Photox

Introduction

Air purifiers manufactured by Zentox Corporation are antimicrobial devices manufactured in EPA establishment number 062427-VA-001. Zentox makes no claims regarding the prevention, treatment or cure of any disease. However, the unique technology employed in the air purifiers has been proven to significantly reduce concentrations of a wide variety of hazardous and objectionable contaminants in indoor air, including but not limited to volatile organic compounds (VOCs), bacteria, viruses, fungi, ammonia, carbon monoxide, formaldehyde and urine, fecal and cooking odors.

Theory of Operation

All Photox purifiers work by photocatalytic oxidation (PCO). PCO systems use ultraviolet (UV) light to excite a catalyst such as titanium dioxide which in turn oxidizes or breaks down typical volatile organic compounds (VOC's) and other airborne contaminants in indoor environments. The process requires that an adsorbent catalytic material first be placed on a surface or structure (the substrate). An adsorbent is a material that tends to attract and hold particles of another substance to its surface. A catalyst makes a reaction more likely to happen by reducing the energy needed to accomplish the reaction. A gas stream is made to contact the catalyst while being exposed to UV light. The light provides the energy needed to excite the catalyst, which produces a very powerful short-lived oxidizer. During this process organic materials are oxidized to carbon dioxide and water.

One factor that affects the efficacy of the PCO process is the rate of adsorption of the catalyst. Since the adsorption rate of the system varies proportionately with the surface area of the adsorbent, greater catalytic surface areas result in greater performance. Photox utilizes nanoparticles of fumed titanium dioxide as its catalyst, which have very high surface areas. The surface area of the system will also depend upon the type of surface on which the adsorbent is placed. A fine fiber glass matrix is a particularly good surface to use.[1] Covalent bonding permanently binds the catalyst to the fiberglass support structure.

Although titanium dioxide is a good adsorbent, it is not an effective adsorbent for some challenges such as carbon monoxide, ethylene and hydrogen. Since these challenges are of importance, the Photox system covers the photocatalyst with a very thin layer of Platinum metal.[2] Platinum is an excellent absorber for those challenges where titanium dioxide alone is not effective.

[1]See U.S. Patent 5,766,455 “Fibrous Matte Support for the Photopromoted Catalyzed Degradation of Compounds in a fluid stream”, Elliot Berman and Anatoly Grayfer, Assignee: Zentox Corporation (June

[2]See U.S. Patent 5,834,069 “In situ Method for Metalizing a semiconductor catalyst.”, Elliot Berman and Anatoly Grayfer, Assignee: Zentox Corporation (Nov. 10, 1998).

Device Description

A fan delivers air through a glass fiber media coated with a catalyst of titanium dioxide and platinum. Contaminants in the air stream are adsorbed onto the catalytic surface and are oxidized when illuminated by UV light. The treated air is then discharged back into the room. All Photox air purifiers utilize the same technology, and carry the same certifications. Photox models include LeVOCC NP 100,

Photox NP 100, LeVOCC 200, Photox 200, LeVOCC 500 , and Photox 500. Bench and performance testing was accomplished using different models, but for the sake of simplicity in this document all models will be referred to as Photox machines.

Photox Model Comparison

Model	Fan Size	Case Size	Catalytic Reaction Module (CRM)	UV Lamp	Hour Meter
Photox NP 100	Small (100 scfm)	small	1 – small flat media (APR = 155 CFM/SQFT)	1 small UVA (18 watt)	No
LeVOCC NP 100	Small (100 scfm)	small	1 – small flat media (APR = 155 CFM/SQFT)	1 small UVA (18 watt)	No
Photox 200	Small (100 scfm)	small	1 – small pleated media (APR = 155 CFM/SQFT)	1 small UVA (18 watt)	Yes
LeVOCC 200	Small (100 scfm)	small	1 – small pleated media (APR = 155 CFM/SQFT)	1 small UVA (18 watt)	Yes
Photox 500	Large (500 scfm)	large	4 – large pleated media (APR = 155 CFM/SQFT)	4 large UVC (36 watt)	Yes
LeVOCC 500	Large (500 scfm)	large	4 – large pleated media (APR = 155 CFM/SQFT)	4 large UVC (36 watt)	Yes

Note: 1. See attached Operations and Maintenance Manuals for additional specifications.
2. APR = Air Permeability (porosity) Rating

The Photox machines all use the same media in their Catalytic Reaction Modules (CRM's) that act as active surfaces through which the air being treated passes. The small machines all use the same fan and UV lamps and the large machines all use the same fan and UV lamps.

The CRM's consist of a high airflow (low pressure drop) glass fiber media coated with a platinum-infused titanium dioxide (TiO2) catalyst. The design is such that all air passes through the CRM's with no undesirable short-circuiting or "by-passing" of the catalytic surfaces. The CRM in the 100 models are of flat, single layer construction. Much of the performance and bench testing was accomplished with the 100 series of machines. Since the efficacy of the units is largely dependent on the area of the catalytic surface, the 100 series with its flat CRM (small surface area) represents the worst-case scenario, as its use would produce the poorest results when compared to other Photox machines. The 200 models use the same fan, case and UV lamp as the 100 models, but incorporate a pleated CRM design, which increases the reactive surface area and hence performance of the system. The CRM's in the larger 500 models are also pleated. The 100 models are equipped with one 18 watt UVA lamp, while the larger 500 models use four 36 watt UVC lamps to illuminate the CRM's. Air is circulated though the units by means

of a variable speed fan that is capable of moving up to 100 scfm in the small models or 500 scfm in the large models. Air is introduced into the unit from the bottom or sides of the unit, and then moves through the CRM media on which the PCO process occurs. Treated air is then discharged out or near the top of the unit. The units have only one moving part, a fan, to draw in the air to be treated and recirculated in the room. The units consume very little power and can be safely operated continuously when used according to the operating manuals (attached).

It is recommended that the CRM and UV lamp be changed annually. The CRM, in a normal room with light dust, should be changed once every 8,500 hours or approximately once per year. Likewise, the UV lamps have an effective operating time of about 8,500 hours each or approximately one year of operation at twenty-four hours a day.

Although the CRM is not "consumed" during operation, it may become fouled over time with particulate matter, which could interfere with airflow and the unit's efficiency. In environments where the air is heavily laden with dust, the CRM should be changed more frequently.

A fan pulls ambient air into the bottom of the small units and forces it evenly through the porous cylindrical Catalytic Reaction Module (CRM). UV lamps excite the catalyst on the CRM destroying adsorbed contaminants as air passes through. The clean air is then returned to the room through openings in the top of the units.

Although it is widely understood that UVC light is in itself biocidal, it should be noted that the efficacy of Photox units is not achieved by direct exposure of contaminants to a particular frequency of UV light, but rather through the exceptionally efficient catalytic reaction process. Therefore UVA or UVC bulbs are used with equal effect. The small units use smaller UVA bulbs while the large units use larger UVC bulbs. To preclude inadvertent exposure to UVC rays, the large units all have a safety switch that automatically shuts off the unit in the event someone opens the unit while it is running.

Following are a schematic depicting airflow through the small units and some accompanying photographs.

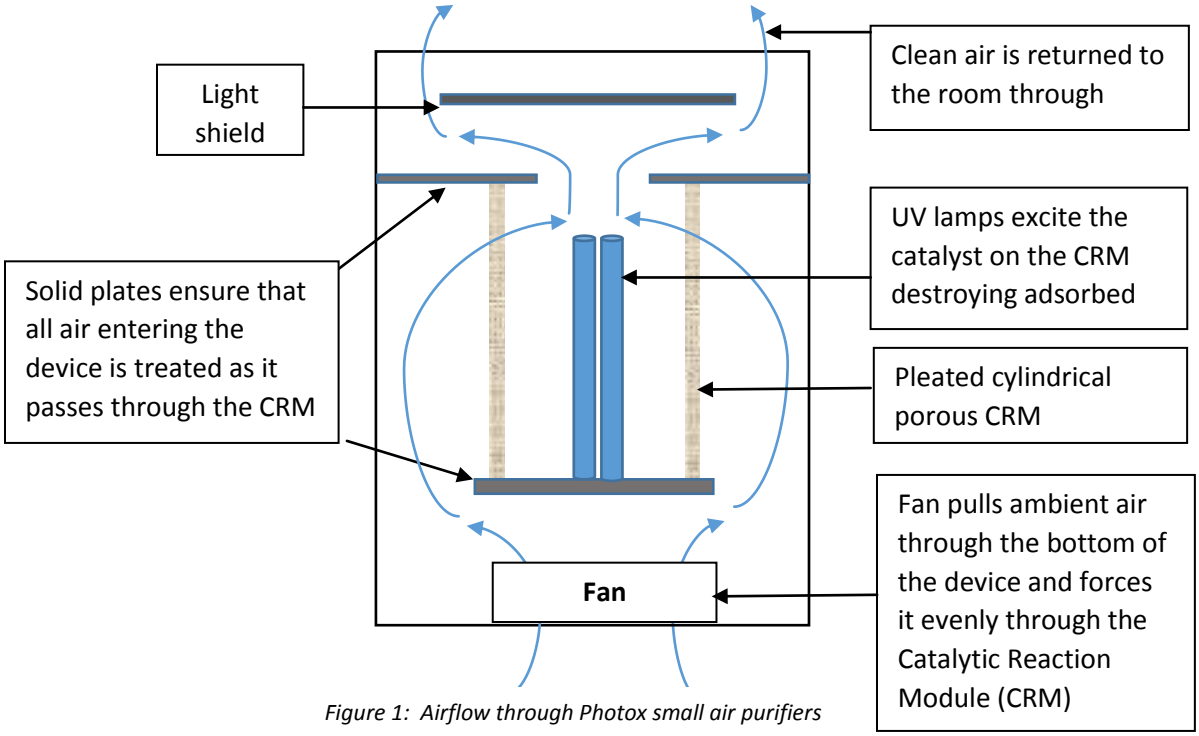

Figure 1: Airflow through Photox small air purifiers

Figure 7: External view of large model showing air intake and egress louvers

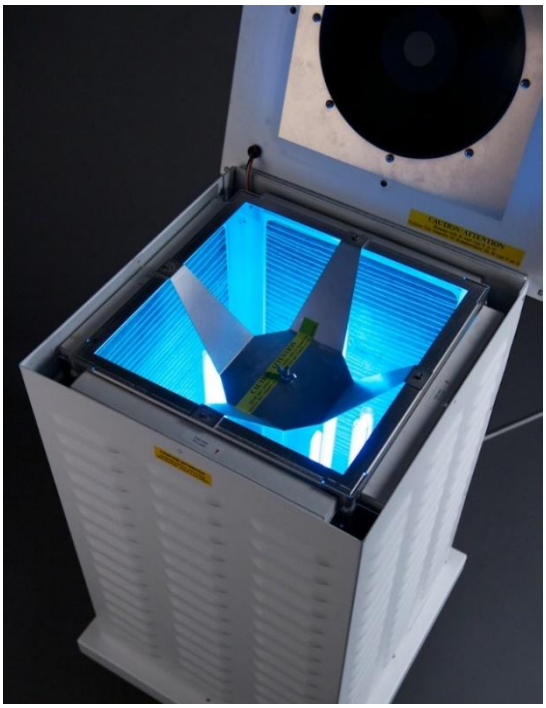

Figure 8: Internal view of large model showing illuminated CRMs and fan housing in open lid (safety switch that normally precludes operation with top open was deactivated only for the purpose of capturing this photograph)

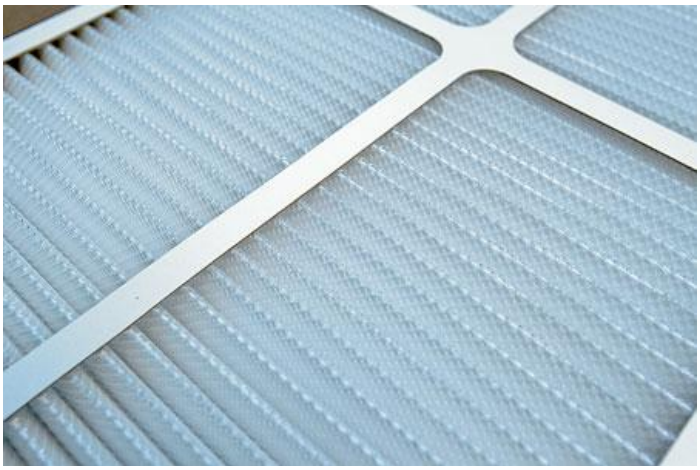

Figure 9: Large model rectangular pleated Catalytic Reaction Module. Entire surface is flooded with UV light making every illuminated point a potential contaminant-destroying reaction site.

Development of the pleated CRM:

The PCO media is a fibrous matte that is coated with a catalyst containing titanium dioxide and platinum. The bonds of the catalyst on the glass mat are permanent. The fibrous mat is porous so that air can flow through. As air flows through the media VOCs such as benzene, toluene, xylene, formaldehyde, etc. are adsorbed onto the titanium dioxide and/or platinum.

A light source excites the catalyst which is photo sensitive. This results in oxidation and/or reduction of the VOC at the surface of the catalyst. VOC oxidation is driven to base components which are typically water and carbon dioxide. With the platinum present, carbon monoxide can also be oxidized. These reactions take place in a normal setting where some humidity is present. The catalyst is "cleaned" as the VOC is removed and will repeat the cycle. The actual process works best with multiple passes through the catalyst as not all the VOC in the air stream will necessarily be adsorbed on the first pass.

Since the heart of the system is to adsorb the VOC onto the surface of the catalyst, the size of the porous opening of the media and the flow rate through the media affect the contact time of the VOC for adsorption onto the catalyst. The small units are sized with a variable speed fan having a maximum air flow of 100 CFM. The media has an Air Permeability Rating (porosity rating) of 155 CFM/SQFT. This means that the maximum air flow through a square foot of media is 155 cubic feet per minute.

The original 100 flat media has an area of 255 square inches. This means that the air flow though the unit in CFM/SQFT for the 100 unit can be calculated at 60 CFM/SQFT.

If the surface area of the media is increased for the same air flow, the result will be a greater exposure of the air to the media surface, thus increasing the contact time and ultimate performance.

The 200 cartridge has a pleated media which has 2.8 times the surface area of the 100 unit with its flat media. When the 200 cartridge is inserted in place of the 100 flat media, the result is an air flow of 20 CFM/SQFT. This lower CFM/SQFT allows a greater exposure of biological contaminants to the catalyst resulting in nearly three times the efficiency as compared to the 100 flat filter. To summarize, the 200 unit with its pleated CRM handles VOC challenges about 3 times the rate of the 100 unit. The 500 models also utilize a pleated CRM design to maximize performance.