An active indoor formaldehyde purification device

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Abstract. Formaldehyde is one of the main sources of indoor air pollution, and the removal effect of formaldehyde of common indoor air purification methods such as placing activated carbon bags or green plants and opening windows for ventilation is not ideal. This paper introduces an active indoor formaldehyde purification device that uses a motor to form the air convection and thus purify the polluted air twice. The multiple activated carbon tubes on the device increase the contact area between the activated carbon and polluted air thereby improve the purification efficiency. The experimental detection has proven that the active indoor formaldehyde purification device has a much better formaldehyde removal effect than ordinary activated carbon products, and has high practical value.

Keywords: Formaldehyde; Air Purification; Technology and Environmental Protection.

1. Background
Formaldehyde is one of the main sources of indoor air pollution. It has been identified as a Group 1 carcinogenic substance by the World Health Organization. Long-term exposure to low-dose formaldehyde can cause chronic respiratory diseases and skin allergies, as well as chromosomal abnormalities in newborn babies and memory loss in teenagers. Severe cases can also cause leukemia and nasopharyngeal tumors, especially in children and pregnant women. Nowadays, people begin to pay more and more attention to indoor formaldehyde pollution, especially after the renovation of the new house, purification measures will soon be taken to remove the formaldehyde released by decoration materials.

At present, there are three common methods for indoor air purification: 1. Placing a large number of activated carbon bags indoors; 2. Planting green plants indoors; 3. Open doors and windows for natural ventilation. Placing a large number of activated carbon bags indoors can achieve a certain degree of formaldehyde removal effect, but the purification range is limited and the absorption efficiency is low. Besides, the ordinary activated carbon bags are easy to saturate, causing a bad formaldehyde removal effect. The absorption rate of green plants is low and the method of natural ventilation is greatly affected by the weather. Therefore, the efficiency of these two methods is slow and the effect of removing formaldehyde in a short period of time is not ideal. The purification device is spherical in shape, imitating the principle of fluffs of dandelion to increase the contact area between formaldehyde in the polluted air and activated carbon in the device to increase the purification efficiency. Also, the device is equipped with a motor, several activated carbon tubes, and activated
carbon bags, which helps to form air convection to purify the air twice to optimize the purification effect.

2. Structural characteristics
The device comprises a hollow substrate, activated carbon bags, a motor, a blade, and activated carbon tubes. The interior of the hollow substrate was separated by a partition to form an air inlet chamber and an exhaust chamber. Twelve activated carbon tubes are arranged on the outer wall of the air inlet chamber, activated carbon particles are placed inside the activated carbon tubes, twenty-eight five-grams activated carbon bags are placed in the air inlet chamber, and the motor is installed on the intermediate partition plate. Each activated carbon tube includes an outer tube, an inner tube, a plug, and a connecting pipe. The connecting pipe is provided with an air inlet channel, and the surfaces of the outer tube and the inner tube are respectively provided with a large number of small holes. The activated carbon tube is 50 centimeters long and can be extended by using connecting pipes, so it can absorb the formaldehyde in every corner of the room to expand the absorption range. The outer and inner tube of the activated carbon tube is both made of silicone, which ensures its flexibility.

In order to set up the maximum number of activated carbon tubes, the device is designed in a spherical shape, imitating the fluffs of dandelion, so that the contact area of polluted air and activated carbon in tubes is maximized. The air inlet chamber, the exhaust chamber, and the partition plate are divided. The air inlet chamber has a hollow spherical structure and the exhaust chamber has a hollow cylindrical structure.

![Figure 1. Three-dimensional structure diagram of the device](image-url)
Figure 2. Longitudinal section views of the device

3. Working Principle
After turning on the device, the motor starts driving the blades to rotate. During the rotation process, a partial vacuum is formed to generate a one-way airflow inside the hollow substrate. The external gas enters the air intake chamber after being adsorbed by the activated carbon in the activated carbon tube and enters the inlet. The gas in the gas chamber enters the exhaust chamber after being adsorbed by the activated carbon bag the second time. A certain degree of air pressure is generated in the exhaust chamber, which pushes the gas in the exhaust chamber to be discharged by the one-way valve. The motor keeps working, and the purification process continuously goes on.

4. Technical Advantages
The device has the following technical advantages:

- The device includes a large number of activated carbon tubes and has fast purification speed and high purification efficiency.
- The length of activated carbon tubes can be adjusted. When the indoor space is large, a longer tube can be used. The tube has a certain flexibility and can be used in every corner of the room, such as the bottom of the bed and the bottom of the table, to expand the purification range.
- The motor can work continuously to make continuous airflow so as to speed up the formaldehyde purification efficiency.
- The device can purify the air twice by using the activated carbon tubes and the spherical activated carbon package to improve the purification effect.

5. Experimental detection
In order to test the actual purification effect of the device, the active indoor formaldehyde purification device and activated carbon bag with the same weight as it contained in the device are placed in two newly installed cabinets of the same volume and size respectively. By continuously detecting the value of formaldehyde in the cabinet, the change in the concentration of formaldehyde within 48 hours was investigated, so as to compare the air purification effect of the device and ordinary activated carbon bag. The controlled testing experiment proved that the purification effect of ordinary activated carbon reaches saturation in 4 hours, while the formaldehyde purification effect of the device continued to be effective, and the purification effect was much better than that of ordinary activated carbon bags.
5.1. **Experimental purpose:**
To investigate the formaldehyde purification effect of active indoor formaldehyde purification device and ordinary activated carbon

5.2. **Experimental conditions:**
Experimental group: Active indoor formaldehyde purification device, which contains 140g activated carbon bags and 720g activated carbon particles
Control group: 140g activated carbon bags and 720g activated carbon particles

5.3. **Equipment:**
1) Two new cabinet drawers of the same volume (size: 53*24*39 cm)
2) Wind speed, temperature, and humidity detector
3) Formaldehyde detector

5.4. **Experimental standard:**
According to GB/T18883-2002 and GB50325-2010 standards, the acceptable indoor formaldehyde level should be \( \leq 0.1 \text{ mg/m}^3 \).

5.5. **Results:**

**Table 1.** Detected level of formaldehyde concentration in control group and experimental group within 48 hours

| Duration | Control group |  |  |  | Experimental group |  |  |  |
|----------|--------------|------------------|---|------------------|------------------|---|---|---|
|          | Formaldehyde content (mg/m³) | Temperature (°C) | Relative humidity (%) | Wind speed (m/s) | Formaldehyde content (mg/m³) | Temperature (°C) | Relative humidity (%) | Wind speed (m/s) |
| 0h       | 0.668        | 26.9             | 63             | 0                | 0.824            | 27              | 62             | 0              |
| 1h       | 0.172        | 27.7             | 59             | 0                | 0.075            | 27.8            | 59             | 0              |
| 2h       | 0.11         | 28.4             | 60             | 0                | 0.044            | 28.2            | 59             | 0              |
| 4h       | 0.203        | 28.3             | 60             | 0                | 0.063            | 28.2            | 59             | 0              |
| 8h       | 0.222        | 27.5             | 61             | 0                | 0.118            | 27.6            | 61             | 0              |
| 12h      | 0.245        | 26.4             | 65             | 0                | 0.114            | 26.5            | 65             | 0              |
| 24h      | 0.381        | 27.5             | 60             | 0                | 0.175            | 27.5            | 60             | 0              |
| 36h      | 0.397        | 27.5             | 63             | 0                | 0.166            | 27.4            | 63             | 0              |
| 48h      | 0.443        | 27.5             | 65             | 0                | 0.142            | 27.2            | 64             | 0              |
5.6. Results and Analysis:
The result of the testing experiment indicates that: First, both the experimental group and the control group could significantly reduce the formaldehyde concentration level in the cabinet within the first hour, but the purification speed of the experimental group was faster, and the formaldehyde concentration level in the cabinet dropped to the acceptable range within an hour. Second, formaldehyde adsorption saturation occurred in both groups at the fourth hour, so the formaldehyde concentration level rebounded and increased. However, the formaldehyde concentration level in the experimental group was still in the acceptable range, while the formaldehyde concentration level in the control group exceeded the standard. Third, at the eighth hour, although the formaldehyde concentration level in the experimental group exceeded the national standard of 0.1 mg/m³, it was still lower than the formaldehyde concentration level in the control group.

6. Conclusion
The experimental data show that the active indoor formaldehyde purification device has a rapid and long-lasting effect in purifying formaldehyde, and its purification effect is much better than that of ordinary activated carbon bags, which shows that it has high practical value.

References
[1] GB/T18883-2002. “Indoor air quality standard”.
[2] GB50325-2010. “National standard for indoor environment”.

Figure 3. Line chart of formaldehyde concentration change in experimental group and control group