

1

Sources of gaseous pollutants

- Sources of **inorganic gases** include **gas stoves**, **tobacco smoke**, and **vehicles**.
- Sources of **organic gases** include **tobacco smoke**, **building materials**, **furnishings**, **animal metabolic processes**, etc.
- **Radon** can also be found in indoor air.

2

Requirements

- Regardless of the type of technology, **three requirements must be fulfilled**.
 - **High filtration efficiency** must be provided for a broad range of chemical substances.
 - **Low airflow resistance** (small pressure drop) is required.
 - The release or **generation of harmful substances** must be **prevented**.

3

Different technologies for removing gaseous pollutants.

- There are **six principal types of gas-phase air cleaners**.
 - Adsorbent media air filters, such as activated carbon (AC)
 - Chemisorbent media air filters
 - Photocatalytic oxidation (PCO)
 - Plasma
 - O₃ generators
 - Plants

4

Filtration – Gaseous Materials Adsorbent Media

- The **adsorption process** can be divided into two main groups:
 - **Physical adsorption** (e.g. the adsorption of AC for gas).
 - **Chemical adsorption** (e.g. activated alumina or AC impregnated with potassium or sodium permanganate, which reacts with formaldehyde and several other compounds).

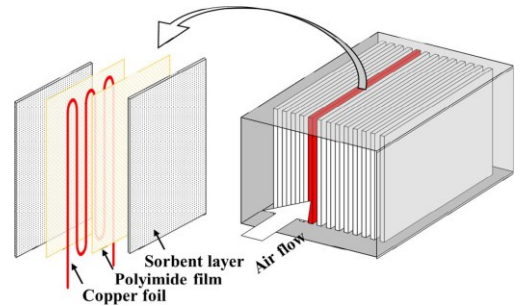
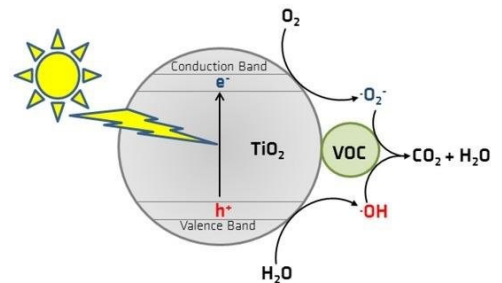


Illustration of the surface temperature adjustable laminated plate structure (left) and the air purifier module comprising multiple parallel plates (right). (Chen et al., 2019).

5

Filtration – Gaseous Materials Photocatalytic Oxidation (PCO)

- The PCO process is where, upon adsorption of a photon, a semiconductor acts as a catalyst in producing reactive radicals, primarily hydroxyl radicals, which can oxidise organic compounds and mineralise them.
- Common photocatalysts in PCO are titanium dioxide (TiO₂), zinc oxide (ZnO), tungsten trioxide, zinc sulphide, and cadmium sulphide.



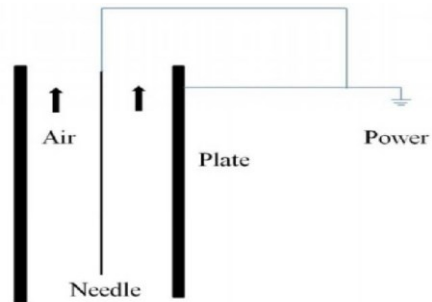
Schematic representation of photocatalytic oxidation of a volatile organic compound (VOC) (Mull et al., 2017).

6

Filtration – Gaseous Materials

Air Ion Generators

- Air ions are electrically charged molecules or atoms in the atmosphere.
- An air ion is formed when a gaseous molecule or atom receives sufficiently high energy to eject an electron.
- Negative air ion (NAI) generators gain electrons, whereas positive air ion generators lose electrons.
- Several types of negative air ion generators are based on corona discharges, thermionic electron emission, photoexcitation, and the Lenard effect for creating NAIs.



Schematic view of the corona discharge ioniser technology (Rahimi, 2013).

Filtration – Gaseous Materials

Ozone Generators

- An O_3 generator is a device that produces O_3 by adding energy to oxygen molecules (O_2), which causes the oxygen atoms to separate and temporarily recombine with other oxygen molecules.
- The process can be accomplished in the following methods: corona discharge and UV radiation.



Visualisation of how a corona discharge ozone generator operates (Ozone solutions. 2021).

Filtration – Gaseous Materials Plant

- Several articles have described air-cleaning plants used by NASA .
- Wolverton et al. (1989) found that indoor plants can scrub the air of cancer-causing VOCs, such as formaldehyde and benzene.
- Orwell et al. (2004) found that soil microorganisms in potted plants also play a part in cleaning indoor air.
- Kim et al. (2010) examined 86 species of houseplants from five general classes for their ability to remove formaldehyde.

9

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Effect of Portable Gas-Phase Air Cleaners on Indoor Air Quality

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Pages 28 - 35

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Summary of the technologies

Technology	Advantage	Disadvantage	Application
Absorbent	<ul style="list-style-type: none"> • Gaseous pollutants adsorb on porous granular media or cellulose in pores of media. • Many types of materials with activated carbon used successfully used. • Widely available technology • Can remove broad range of gaseous pollutants with moderate to high efficiency 	<ul style="list-style-type: none"> • Pollutants can be released from sorbent into indoor air • Low efficiencies for low molecular weight pollutants including formaldehyde • Must periodically replace sorbent • Sorbent effective for indoor air applications not well understood • Large amount of sorbent needed for long lifetime • High sorbent cost • High air-flow resistance increasing fan energy use 	<ul style="list-style-type: none"> • Installed in heating, ventilating and air conditioning systems or in stand-alone portable air cleaners
Chemisorbent	<ul style="list-style-type: none"> • Gaseous pollutants adsorb on and chemically react with porous granular media • Widely available technology • Can remove broad range of gaseous pollutants with moderate to high efficiency 	<ul style="list-style-type: none"> • High development cost • Often high air-flow resistance increasing fan energy use 	<ul style="list-style-type: none"> • Installed in heating, ventilating and air conditioning systems or in stand-alone portable air cleaners
Photocatalytic Oxidation	<ul style="list-style-type: none"> • Gaseous pollutants adsorb on a surface coated with a photocatalyst that is irradiated with a light source (usually a source of ultraviolet light), which activates the photocatalyst • Can remove a range of gaseous pollutants • Usually lower air-flow resistance than sorbents and chemisorbents. Thus, lower fan energy use • Can destroy several bioaerosols • Many systems have low pollutant removal efficiency 	<ul style="list-style-type: none"> • Low energy use • Cost of periodically replacing lamps • Photocatalyst becomes inactive with unknown photocatalyst life • Incomplete breakdown of some pollutants can result in formation of new pollutants potentially harmful to health 	<ul style="list-style-type: none"> • Installed in heating, ventilating and air conditioning systems or in stand-alone portable air cleaners
Air Ion Generator	<ul style="list-style-type: none"> • Neutralizes (total reaction) neutralized charged particles, discharge can oxidize and decompose volatile organic compounds and bioaerosols • Quiet and energy efficient • May improve particle removal performance of some portable air cleaners 	<ul style="list-style-type: none"> • Very limited data available on pollutant removal performance in buildings • Can produce ozone, see comments on ozone air cleaners 	<ul style="list-style-type: none"> • Used application in a stand-alone portable air cleaner
Ozone Generator	<ul style="list-style-type: none"> • Ozone generated and released into indoor air can react with and breakdown some airborne volatile organic compounds • Quiet and energy efficient 	<ul style="list-style-type: none"> • Releases ozone into indoor air and ozone is harmful pollutant • Generally ineffective in significantly reducing airborne volatile organic compounds unless ozone concentrations are very high • Reactions of ozone with airborne volatile organic compounds can lead to production of formaldehyde and other particles that pose health risks 	<ul style="list-style-type: none"> • Used application in a stand-alone portable air cleaner
Plant	<ul style="list-style-type: none"> • Plants in buildings can remove some volatile organic compounds 	<ul style="list-style-type: none"> • Not proven to significantly reduce indoor pollutant levels with practical number of plants 	<ul style="list-style-type: none"> • Plants placed throughout building or in attached greenhouse

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SIDE 10

10

Effect of Portable Air Cleaners on Indoor Air Quality: Particle Removal from Indoor Air



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The purpose of this literature review was to examine the studies, published in the last decades that analysed possibilities, applications and limitations of using portable air cleaners in order to improve indoor air quality. The article discusses the strengths and weaknesses of different air cleaning technologies by considering factors such as air quality improvement, filtering performance and energy aspect.

Keywords: particle, removal, indoor air, air cleaner, ventilation

11

13:44



Testing Portable Air Cleaning Units – Test Methods and Standards: A Critical Review



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12

Thank you for
your attention