 ISBN: 978-93-5917-518-8

Photocatalysis Method for Air purification

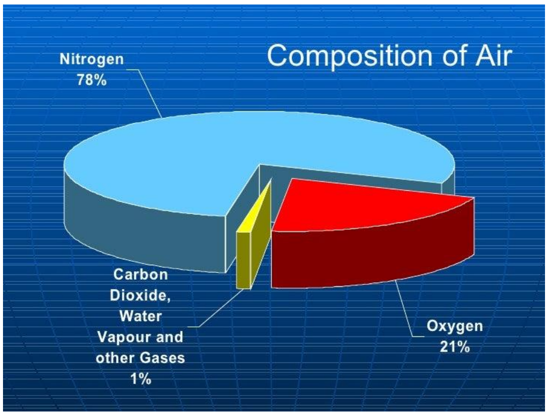
Ms.Najeera P C

Assistant Professor (Ad-hoc), Department of Chemistry,

KAHM Unity Women's College Manjeri,

Email:najeerapc@gmail.com

Air, mixture of gases comprising the Earth's atmosphere. The mixture contains a group of gases of nearly constant concentrations and a group with concentrations that are variable in both space and time. The atmospheric gases of steady concentration (and their proportions in percentage by volume) are as follows:



The uniformity of composition is maintained by mixing associated with atmospheric motions; but, above a height of about 90 km (55 miles), diffusional processes become more important than mixing, and the lighter gases (hydrogen and helium, in particular) are more abundant above that level.

water vapour (H_2O)	0 to 7
carbon dioxide (CO_2)	0.01 to 0.1 (average about 0.032)
ozone (O_3)	0 to 0.01
sulfur dioxide (SO_2)	0 to 0.0001
nitrogen dioxide (NO_2)	0 to 0.000002

Although present in relatively small amounts, these variable constituents may be very important for maintaining life on Earth's surface. Water vapour is the source for all forms of

 ISBN: 978-93-5917-518-8

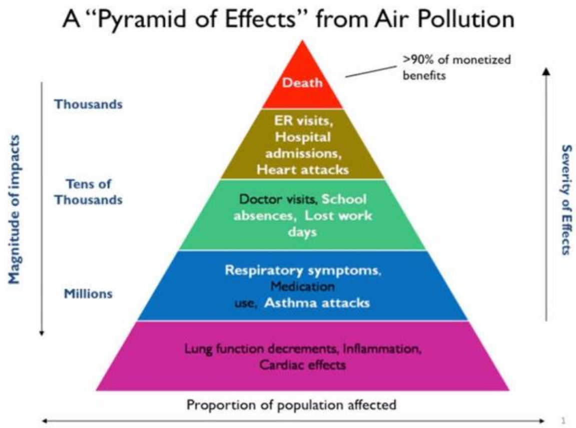
precipitation and is an important absorber and emitter of infrared radiation. Carbon dioxide, besides being involved in the process of photosynthesis, is also an important absorber and emitter of infrared radiation. Ozone, which is present mainly in the atmospheric region 10 to 50 km (6 to 30 miles) above the Earth's surface, is an effective absorber of ultraviolet radiation from the Sun and effectively shields the Earth from all radiation of wavelengths less than 3,000 angstroms.

Air Pollution

Air pollution is a mixture of hazardous substances from both human-made and natural sources. Vehicle emissions, fuel oils and natural gas to heat homes, by-products of manufacturing and power generation, particularly coal-fueled power plants, and fumes from chemical production are the primary sources of human-made air pollution. Nature releases hazardous substances into the air, such as smoke from wildfires, which are often caused by people; ash and gases from volcanic eruptions; and gases, like methane, which are emitted from decomposing organic matter in soils.

Consequence of air pollution

Air pollution has a disastrous effect on children. Worldwide, up to 14% of children aged 5 – 18 years have asthma relating to factors including air pollution. Every year, 543 000 children* younger than 5 years die of respiratory disease linked to air pollution. Air pollution is also linked to childhood cancers. Pregnant women are exposed to air pollution, it can affect fetal brain growth. Air pollution is also linked to cognitive impairment in human beings.



Photocatalysis for air purification

It is a fascinating technology that uses light energy to activate catalysts, typically titanium dioxide (TiO_2), to break down pollutants in the air into harmless substances. Here's how it works:

Photocatalyst: Titanium dioxide is applied as a thin coating onto a surface, such as filters, walls, or building materials.

Activation by Light: When exposed to ultraviolet (UV) light, TiO_2 generates electron-hole pairs, creating highly reactive free radicals.

Pollutant Breakdown: These free radicals then oxidize and decompose organic compounds, such as volatile organic compounds (VOCs), bacteria, viruses, and other airborne pollutants.

Harmless Byproducts: The pollutants are broken down into simpler, less harmful substances like carbon dioxide and water.

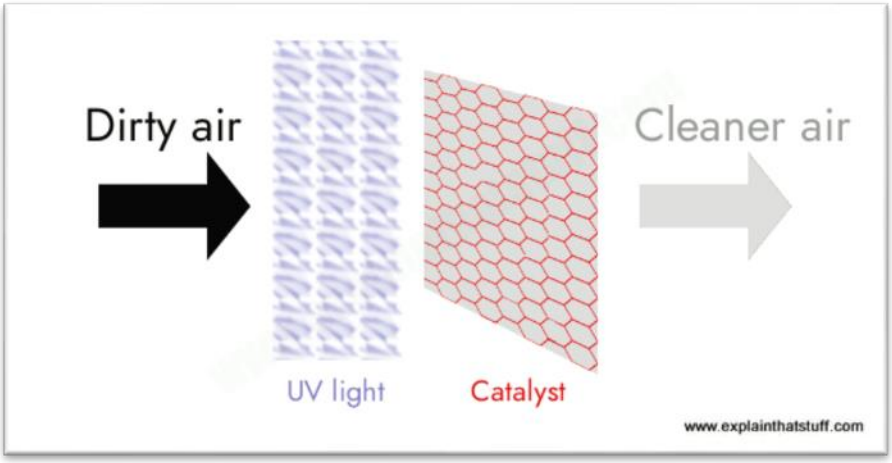
Photocatalysis is known for its ability to continuously break down pollutants and pathogens without being consumed itself, making it a promising solution for indoor air quality improvement. However, there are some considerations:

Light Source: It requires UV light for activation, which can be provided by sunlight or artificial UV lamps.

Effectiveness: The effectiveness can vary based on factors like the intensity of UV light, surface area coated with the catalyst, and the types of pollutants present.

Maintenance: Over time, the catalyst might degrade or get contaminated, affecting its efficiency. Regular cleaning or replacement might be necessary.

This technology has been applied in various settings, from indoor air purification systems in buildings to self-cleaning surfaces in hospitals, reducing the presence of harmful microbes and pollutants in the environment. It's an area of ongoing research and development aimed at improving efficiency and practical applications.



Light is an amazing source of energy—the power behind virtually everything that happens on Earth. Light from the Sun brightens the dark depths of space, makes plants leap to life, and (indirectly) powers our bodies. In air purifiers that work using a method called photocatalysis, light energy kick-starts a process that zaps all kinds of nasty air pollutants and turns them into harmless substances instead. For people who suffer from asthma and allergies, light-powered air purifiers like these are another weapon in the fight for cleaner air and better health. The activation of photocatalysts and corresponding reactions on the photocatalyst surface can be described by the following 5 steps.

1. Adsorption of photons with an energy that matches or is greater than its band gap energy of the semiconductor.
2. Promotion of an electron from the VB to the CB, with concomitant generation of a hole in the valance band
3. Electron and hole diffusion and migration to the surface where they can react .Recombination of electron–hole pairs.
4. Stabilization of electro and hole at the surface to form a trapped electron and a trapped hole, respectively.
5. Reduction of a suitable electron accepter and oxidation of a suitable electron donor.

The photocatalytic purifier includes filter structures coated with a catalytic material. One or more UV lamps are interposed between the filter structures. The catalytic layer reacts with airborne VOCs and bioaerosols when activated by the UV lamps to thereby oxidize the VOCs and destroy the bioaerosols. The photocatalytic air purifier does not need to be replaced or regenerated after a period of continuous usage. The photocatalytic purifier of the present invention substantially eliminates odors, VOCs, and bioaerosols from air directed through the fan coil. The photocatalytic air purifier includes a control system that optimizes operating costs. Because of these features, service, maintenance, and filter replacement are reduced to a minimum. At the same time, the wellbeing of persons living in the space conditioned by the photocatalytic air purifier is improved.

Despite many advantages, photocatalytic air purification has serious limitations, such as a slow rate of treatment. The combination of photocatalysis with other technologies, such as adsorption-photocatalysis, photothermal catalysis, and plasma photocatalysis, has been proposed as a promising method to provide synergistic advantages. Hybridization of an adsorbent and a photocatalyst should increase the treatment capacity by rapidly capturing incoming target compounds on the catalyst/adsorbent surface, especially when the photocatalytic degradation capacity cannot match the rapid influx of target compounds onto the surface in real time. The adsorbed target molecules can be gradually degraded on the photocatalytic active sites by regenerating the adsorbent surface. Photothermal catalysis combines the high efficiency and durability of thermocatalytic oxidation with the low energy consumption of photocatalytic oxidation. Plasma promotes the degradation of air pollutants, and photocatalysis reduces the formation of undesired by-products (e.g., NO_x and O_3) that are often produced in plasma-driven catalysis.

Air purification would be considered one of the most promising technologies to prolong storage life, increase food safety, and protect the environment from pollutants .As in both developed and developing countries, outdoor and indoor air pollution is a primary health issue that needs to be purified by air purification techniques. There is a need for air purification and understanding the concept of controlling common indoor pollution, reducing indoor air health problems.

References

1. Vandyck T, et al. (**2018**) Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges. *Nat. Commun.* ;9:4939. doi: 10.1038/s41467-018

2. Weon S, He F, Choi W. (**2019**) Status and challenges in photocatalytic nanotechnology for cleaning air polluted with volatile organic compounds: visible light utilization and catalyst deactivation. *Environ. Sci. Nano.* 6:3185–3214. doi: 10.1039/C9EN00891.

3. Verbruggen SW. (2015) TiO_2 photocatalysis for the degradation of pollutants in gas phase: From morphological design to plasmonic enhancement. *J. Photochem. Photobiol. C.* , 24:64–82. doi: 10.1016/j.jphotochemrev.2015.07.00

4. Weon S, et al.(**2018**) Active {001} facet exposed TiO_2 nanotubes photocatalyst filter for volatile organic compounds removal: from material development to commercial indoor air cleaner application. *Environ. Sci. Technol.* 52:9330–9340. doi: 10.1021/acs.est.8b02282.

5. Weon S, Choi W. (**2016**) TiO_2 nanotubes with open channels as deactivation-resistant photocatalyst for the degradation of volatile organic compounds. *Environ. Sci. Technol.* 50:2556–2563. doi: 10.1021/acs.est.5b05418.

6. Li YX, et al. (**2016**) Constructing solid-gas-interfacial fenton reaction over alkalinized-C_3N_4 photocatalyst to achieve apparent quantum yield of 49% at 420 nm. *J. Am. Chem. Soc.* 138:13289–13297. doi: 10.1021/jacs.6b07272.

7. Kim HI, et al. (**2016**) Robust co-catalytic performance of nanodiamonds loaded on WO_3 for the decomposition of volatile organic compounds under visible light. *ACS Catal.* 6:8350–8360. doi: 10.1021/acscatal.6b02726.