Design of Air Purification Device Based on Efficient Photocatalysis

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Abstract. In order to solve the problem that the existing photocatalyst recovery efficiency and photocatalytic efficiency cannot be obtained at the same time, the inner cavity structure of the inner cavity designed according to the Kangda effect has excellent fluid performance, and the light-shielding and breathable structure designed to imitate the louver structure can prevent the damage caused by ultraviolet radiation overflow, the inner surface reflective layer can reduce the waste of light energy. This high-efficiency photocatalytic air purification device has been designed, the overall structure is simple and efficient, and easy to clean and maintain. The whole is small and compact, and the placement is not limited, adapt to a variety of more closed space, adapt to all kinds of people.

1. Introduction
In modern cities, the degree of air pollution in closed environments is many times higher than outdoors. The results of spot checks by the national health, 68% of indoor and car decoration materials are contaminated with toxic gas. More than 300 volatile organic compounds can cause headaches, convulsions, difficulty breathing, and even cancer.

Therefore, it is necessary for us to treat closed ambient air. The general treatment methods include ventilation, physical adsorption, plant purification, etc. However, the applicability of ventilation is poor, the physical adsorption has not solved the fundamental problem, and the plant purification effect is poor. Therefore, there is an urgent need to develop an efficient, green and simple indoor pollution air treatment technology.

The results of the study found that under the action of ultraviolet light, photocatalysts can generate free radicals with high catalytic activity, which can produce strong photooxidation and reduction capabilities, and can catalyze and photolysis a variety of organic matters and some inorganic matters attached to the surface of objects, and the degradation products are pollution-free.

2. Research content and research significance
In order to solve the above-mentioned problem that the photocatalyst recovery efficiency and the photocatalytic efficiency cannot be obtained at the same time, we have designed a new type of air purification device, and the device structure auxiliary carrier further improves the catalytic efficiency. Optimize the device structure based on the Kangda effect and geometric optics principles. From the perspective of macro physics, improve the photocatalytic efficiency, so that it can not only purify the...
air efficiently and energy-efficiently, but also effectively inhibit the overflow of internal ultraviolet light to harm the human body, and the developed structure has both functionality and aesthetics, expanding the applicable surface, which is conducive to the promotion of the device.

3. Project implementation plan

Supported photocatalytic technology is to load photocatalyst on the carrier. The photocatalyst is excited by the specific wavelength of light after photochemical reaction to generate strongly oxidizing hydroxyl radicals, which can decompose organic matter, bacteria, etc., to produce carbon dioxide and water. At present, the main ways to improve the efficiency of photocatalytic reactions are improve the photocatalyst activity from the chemical perspective, optimize the photochemical reaction efficiency, widen the wavelength range of the photoreaction, and increase the specific surface area of the load from the physical perspective. However, with the increase of specific surface area, light conditions are ignored, causing the photocatalysts on some surfaces to fail to react, affecting the overall reaction efficiency.

In order to further improve the application of photocatalytic technology in the treatment of air, we have designed a more efficient photocatalytic air purification device. On the one hand, the device provides necessary conditions for the reaction; on the other hand, it enhances the efficiency of the photocatalytic reaction from the device structure. In turn, the efficiency of processing air is improved.

4. Device structure design

4.1. Overall structural design

Figure 1 is a three-dimensional and two-dimensional cross-sectional view of the structure and function of the device. The appearance of the device is designed as a cylindrical structure. The airflow inlet and outlet are at the two ends of the cylinder, respectively. The ultraviolet lamp with a power of 15W and a main wavelength of 254nm penetrates both ends at the axis.

The main channel for processing air is a large channel from left to right. The power for gas circulation is blown by the lower part 6) a small turbo blower, combined with 2) the internal structure of the cavity to form a high-speed airflow, which drives the gas flow in the main channel. When the harmful gas into the cavity, the photocatalyst loaded on 1) the carrier is excited by the light emitted from the 3) ultraviolet tube to generate superoxide ion radicals, hydroxyl radicals, and superoxide hydroxyl radicals, which have a strong oxidation effect, it can not only oxidatively decompose toxic and harmful gases such as formaldehyde, benzene, toluene, xylene, ammonia, TVOC, pollutants, odors, bacteria, etc. into harmless CO\textsubscript{2} and H\textsubscript{2}O, but also has high efficiency and broad spectrum disinfection performance.

1) Catalyst carrier; 2) Cavity; 3) Ultraviolet lamp tube; 4) Breathable reflective end cap; 5) Filter screen; 6) Small turbine fan; 7) Circuit controller

**Figure 1.** Schematic diagram of device structure and function.

In order to reduce the overflow of light and make full use of light energy, a mirror layer is coated in the inner cavity, and the reflected light compensates light on the outside of the carrier and the backlight surface. For the 4) end caps that require ventilation, the original design of a breathable
reflective structure can not only ventilate the gas, but also reflect light, and finally realize the complete absorption and utilization of ultraviolet rays leaking from the gap of the carrier.

In order to prevent tiny particles from entering the cavity and to deal with residual pollutants, 5) filter screens are provided on the outer layers of the end caps at both ends of the main channel, and the filter screens include an activated carbon adsorption layer and a HEPA filter layer.

4.2. Cavity Structure Design
Based on the Kangda effect and drawing on the design principle of the bladeless fan, we designed the structure of the device cavity. As shown in Figure 2, the wind coil of the cavity is pressurized by a small turbine fan. The air pressure in the wind coil is greater than the air pressure in the main passage of the cavity. Gas is ejected from the narrow air outlet at high speed. The high-speed airflow will drive the surrounding gas forward synchronously, negative pressure is applied at the inlet end, and gas is replenished inward.

Using ANSYS CFD to perform fluid simulation on the cavity structure, it can be seen that the velocity of the airflow ejected from the gap is significantly higher than the fluid velocity in the wind circle. As shown in Fig. 3, by setting the length L and width b of the cross section of the wind coil, the opening width h of the gap and the inclination angle θ of the exit, and performing a simulation test, and a relatively ideal numerical relationship can be obtained. The structure designed in turn is more energy-saving on the premise of achieving the same effect.

![Functional principle of cavity](image1)

**Figure 2.** Functional principle of cavity.

![Structural fluid simulation](image2)

**Figure 3.** Structural fluid simulation.
4.3. Design of breathable and reflective structure
The structural characteristics of the louvers allow it to ventilate the air and block the passage of the light coming from a certain range, but the light coming from other directions can pass, as shown in Figure 4. Improve the design by imitating the structural characteristics of the louvers, and obtain a structure that can both breathe and block light penetration in all directions. As shown in FIG. 5, this structure can be understood as a mirror-symmetrical change of the louvers. When the apex of the bending angle is within the line connecting the bottom edge, any direction of light cannot once penetrate the structure. The reflective layer is covered on the folded plate surface that can be irradiated by light. The micro-light structure of the reflective layer is shown in the figure. According to the geometrical optical reflection theorem, after two reflections on the right-angle reflective structure, the light returns in the opposite direction of incidence. Reduce unnecessary loss of light.

![Figure 4. Louver structure.](image)

![Figure 5. Breathable and reflective structure.](image)

5. Conclusion
With the improvement of people's requirements for the quality of life, good indoor, car and other relatively closed space air quality more and more attention to the public. At the same time, people's technology for treating air is no longer only capable of being processed, but also can deal with it efficiently without additional adverse effects. The application of this technology and device has outstanding benefits in treating air, at the same time consumes less energy, and has lower noise, which is in line with the social concept of low-carbon environmental protection and has conditions for promotion and popularization.
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