PORTABLE UV PLASMA AIR PURIFIER IN AUTOMOBILE

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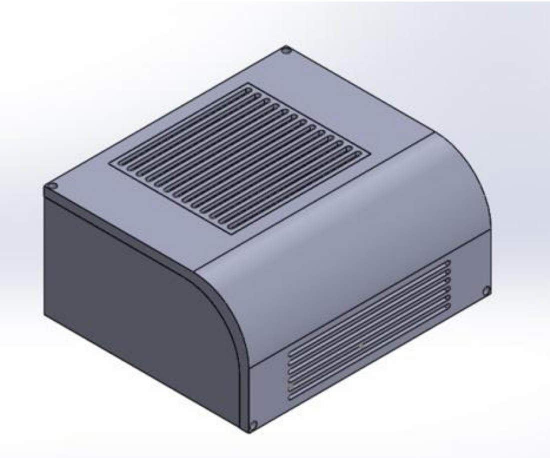
GRAPHICAL ABSTRACT



ABSTRACT

Air quality in automobiles is worse than the air outside. As such, there is a need to develop efficient air purifier to remove air pollutants in automobiles. In this study, a prototype has been assembled and tested for its functionality and performance using air quality measuring devices. Performance test has been done to test the efficiency of the air purifier in removing five different air pollutants, which are CO_2, NOx, CH_2, CH_3 and SO_2. The percentage change of removal of each air contaminant is quite high, having removed SO_2 with 93%, CO_2 with 48.85%, NOx with 35.96%, CH_2 with 27.05% and CH_3 with 25.35%. Overall, the air purifier is highly efficient in removing air pollutants.

KEYWORDS

Air purifier; automobile; UV plasma; air pollutants

INTRODUCTION

The increase of industrial activities and automobiles nowadays has increased the pollution in air. Although most people tend to think that the air inside their automobiles is cleaner than the air outside, studies has found that the air quality inside the automobile is filthier compared to outdoor, as pollutants from the outside flow into the automobiles and influence the air quality in cars negatively [1,4,6].

There are many pollutants present in automobiles, such as volatile organic compounds (VOCs) [2] carbon dioxide (CO_2), sulphur dioxide (SO_2), particulate matter (PM) [7], carbon monoxide (CO), nitrogen oxides (NOx) [8], biocontaminants and many more. Removal of these hazardous air pollutants effectively and quickly is necessary.

Thus, it is important that air purifiers be installed inside automobiles to improve the air quality. There are many types of air purifiers available in the market. There are UV (ultra-violet) air purifiers [3] and plasma technology air purifiers [5].

In this study, a UV plasma air purifier, which combines the UV and plasma technologies, is proposed for assembly and test. Other types of filters are also proposed for assembly in the air purifier to increase the efficiency of air pollutants removal of different types and sizes.

METHODOLOGY

Design, Assembly and Fabrication

The proposed air purifier was designed according to aspects of health, comfort, environment and energy consumption. After a detailed design drawing was obtained, the prototype was fabricated according to the configuration specified in the detailed design drawing. The casing of the air purifier and its holders inside were printed using a 3-D printer. After all the components were gathered, the air purifier was assembled. Figure 1 shows the detailed drawing of the final design of the prototype.

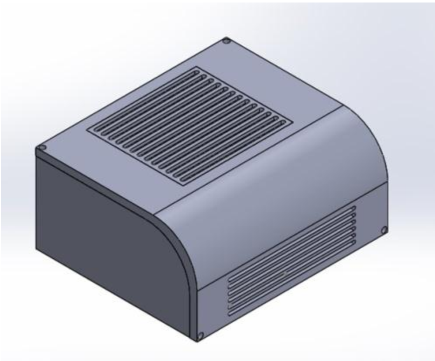


Figure 1: Detailed drawing of final design

Functional Testing

Once the prototype was completed, it was put into testing for functionality and electrical power consumption. A non-regulated DC power supply was used to power up the prototype and check for its functionality. A digital multimeter was used for continuity check on the electronic circuit and measuring the DC current consumed by the air purifier. An anemometer was then used to measure the air flow and air velocity of the air purifier.

Performance Testing

Four tests were carried out to determine the performance of the air purifier. First, a MKS Cirrus 2 atmospheric pressure gas monitor or a residual gas analyser was utilized to measure the performance of the air purifier in removing four air pollutants i.e. CO_2, NOx, CH_2 and CH_3. The test was carried out in a wooden box of dimension 370mm x 470mm x 475mm under controlled conditions. The second test was measuring the removal of SO_2 using a YESAIR indoor air quality monitor. This test was carried out inside a closed car with extreme conditions of smoke from a burning cigarette. The third testing condition was the testing of the effectiveness of removing CO_2 by UV plasma technology, while the fourth test was to test the effectiveness of removal of CO_2 under different airflow velocities (1.90 m/s, 2.40 m/s, 2.90 m/s). These last two tests were carried out using the box as mentioned above.

For all the tests, the concentration of the air pollutants were monitored and measured. Then, all data were plotted in graphs and the rate of change (gradient of best fit line) was measured. The percentage change was also calculated using the following equation:

$$\text{Percentage change} = (x_j - x_i) / x_i * 100 \quad (1)$$

where x_i is the initial value and x_j is the final value.

RESULTS AND DISCUSSION

Effectiveness Testing in Pollutants Removal

The testing was carried out under a temperature of 28°C and relative humidity of 74.2%. Figures 2, 3, 4, 5 and 6 show the graphs of the air pollutants (CO_2, NOx, CH_2 and CH_3) pressure change over time.

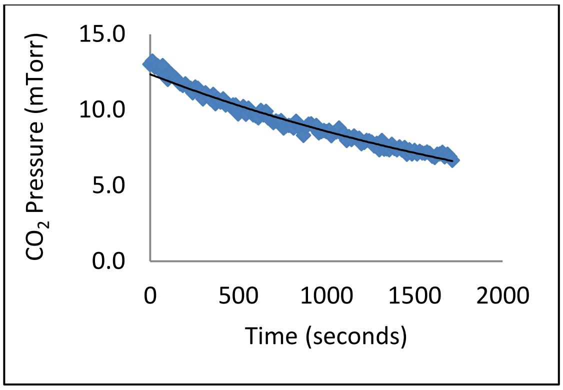


Figure 2: CO_2 pressure over time

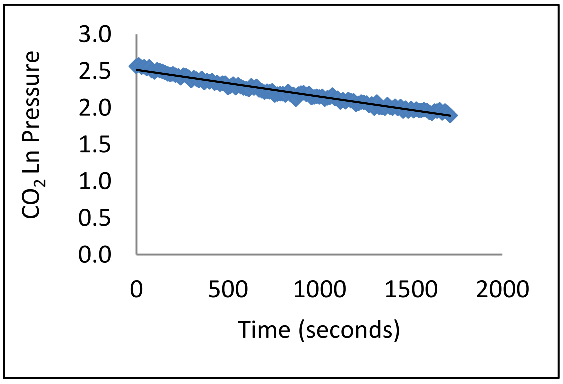


Figure 3: CO_2 ln (pressure) over time

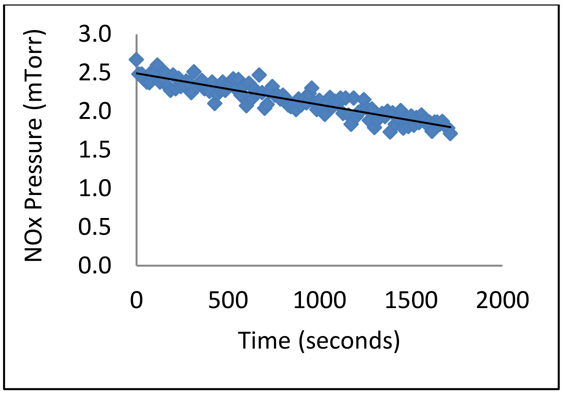


Figure 4: NOx pressure over time

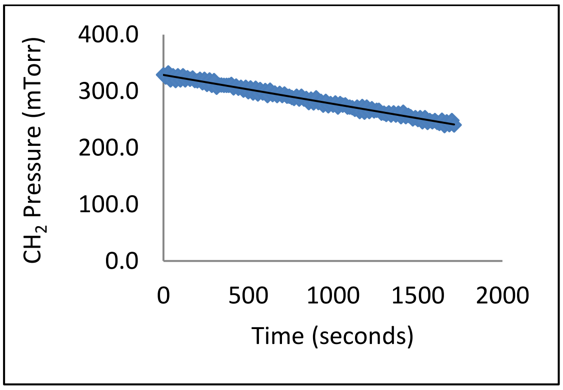


Figure 5: CH_2 **pressure over time**

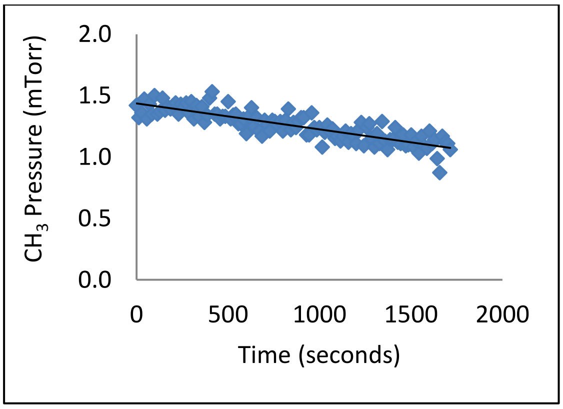


Figure 6: CH_3 **pressure over time**

Table 1 shows compilation of the rate of decrease and percentage change of each air pollutant. The rate of decrease of the pressure of CH_2 was the highest, while the decrease of CH_3 was the lowest. Though the rate of decrease of CH_2 was higher than the rate of decrease of CO_2, the percentage change of CO_2 was almost two times the percentage of CH_2. This testing shows that all components could be cleaned off by the air purifier. CO_2 was the most efficiently removed component by the air purifier. Overall, the air purifier had been found highly efficient in removing CO_2 compared to NOx, CH_2 and CH_3 components.

Table 1: Rate of decrease and Percentage change of CO_2**, NOx,** CH_2 **and** CH_3

Types	CO_2	NOx	CH_2	CH_3
Rate of decrease (mTorr/second)	0.0004	0.0004	0.0511	0.0002
Percentage change (%)	48.85	35.96	27.05	25.35

Effectiveness of Removing SO_2

Figure 7 shows the graph of SO_2 content over time. It shows a decreasing trend of the SO_2 content after the installation of the prototype. The test was carried out under temperature of 28.8^{o}C and relative humidity of 80.0%. The rate of decrease of the SO_2 was 0.003ppm/second while the percentage change was 92.86 %. This shows a really high efficiency in removing the SO_2 from the atmosphere, as almost 93% of the SO_2 had been removed in 15 minutes (900 seconds) with a rate of 0.003 ppm per second.

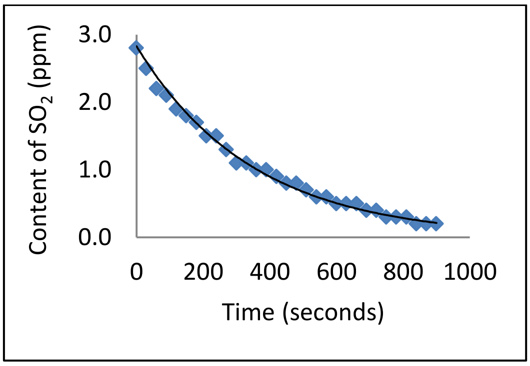


Figure 7: SO_2 **content over time**

EffectivenessCO_2 Content for Different Airflow Velocities

The readings of the change in CO_2 under airflow velocities 1.90 m/s, 2.40 m/s and 2.90 m/s were taken under temperature of 28.8°C and relative humidity of 80.0%. Figure 8 displays the content of CO_2 over time for different airflow velocities.

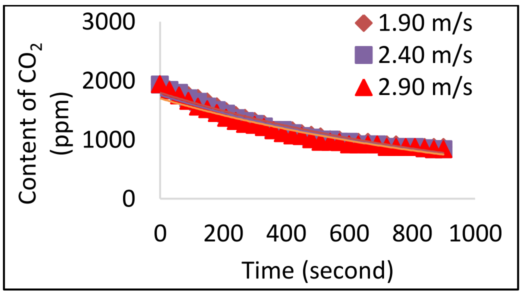


Figure 8: CO_2 **content for different airflow velocities**

As shown in Table 2, it was found that with higher airflow velocity, the rate of decrease in CO_2

became larger. These two parameters were proportional to each other. This shows that with higher the airflow velocity, the removal of CO_2 over time became more efficient. The percentage change also showed agreement by showing that there was an increase in removal of CO_2, with the increase of percentage changing from 2.40 m/s to 2.90 m/s, less than 1%. Based on these findings, we can conclude that the airflow velocity should be higher to ensure the efficiency of the air purifier to remove CO_2 from the intended surrounding.

Table 2: Rate of decrease and percentage change of CO_2 under different airflow velocities

Airflow velocity	1.90 m/s	2.40 m/s	2.90 m/s
Rate of decrease (ppm/second)	1.33	1.51	1.54
Percentage change (%)	54.64	56.79	56.83

Conclusions

The results prove that the air purifier can remove air pollutants found in automobiles, which are CO_2, NOx, CH_2, CH_3 and SO_2. The air pollutants removal efficiency by the air purifier from high to low is as follows: SO_2> CO_2> NOx > CH_2> CH_3. It is also proven that the UV plasma technology combination is more efficient than utilizing only one technology. Higher airflow velocity will increase the efficiency of the air purifier in removing air pollutants from the environment.

Acknowledgements

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