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Abstract. Global air pollution causes a lot of health problems every year, especially in developing countries. In this study, chemical decomposition and spray technology are used to deal with the six main pollutants in the air. Acid and alkaline sprays are used to treat different pollutants, which cause the chemical pollution gas to be toxic and left behind in the reaction device. The air purifier with traditional filter technology has better effect.

1. Introduction

The world health organization (WHO) released the latest global air quality report, the report shows: the global air pollution is serious, every 10 people 9 people breathe the air contains high concentration of pollutants; The eastern Mediterranean and southeast Asia have the highest level of environmental air pollution, and the annual average is usually more than 5 times of the WHO limit. In 2016, the average annual exposure concentration of PM2.5 in China dropped to 48.8 g/m3, but it was still four times higher [1-3]. Each year, 7 million people worldwide die prematurely from indoor and outdoor air pollution. Of these, 21 percent die from pneumonia, 20 percent from stroke, and 7 percent from lung cancer. Every year, 3.8 million people die prematurely due to indoor air pollution, and women and children are most at risk [4-6]. At present, more than 4,300 cities in 108 countries (including more than 300 cities in China) have been included in the WHO database on environmental air pollution. The database collects annual average concentrations (PM10 and PM2.5), which contain the most health-threatening pollutants such as sulfates, nitrates and black carbon. The main sources of air pollution caused by particulate matter include the inefficient use of energy by households, industry, agriculture and transport sectors, and coal-fired power plants. In some areas, sand and dust, waste burning and deforestation are also sources.

At present, the household air purifiers on the market are mainly used for filtering through the filter screen to achieve the purpose of purification. These products are relatively expensive, relatively single function, and the lack of fresh air system, many purifiers virtual standard purification effect is common. In addition, there are many pollutants in the air, and filtration can only solve part of the problem, but the treatment of sulfur dioxide, carbon monoxide and other toxic gases is missing and ineffective. The actual effect will lose its function with the saturation of the filter screen. Since the filter screen needs to be replaced regularly, the later maintenance cost is relatively high [7-10].

At present, the detection and evaluation of Air Quality mainly rely on the "Air Quality Index" (AQI), which is a numerical value used to describe the Air Quality level quantitatively. The value

range of AQI is between 0 and 500. There are many types of environmental air pollutants. The main pollutants monitored and detected by AQI include PM2.5, PM10, ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) [11]. Therefore, the air purification technology we study is to eliminate the above six pollutants, through adsorption, chemical degradation and other procedures, so that the toxic substances in the air greatly reduced or disappeared, so that there is no dust pollution in the air, there is no toxic gas. Therefore, this technology also has the air essence and the air antivirus double effect.

2. Development of purification technology methods

In order to solve the six major pollutants in the air, we studied a series of technical solutions to achieve. The patent for this technology-related application has been authorized and protected by the Patent Office of China intellectual property office, certificate No.: ZL201720122972.7.

2.1. Dust treatment technology

PM2.5, PM10, we no longer use the traditional filter technology, but the spray adsorption technology. This process is carried out under the condition of sealing. The required raw material is water. The liquid water is transformed into extremely fine water mist through a sprayer. Further, in order to prevent the formation and precipitation of carbonate, resulting in visible sediment, blocking the pipeline, you can add a certain amount of hydrochloric acid in water, hydrochloric acid concentration control between 1% and 20%. To further reduce the less likely problem of carbonate deposition, liquid water can be as pure as possible.

2.2. *Ozone (O_3) treatment technology*

In general, the amount of ozone in the atmosphere is relatively low. However, concentrations may be higher in households where ozone disinfectors are used in some production plants. The main harm of ozone is irritation and damage to human skin and respiratory tract. But ozone chemistry is extremely volatile. Ozone with a content of less than 1% has a decomposition half-life of about 20-30 minutes in the air at normal temperature and pressure. As the temperature increases, the decomposition speed increases. If the concentration of ozone in water is 6.25 10-5mol/L(3mg/ L), its half-life is 5 ~ 30min. Ozone can be dissolved well in multiple sprays. Therefore, ozone treatment is not difficult.

2.3. *Treatment technology of sulfur dioxide (SO2) and nitrogen dioxide (NO2)*

These pollutants can be called acidic gases. Acidic gases are usually eliminated by the use of alkaline solutions. We can achieve the PH value of the solution between 7 and 14. The preferred alkaline substances are sodium hydroxide and sodium oxide. Sodium salts do not readily precipitate to block the ducts and are therefore preferred. Sodium hydroxide and sodium dioxide can form sodium sulfite. The equation is as follows: 2NaOH + SO2=Na2SO3 + H2O.

The basic substance is always larger than the molecular weight of the acidic gas. As the PH of the solution decreases, the alkalinity is added again. But if sulfur dioxide is filtered, sodium bisulfite can also be produced: Na2SO3+SO2+H2O=2NaHSO3.

After the neutralization reaction of acid and base, the toxicity of acid gas disappears. The resulting sodium sulfite dissolves in water and does not precipitate to block the catheter.

2.4. *Ttreatment technology for carbon monoxide (CO)*

Carbon monoxide is toxic at a concentration of 1.3g/L. Carbon monoxide is easy to combine with hemoglobin, form carbon oxygen hemoglobin, make hemoglobin lose the ability that carries oxygen and action, cause tissue to suffocate, die when serious. Carbon monoxide poisoning kills nearly 400 people in the United States each year and is the leading cause of death in the United States. Although carbon monoxide has good reducibility, it is difficult to produce chemical reaction at room temperature and pressure. It's also hard to adsorb. Therefore, the elimination of carbon monoxide is the technical difficulty. In tests, carbon monoxide is usually REDOX at high temperatures. In order to

react carbon monoxide at room temperature, we introduced catalysts such as palladium chloride [12-13].

In the presence of water and under the action of carbon monoxide, phosphomolybdate, palladium chloride and potassium permanganate, the equation is: CO+PdCl2+H2O=CO2+Pd +2HCl. Then Pd of phosphomolybdate oxidation is PdCl2, molybdenum blue. For example: Mo4O10(OH)2 and Mo8O15(OH)6. The resulting carbon dioxide gas can be absorbed by the alkaline solution.

Because carbon monoxide is low in most cities with polluted air, it is less harmful than acidic gases. In addition, the catalyst itself is toxic. Therefore, although carbon monoxide can be degraded at room temperature technically, it is not necessary to use this technology in ordinary homes and offices. The problem of carbon monoxide accumulation can also be solved by strengthening the ventilation of the fresh air system. This technology can only be used to eliminate carbon monoxide under special production, indoor coal burning and other special conditions.

3. Design of core components of the purifier

3.1. *Design*

In order to fully demonstrate the six air pollution treatment processes, we specially designed a circulating essence treatment device, as shown in the following figure:

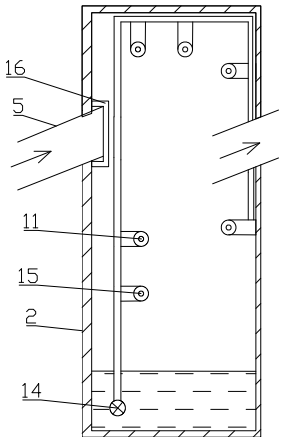

Figure 1. As shown in figure 1, 1, 2, 3, 4 are bottles 1-4. 5 is a one-way air inlet pipe, 6 is an indoor air inlet, 7 is an outdoor air inlet, 8,10,12 are an air inlet pump, 9 are an internal gas circulation pipe, 18 are walls, the imaginary horizontal line in the bottle is liquid, and the arrow is the direction of air flow.

3.2. *Description of working principle*

The equipment comprises a purification bottle no. 1, a purification bottle no. 2, a purification bottle no. 3 and a purification bottle no. The first purification bottle is connected with an inlet pipe, and the fourth purification bottle is provided with an outlet pipe; The no. 1 purification bottle contains ethanol solution; The second purification bottle contains acid potassium permanganate solution containing palladium chloride; No.3 purification bottle contains alkaline solution; Number four contains pure water.

No. 1 purifying bottle is a liquid mixed with water and appropriate amount of ethanol. The proportion of ethanol is between 1% and 50%. However, ethanol should not be too large, or volatile. A small amount of the volatile ethanol may drift into the second bottle, where it can be eliminated by reacting with potassium permanganate. The air inlet of bottle no. 1 can be connected to the outside, and the air is introduced into the room from outside the wall and the outside, and finally discharged into the room from bottle no. 4, which functions as a fresh air system. When the outdoor air pollution is serious, the indoor circulation mode can also be opened. The air inlet is opened indoors and the

outdoor air inlet is closed to purify the indoor air without introducing fresh air. In order to enhance the air flow speed, can be added in the air inlet one-way air compression pump as an intake pump.

No. 2 purification bottle for potassium permanganate, phosphomolybdate, sulfuric acid and hydrochloric acid, or sulfuric acid and nitric acid, or hydrochloric acid and nitric acid together into a more acidic solution, the PH value maintained between 1 and 7, at the same time adding trace palladium chloride as a catalyst, can make carbon monoxide and potassium permanganate reaction, the elimination of carbon monoxide at room temperature. Palladium chloride is toxic, but as a catalyst requires only a tiny amount.

No. 3 bottle is a highly alkaline solution with a PH between 7 and 14. It is designed to eliminate acidic gases in the air stream and acidic substances that may come from no. 2 bottle.

No. 4 bottle is pure water, which can be added with natural aromatic substances to improve indoor odor. Bottle no. 4 and no. 1 are connected by a separate conduit that allows for multiple cycles of air purification. The air outlet of the fourth bottle can be added with an air pump to enhance the air circulation speed.

Each bottle above is provided with a live multiple sprayers, which can transform the liquid in the bottle into water mist, increase the contact area with the incoming gas and improve the efficiency. In order to prevent the reverse flow of the liquid in each bottle, one-way valves are used at the joint of no. 4 bottle from no. 1 bottle to avoid the reverse flow of the liquid in the next bottle. Since the catheter is tilted, it is also possible to return the liquid from the previous bottle and avoid entering the next bottle.

There is a circulation pipe between the no. 1 and no. 4 purification bottles. It is convenient to filter the air with high concentration of pollutants for many times to improve the purification effect. The catheter can add an air inlet pump, which can realize the gas circulation purification and enhance the purification effect.

Further, the air purifier can be designed with a housing equipped with sensors to detect air quality, as well as microcomputer control units, such as control of purification mode and intensity. Sensors include air quality index sensors, humidity sensors, temperature sensors, etc. The whole purifier can be hung outside the wall, and only the air outlet, sensor display screen and remote control structure after purification need to be placed indoors, so as to avoid the noise generated by the purifier from entering the room and save the indoor space.

4. Effect test

4.1. *Experimental methods*

8 offices of 17 square meters with normal electrical appliances and office furniture were selected. Among them, 4 offices were used as the control group and mile-brand air purifiers made in China were used. The other 4 offices were used for air purification by this method. Before the test, open all doors and Windows for 10 minutes, and then close the doors and Windows. The experiment was carried out for 30 minutes, and indoor circulation purification was adopted. The data collector arrived in the room in advance, tried to keep the static state to avoid the influence on air flow, and measured the air pollutants before and after the experiment. The detection instrument is an air quality detector produced by lianyungang lanbao electronic technology co., LTD., model: lb-hd08. Time: may, 2018. Location: chengdu, China.

4.2. *Data collection and processing*

As the air quality index (AQI) is used to calculate the values of 6 pollutants, the largest one is the AQI value. The formula is as follows: AQI= Max {IAQI1, IAQI2, IAQI3... , IAQI6}. According to the AQI data of the local meteorological bureau, PM10 is usually larger than PM2.5. In the actual measurement, PM10 is also larger than PM10. Before and after the experiment, the AQI of the outside was 80 and 83 respectively, and there was little change before and after the experiment. Results SPSS25.0 version was used to test the intra-group matching and inter-group independent samples. Compared with the AQI values of the two groups of rooms before the test, the significance P=0.780 >

0.05, with homogeneity of variance. The results showed that there was no difference between the groups before the test, and the test conditions were consistent and comparable.

4.3. *AQI test results*

The experimental results showed that both purification methods could reduce the air quality index (aqi). However, the purification effect of this technology is better, and there are significant differences between groups. See table 1 for details.

Table 1. Intra-group and inter-group comparison between the experimental and the control group

group	N	Before the test	After the test	*T*	*P*	*T'*	*P'*
experimental group	4	77.25±0.96	21.50±2.65	65.29	0.000	-8.416	0.000
control group	4	77.25±1.26	43.50±4.51	13.52	0.001		

(note: T and P are T tests of paired samples in each group. T ',P 'are the T test results of independent samples between groups.)

4.4. *Change results of six major air pollutants*

The horizontal axis represents the values of different rooms. Rooms 1 to 4 are for the experimental group, and rooms 5 to 8 are for the control group. As can be seen from the results, the six pollutants in the experimental group decreased a lot, while the overall decrease in the control group was less. Although PM2.5 and PM10 in the control group were significantly reduced, the reduction of other four pollutants was not significant. It shows that the experimental technology has outstanding advantages in dealing with ozone, acid gas and carbon monoxide

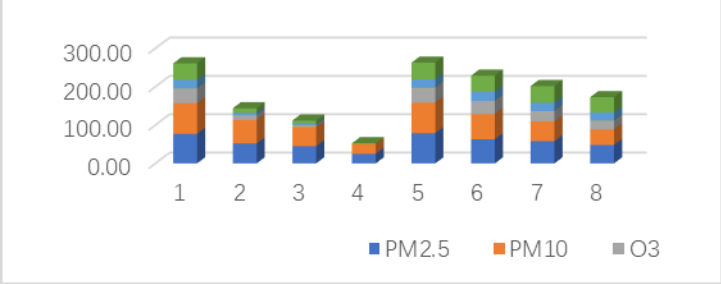

Figure 2. Changes of six pollutants with the purification time

5. Conclusion

Air used in the purification plant organic dissolved with ethanol, acid, alkali, respectively, with the air pollution of chemical reaction, in theory, can eliminate the harm of the pollutants in the air, and even to some poison also have eliminate the effect, of killing the microorganisms in the air also have multiple links, at the same time many times washing and liquid washing let the dust in the air has also been greatly reduced. Through scientific research practice, the invention has reliable technology and satisfactory purification effect. When indoor air quality is heavily polluted, half an hour can reach an excellent level. The raw material cost is low, easy to obtain, the later maintenance is cheap, has the great market promotion potential. It can be used in home, office, school, hospital, production workshop and other places. Can also meet the needs of anti-chemical weapons, poison gas. Its application prospect is broad.

References

[1] Information on https://www.who.int/zh
[2] Matthew Shupler, William Godwin,Joseph Frostad. Global estimation of exposure to fine particulate matter (PM 2.5) from household air pollution. Environment

International,2018,120.
[3] Xiao yu wang, Wang Yuan, jintai. Outdoor air pollution and preterm birth and low birth weight: the world health organization (who) maternal and perinatal care global survey analysis. Journal of environmental and occupational medicine, 2014, 31 (12): 988-993.
[4] Kristin Aunan,Mette Halskov Hansen, Zhaohui Liu. The Hidden Hazard of Household Air Pollution in Rural China. Environmental Science and Policy,2019,93.
[5] Wei lili. Current situation analysis of self-statement of enterprise standards for air purifiers. Standardization in China,2016 (08):45-50.
[6] Jingjing Pei, Lili Ji. Secondary VOCs emission from used fibrous filters in portable air cleaners and ventilation systems. Building and Environment,2018.
[7] Pan benfeng, li lina. Comparison of calculation methods and grading schemes of air quality index. China environmental monitoring,2016,32 (01):13-17.
[8] Li Qiaohong, Qiao Luyang,Chen Ruiping. Carbon monoxide oxidation catalysed by defective palladium chloride: DFT calculations, EXAFS, and in situ DRIRS measurements.. Physical chemistry chemical physics : PCCP,2016,18 (4).