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Review study on various types of filters to increase the efficiency of air purifier

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Abstract
This article represents a general study of various types of filters used in air purifiers. Air purifiers are devices designed to improve indoor air quality by removing contaminants and pollutants. This short abstract highlights the importance of air purifiers in mitigating air pollution and improving human health. It emphasizes the various types and mechanisms of action of air purifiers, their effectiveness in reducing air pollutants, and the potential health benefits associated with their use. The abstract also acknowledges the need for further research to optimize air purifier performance and assess long-term effects. Overall, air purifiers play a crucial role in creating healthier indoor environments and combating the adverse effects of air pollution.

Keywords: Volatile organic compounds, UV germicidal irradiation, ozone generator, clean air delivery rate, sleep quality, indoor pollutants, filtration efficiency, HEPA filter, photo electrochemical reaction

Introduction

An air purifier is a device designed to improve the air quality in enclosed spaces by removing contaminants and pollutants. It works by drawing in air from the surrounding environment, filtering out harmful particles, and then releasing clean and purified air back into the room.

The need for air purification arises due to the presence of various pollutants in indoor environments, such as dust, pet dander, pollen, smoke, Mold spores, and volatile organic compounds (VOCs) emitted by household products and chemicals. These pollutants can have adverse effects on human health, especially for individuals with allergies, asthma, or other respiratory conditions. Air purifiers typically employ one or more filters to capture and trap airborne particles. The most common type of filter used is a High-Efficiency Particulate Air (HEPA) filter, which can capture over 99% of particles as small as 0.3 microns. Some air purifiers also incorporate activated carbon filters to remove odors and certain chemicals from the air. In addition to filters, air purifiers may utilize other technologies to enhance their effectiveness.

Air purifiers come in various shapes and sizes, ranging from small portable units suitable for single rooms to larger models that can purify the air in an entire house or office space. They can be standalone units placed on a floor or table, or they can be integrated into the HVAC (Heating, Ventilation, and Air Conditioning) system of a building.

When choosing an air purifier, it is important to consider factors such as the size of the area you want to purify, the specific pollutants you want to target, the noise level produced by the device, and the maintenance requirements of the filters. Some air purifiers also provide additional features like air quality sensors, programmable timers, and remote-control operation. Overall, air purifiers are valuable appliances that can significantly improve indoor air quality and create a healthier and more comfortable living or working environment. By removing harmful particles and pollutants, they contribute to reducing the risk of respiratory problems and enhancing overall well-being. Air purifiers offer a practical solution to enhance the quality of the air we breathe indoors. While they are not a replacement for good ventilation and other healthy habits.

Filter Assembly

The filter assembly is a critical component of air purifiers responsible for capturing and removing airborne contaminants from indoor air. It consists of one or more filters designed to target specific types of pollutants and improve the overall air quality within space. In addition to HEPA filters, air purifiers may incorporate other types of filters in their assembly. Activated carbon filters are commonly used to absorb and remove volatile organic compounds (VOCs), odors, and chemicals present in the air. These filters contain a porous carbon material that traps and chemically binds these pollutants.

Materials and methods

Types of filters used in Air Purifier

The assembly of an air purifier involves the integration of several components to create an effective air purification system. The outer structure, known as the housing or enclosure, provides support and protection for the internal components. Within the housing, a fan is strategically placed to draw air into the purifier and create airflow throughout the device. The heart of the air purifier lies in the filter assembly, which typically consists of multiple filters. A pre-filter serves as the initial barrier, capturing larger particles like dust and hair. The primary filter, often a High-Efficiency Particulate Air (HEPA) filter, targets smaller particles, such as allergens, pollen, and mold spores.

Results

Studying the various types of filters used in air purifiers holds significant importance for several reasons. Firstly, it provides a comprehensive understanding of how each filter functions, thereby aiding in the selection of an appropriate air purifier. Different filters are designed to target specific pollutants, such as allergens, odors, volatile organic compounds (VOCs), and more. By delving into the

intricacies of these filters, individuals can make informed decisions based on their unique air quality requirements.
Furthermore, the study of filters enables individuals to align their needs with the capabilities of different air purifiers. This is particularly useful when dealing with diverse air quality concerns, such as pet danger, smoke, pollen, or chemical emissions. The ability to match specific pollutants with corresponding filter technologies ensures that the chosen air purifier is effective in addressing these concerns.

Discussion

Types of filters used in Air Purifier

HEPA filter

HEPA (High-Efficiency Particulate Air) filters are a vital component of air purifiers, renowned for their exceptional filtration efficiency. These filters are designed to capture and remove a wide range of airborne particles, including dust, pollen, pet dander, mold spores, and other allergens. Air turbine.
HEPA filters are constructed from a dense mat of randomly arranged fibers, usually made of fiberglass. The fibers are pleated and tightly woven together to form a dense barrier through which air must pass. This intricate design allows the filter to trap particles as small as 0.3 micrometers with remarkable efficiency.

Some key points about HEPA filters

Filtration Efficiency

HEPA filters are highly efficient, capable of capturing at least 99.97% of particles that are 0.3 micrometers in size or larger. They can also trap particles smaller and larger than 0.3 micrometers with even higher efficiency.
Particle Removal: HEPA filters effectively capture a wide range of airborne particles, including dust, pollen, pet danger, mold spores, bacteria, and some viruses.

Allergen Reduction

HEPA filters are particularly effective in reducing allergens in the air, making them beneficial for individuals with allergies, asthma, or other respiratory conditions.
Maintenance and Replacement: Regular maintenance and filter replacement are essential to maintain the effectiveness of HEPA filters. Over time, captured particles accumulate and clog the filter, reducing its efficiency.

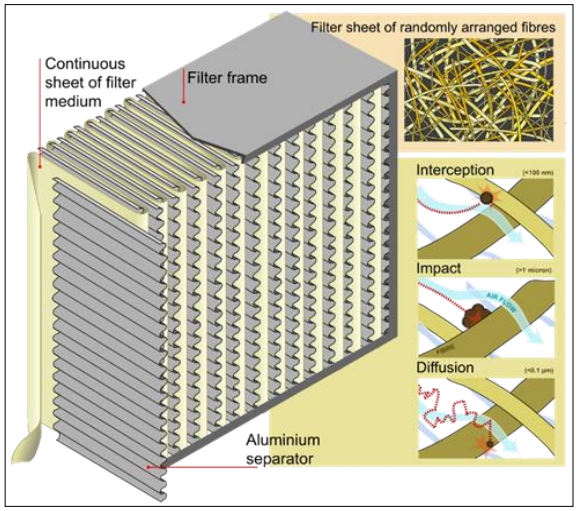

Fig 1: General structure HEPA

Fig 4 you can see how mechanism of Capture: HEPA filters capture particles through a combination of interception, where larger particles collide with and adhere to the filter fibers, and diffusion, where smaller particles collide with gas molecules and become trapped.

Activated Carbon Air Purifiers

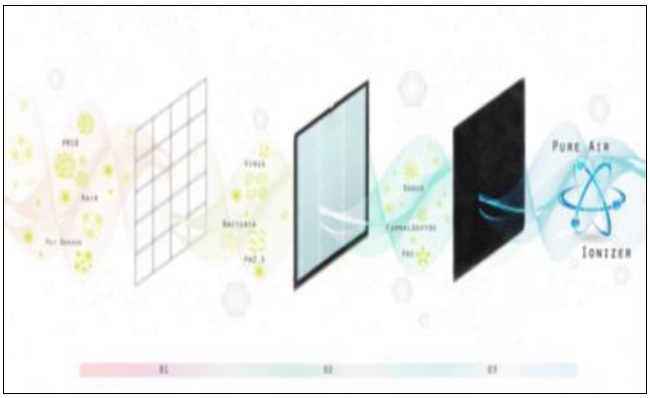

Fig 2: Entire system with the case and core

Activated carbon air purifiers, also known as charcoal air purifiers, are a type of air purifier that utilizes activated carbon filters to remove gases, odors, and chemical pollutants from the air.
The activated carbon material used in these filters undergoes a special activation process, which creates a highly porous structure with an enormous surface area. This increased surface area enables the carbon to effectively adsorb and trap a wide range of pollutants as air passes through the filter.
The porous structure of activated carbon provides ample surface area for the pollutants to meet the carbon particles, allowing for efficient adsorption. As a result, unpleasant odors are neutralized, harmful gases are reduced, and certain VOCs are removed, improving the overall air quality in the room. Regular maintenance and replacement of the activated carbon filter are essential to ensure its continued effectiveness. Over time, the carbon becomes saturated with adsorbed pollutants, reducing its ability to capture additional contaminants. Manufacturers typically provide guidelines on the recommended replacement intervals for these filters.

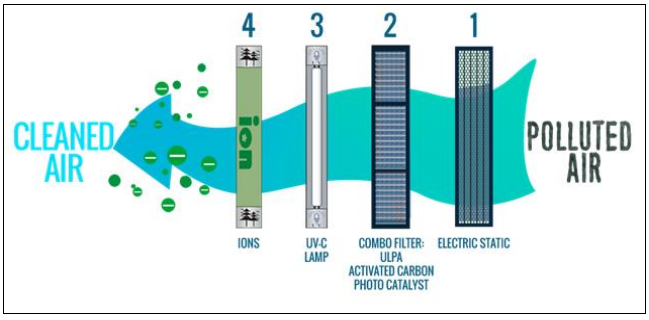

Fig 3: Flow of air in filter

Electrostatic Filter

Electrostatic filters are an important type of filter used in air purifiers to capture and remove airborne particles. These filters work based on the principle of electrostatic attraction, which utilizes static electricity to trap particles as they pass through the filter.

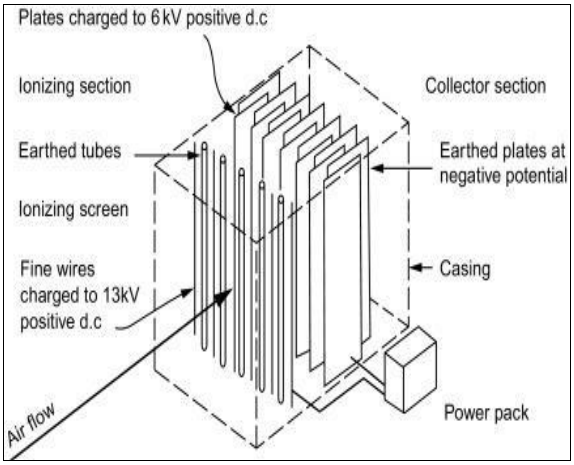

Fig 4: Plate arrangement of electrostatic type filter

These plates or fibers are charged with an electrostatic charge, creating an electrostatic field that attracts and captures particles. As air flows through the electrostatic filter, the charged plates or fibers generate an electrostatic charge on the particles in the air. This charge causes the particles to be attracted to the oppositely charged surfaces of the filter. The particles adhere to the filter media, effectively removing them from the air stream.

It is important to note that while electrostatic filters can be effective in capturing particles, they may not be as efficient as HEPA filters in removing extremely small particles or certain allergens. Additionally, over time, the electrostatic charge may weaken, reducing the filter's effectiveness. Therefore, it is crucial to follow the manufacturer's instructions regarding maintenance and replacement to ensure optimal performance.

Electrostatic filters provide an additional layer of filtration in air purifiers, helping to improve indoor air quality by capturing and removing airborne particles using electrostatic attraction.

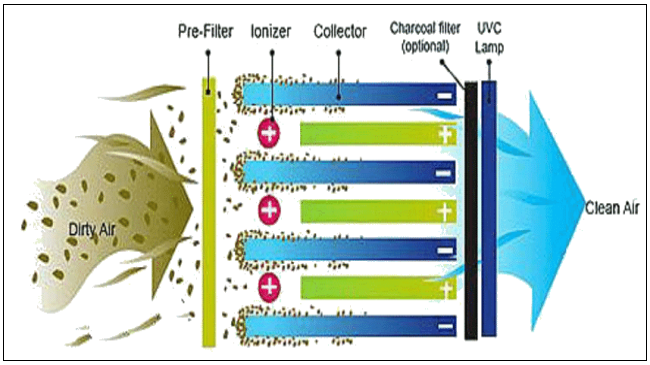

Fig 5: Working of Electrostatic filter

UV-C Filters

It's important to choose electrostatic filters that are compatible with your specific HVAC system or air purifier, and to follow the manufacturer's instructions for proper installation.

UV-C filters, also known as ultraviolet germicidal irradiation filters, utilize ultraviolet (UV) light to disinfect the air by killing or neutralizing microorganisms. These filters utilize short-wavelength ultraviolet light to neutralize and eliminate airborne pathogens, including bacteria, viruses, and mold spores.

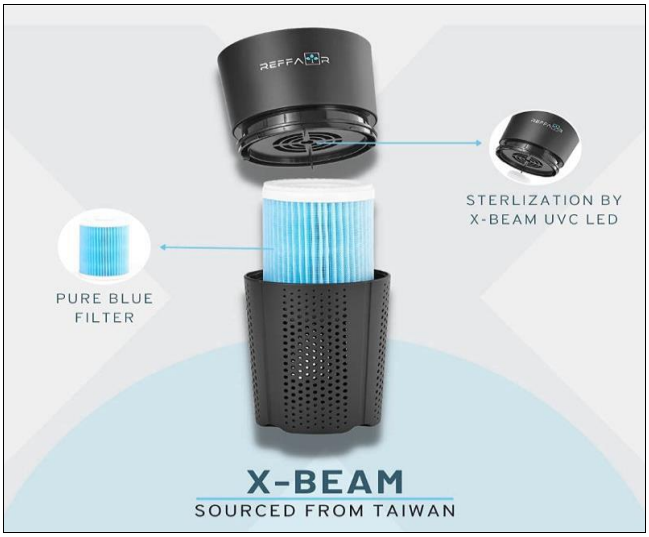

Fig 6: UC-V filter

UV-C filters typically consist of a UV lamp or bulbs placed within the air purifier. As air passes through the purifier, it is exposed to the UV-C light, which penetrates the genetic material of microorganisms and disrupts their DNA structure. This effectively renders the pathogens unable to reproduce or cause harm.

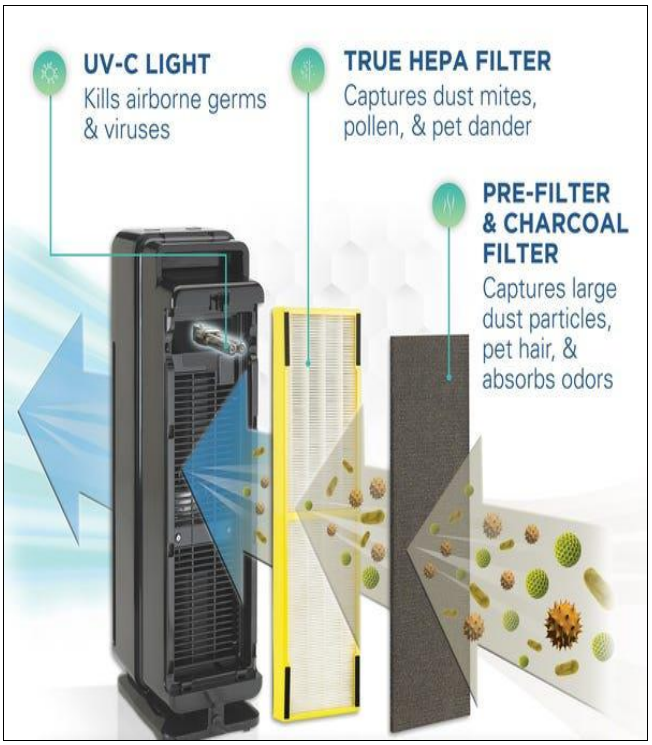

Fig 7: Air Purifier with HEPA filter with UV sanitizer.

To maintain the effectiveness of UV-C filters, it is crucial to periodically clean and replace the UV lamps or bulbs according to the manufacturer's instructions. Over time, the intensity of the UV-C light may diminish, reducing the filter's disinfection capacity. When considering an air purifier with a UV-C filter, it is essential to select a model that adheres to appropriate safety standards. UV-C light can be harmful to human health, so proper design and shielding mechanisms should be in place to prevent direct exposure to the light source.

Table 1. Common materials used for ultraviolet dielectric thin-film coatings		
Common Name	Chemical Formula	Lowest Wavelength (nm)
Silica	SiO_2	180
Alumina/sapphire	Al_2O_3	200
Hafnia	HfO_2	240
Zirconia	ZrO_2	270
Magnesium Fluoride	MgF_2	140
Aluminum Fluoride	AlF_3	150
Lanthanum Fluoride	LaF_3	170
Yttrium Fluoride	YF_3	200

Fig 8: Ultraviolet dielectric thin film coating material

Photocatalytic Oxidation (PCO) Filters

Photocatalytic Oxidation (PCO) filters are a type of filter used in some air purifiers to enhance air purification effectiveness. These filters utilize a photocatalyst, often titanium dioxide (TiO2), combined with ultraviolet (UV) light to produce a reaction that breaks down organic compounds and eliminates certain pollutants. Within the air purifier, the PCO filter is typically positioned alongside other filtration stages

Overall, UV-C filters offer an additional layer of protection against airborne pathogens, enhancing the overall air purification capabilities of an air purifier. By incorporating UV-C technology into the filter assembly, these purifiers provide a comprehensive solution for creating cleaner and healthier indoor environments.

This process generates reactive oxygen species, such as hydroxyl radicals, which have strong oxidizing properties. These radicals effectively neutralize or decompose organic compounds, including volatile organic compounds (VOCs), bacteria, viruses, and some airborne chemicals.

PCO filters offer several advantages. They can effectively target a broad range of pollutants, including odors and harmful gases. By breaking down these pollutants at a molecular level, PCO filters help eliminate them from the air, reducing their presence and improving overall indoor air quality. Additionally, PCO filters can contribute to the reduction of certain pathogens, enhancing the air purifier's germicidal capabilities.

However, it is important to note that the effectiveness of PCO filters may vary depending on factors such as the quality of the photocatalyst, the intensity of the UV light, and the contact time between the pollutants and the filter surface. PCO filters may also produce trace amounts of ozone as a byproduct, although many modern designs have addressed this concern by incorporating additional filtration or ozone-decomposition technologies.

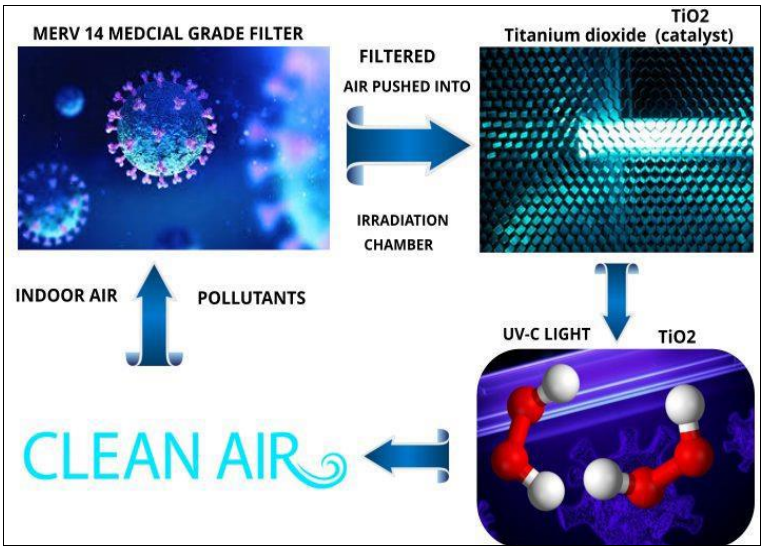

Fig 9: Flow of air in Photocatalytic Oxidation filter

PCO filters are often used in combination with other filtration technologies, such as HEPA filters or activated carbon filters, to achieve comprehensive air purification. This combination allows for the removal of a wider range of airborne contaminants, providing a more thorough and efficient purification process.

In summary, PCO filters harness the power of photocatalysis and UV light to break down organic compounds and neutralize certain pollutants in the air. By incorporating PCO technology into air purifiers, these filters contribute to enhanced air purification and can help improve indoor air quality by reducing odors, VOCs, and certain pathogens. It's important to consider the specific needs of your space and consult with the manufacturer to determine if PCO technology is suitable for your air purification requirements. he chemical reactions initiated by UV light

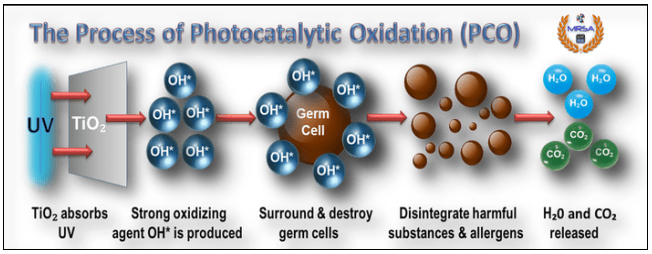

Fig 10: Photocatalytic Oxidation Process

Conclusions

In conclusion, air purifiers utilize various types of filters to target and remove specific pollutants from indoor air. HEPA filters are highly effective in capturing fine particles, allergens, and other airborne contaminants, while activated carbon filters excel at adsorbing odors, volatile organic

compounds (VOCs), and some chemicals. Pre-filters serve as the initial line of defense, capturing larger particles and prolonging the lifespan of the main filter.

Additionally, electrostatic filters use an electric charge to attract and trap particles, UV filters utilize ultraviolet light to deactivate microorganisms, and photocatalytic oxidation (PCO) filters break down organic compounds through a chemical reaction induced by UV light and a photocatalyst. Each filter type offers unique benefits and addresses specific pollutants, enabling comprehensive air purification.

Further development of the device can be achieved by incorporating UV ionization lamps. This can increase the duration of use of the filter and could cause internal pre-decontamination of the device. If we want to use a UV lamp, its operation should be done only when the device is not used by medical staff. In order not to affect the autonomy of operation, we recommend using the UV lamp only while charging the battery.

Combining multiple filter types in air purifiers allows for a comprehensive approach to indoor air purification, capturing a wide range of pollutants and improving overall air quality. The choice of filters depends on the specific needs and concerns, such as targeting allergens, odors, or chemical pollutants. It is important to consider the filtration efficiency, lifespan, and availability of replacement filters when selecting an air purifier. Regular maintenance and filter replacements are necessary to ensure continued effectiveness in removing pollutants from the air. By understanding the types of filters used in air purifiers and their respective capabilities, individuals can make informed decisions to create healthier indoor environments and combat indoor air pollution.

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