of ROS or heat stress caused by an increase in temperature. These processes are known as photodynamic therapy and photothermal therapy (Bhole et al., 2021). These nanomaterials can significantly enhance purification levels, decrease energy consumption, and extend filter lifespans, leading to technological advances in air purification techniques. Photocatalysts and materials such as zinc oxide (ZnO), silver oxide (Ag_2O), and copper oxide (CuO) have been reported to have an antiviral activity of up to 99%. Additionally, filters made from Ag_2O-based material showed the full inhibition of bacterial growth within a 24-hour studies(Alavi and Morali, 2022). Although the aforementioned metal oxides exhibit excellent antimicrobial properties, they are not easily disposed of and require expensive methods to avoid harming the environment. Recently, there has been an increasing trend in exploring carbon-based materials, especially carbon nitride (CN), for environmental remediation. Studies have shown that CN-based materials possess excellent antimicrobial properties. For example, CN-based materials have been reported to inhibit the growth of *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*) by up to 99% and 90%, respectively (Syrgiannis and Christoforidis, 2021).

However, there are some limitations associated with CN, such as low solubility, biocompatibility issues, aggregation, and limited utilization efficiency of visible light (Zhou et al., 2018). Therefore, in these studies, a CN with high crystalline properties is proposed to overcome these limitations. Crystalline CN has demonstrated great potential as an antimicrobial agent due to its outstanding features, such as high stability, low toxicity, reduced band gap structure, and facile synthesis. The reduced band gap energy allows for better electron charge transfer and extended light absorption in longer wavelengths (Cao et al., 2015). Hence, this modified CN is an attractive material for antimicrobial applications.

2.0 OBJECTIVE

The study aims to develop a carbon-nitride-modified air filter for the removal of airborne bacteria and viruses, particularly two respiratory pathogens: *Streptococcus pneumoniae* and *Pseudomonas aeruginosa*. These pathogens have been progressively linked to several diseases such as meningitis, pneumonia, and chronic obstructive pulmonary disease (COPD), as well as infections and other respiratory conditions including bronchitis.

3.0 METHODOLOGY

3.1 Material Preparation

The CN will be prepared via the ionothermal condensation method. Approximately 5 g of melamine, as a precursor of CN, will be mixed with a salt melt composed of 2.26 g of lithium chloride (LiCl) and 2.74 g of potassium chloride (KCl) and 0.2 g of 2,4,6-triaminopyrimidine. The purpose of the salt melt is to induce the crystallinity of CN. The precursor will be stirred in 30 ml of ethanol solution for 1-2 hours until all the ethanol evaporates before being calcined at a temperature of 550 °C for 4 hours. The product will then be washed with ethanol and dried in an oven at 80°C overnight. Figure 1 illustrates the experimental procedure in preparing the material.

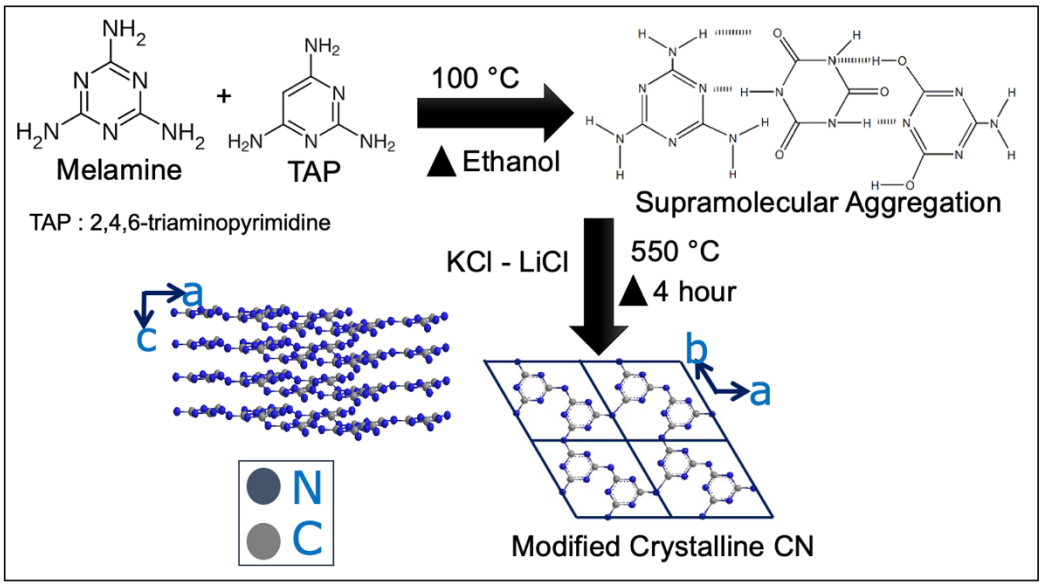

Figure 1 : Preparation of modified crystalline CN

3.2 Air Cleaner Preparation

Figure 2 illustrates the diagram of the air cleaner. The air purifier will be equipped with a high-efficiency particulate air (HEPA) filter, a pre-filter, and an activated carbon filter as the primary filtration components. The HEPA filter can theoretically remove up to 99% of dust, pollen, and airborne particles as small as 0.3 microns (µm). Illumination

will be provided by solar light irradiation (150 W, λ > 230 nm, I = 100,000 Lux). A centrifugal fan will be used to draw air in at the front of the air cleaner and exhaust it at the top, as shown in Figure 2. The flowrate will be set to 5 m^3/min. The modified CN filter will be mounted on the top of solar lamp.

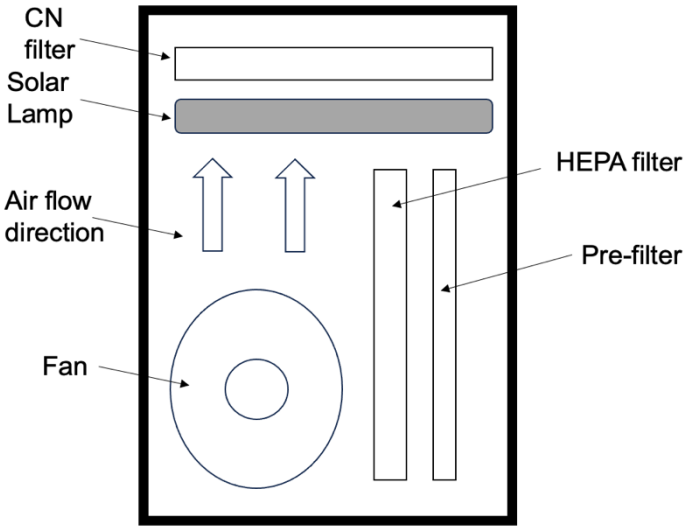

Figure 2 : Schematic diagram of the proposed CN-modified air filter

4.0 Expected Result

The main mechanisms for inactivation of the airborne viruses and bacteria in this process are the chemical oxidation by ROS, such as hydroxyl radicals, superoxide, single oxygen, and hydroperoxide. These ROS are pervasive since they are produced from oxygen, which is abundant. The produced ROS may cause damage to DNA, RNA, and proteins, leading to cell death. The mechanism of action is illustrated in Figure 3. Figure 4 illustrates that when these charges react with water molecules, which are present in the air, they lead to the formation of ROS. The photon (light) is absorbed by the material and generate an excited electron–hole pair which can then migrate to the surface of the particle. The electron can then reduce atmospheric oxygen to the more labile superoxide radical. The formation of ROS within the respective cells is known as oxidative stress. This process destroy the proteins, DNA and RNA, as well as leading to the death of cell.

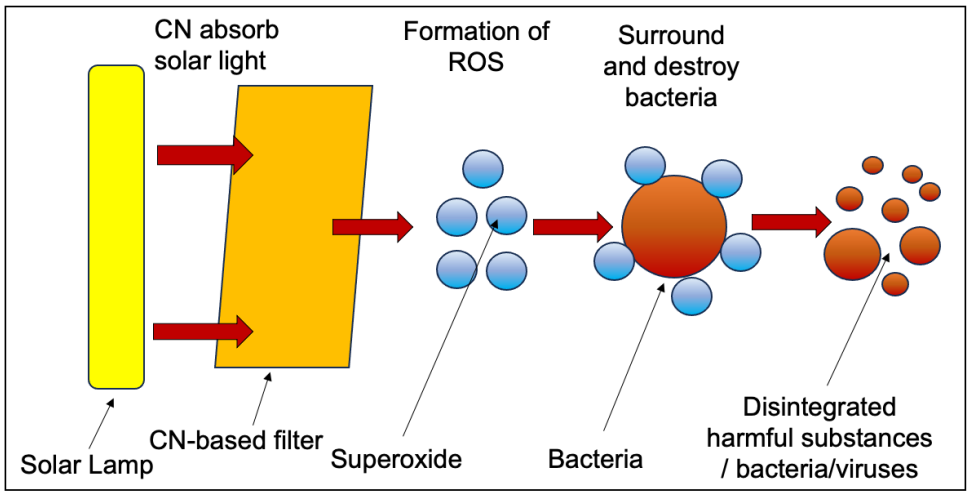

Figure 3 : The main mechanisms for inactivation of the airborne viruses and bacteria.

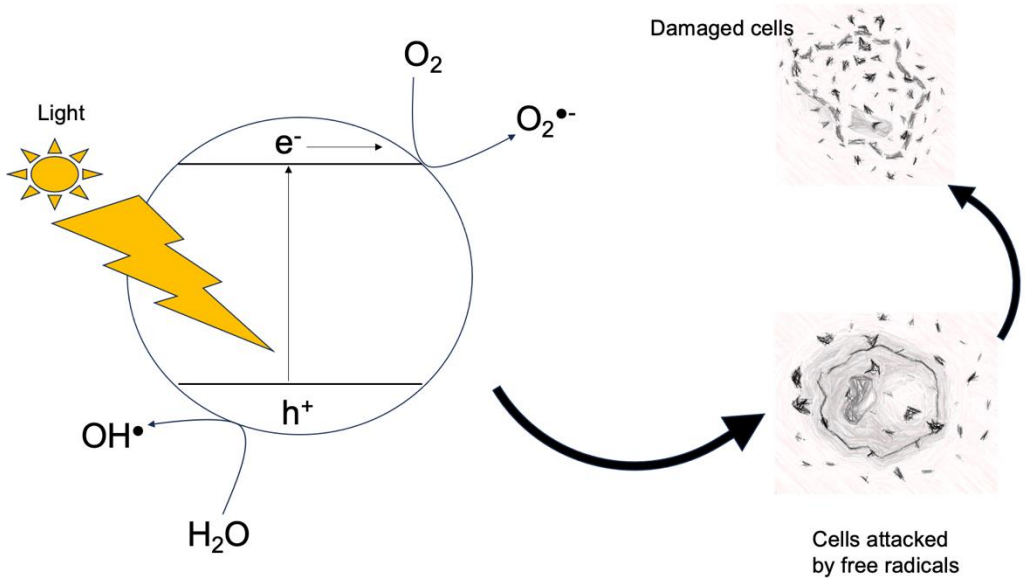

Figure 4 : Generation of ROS via photocatalytic oxidation process and cells damaged caused by oxidative stress.

5.0 CONCLUSION

The photocatalytic technique can be a promising technology for purifying indoor air containing viruses. However, different materials can affect the performance of the photocatalytic process in inactivating airborne viruses. Therefore, a single viral model may not be generalizable to other airborne viruses.

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