Fine Dust Removing by Using Li+ Batteries and High-performance Supercapacitor Parallel Connection

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Abstract. One of the most serious problem in the world, Fine dust issue is going to happen in whole world. ‘Fine dust’ is defined under these standard, if its diameter particle is less than 10um, it is called as ‘fine dust’, 2um, it is called as ‘super fine dust’. Actually, ‘Fine dust’ is assigned as 1st level hazardous substances by WHO (World Health Organization). In this paper, I suggested new way to solve this kinds of problem by using Li+ batteries and high-performance supercapacitor. A lot of kinds energy source such as fossil fuel, one of the reason of environment problem can be changed to eco-friendly energy such as solar power. We can solve two factors (cause / result) of fine dust by using eco-friendly energy source.

1. Introduction
Nowadays, the amount of demand of fossil fuels for personal vehicle and factory has been increased for a long time. This kinds of wave has brought serious problem in recent. The components of fine dust (Figure 1) are composed of Sulfide, Nitrate and Carbon, Metal things. Usually, we used to think ‘Fine Dust’ as just one kind of particulates like sand storm but it is needed to call as micro metal dust. In the case of dust and sand storm, it’s a natural weathering phenomenon. However, in the case of the fine dust, too much soot and smoke happened in the air so that it is getting clutter with sulfide, water and etc. So it has totally different mechanism with just dust and ‘Fine Dust’ as I defined [1].

![Figure 1. Components of Fine Dust](image_url)

In other words, super-micro metal powder is always around you and even you don’t know when you have some powder in air every single breath. The particle size of fine dust is a very small as less than few micro meter so it’s difficult to recognize and remove.
There are 3 ways to remove the fine dust, it is mainly using a filter, centrifugal force and electrostatic dust collection. One of this, the dust collection way is not efficient for the small particles. Further more, the way of using a filter is non-economic because it’s essential to be placed somewhere which has enough space. In this study, I suggested the new design of fine dust removing by using Li+ batteries and supercapacitor parallel connection. I hope it can be the one of new prototype of technology for fine dust.

2. Experimental

2.1. The principle of fine dust removal
The principle of a corona discharge is based on the electrical discharge by ionizing of a fluid such as air surrounding a conductor that is electrically charged. Naturally corona discharges occur with high-voltage systems unless electric field strength is up to limit. A corona will occur when the strength (potential gradient) of the electric field around a conductor is high enough to form a conductive region, if it’s not high enough to cause electrical breakdown or arcing to objects nearby. As it showed in Figure 2, it’s often seen as a bluish (or other color) glow in the air adjacent to pointed metal conductors carrying high voltages and emits light by the same property as a gas discharge lamp.

![Figure 2. Corona Discharger](image)

The electrostatic precipitator is a device for collecting dust that removes fine dust by attracting various dust particles contained in the air to a dust collecting pole just like Figure 3. A corona discharge occurs when a high voltage is between the (+) pole and (-) pole. When it occurs, ions with charges are generated. (-) Charged ions combine with the fine dust particles in the air (-) making the dust migrate to the (+) pole attached to the electrostatic precipitator. This principle makes it easy to remove various kinds of fine dust particles\[2-4\].

![Figure 3. The method to get rid of fine dust](image)

2.2. Design of the circuit and system
Solar energy is one of the green power source and it is no limit. So I designed this system to easy to operate with solar energy. Solar Panel (30W output, 20V), Solar Controller (Output: 12V), Boost Converter (Input : 12V, Output : 40V / Mc34063A IC), Supercapacitor (12V), Li+ Battery (12V) and
Fine Dust Removal System (Input 30-70V) :: Figure 4. Total 30-70 voltage in needed to operate this system, the power comes mainly from Li+ batteries charged by solar energy and supercapacitor. However, the solar panel’s maximum output voltage is only 20V so it’s required to use the boost converter to make output voltage high up to 40V.[5]

2.3. Electrodes
I prepared two different types of aluminum electrodes, one is cylinder shape and the other one is quadrangular prism type. The length is 25cm and the gap distance of separated electrode is 2cm on each electrodes. The reason why I made it two types is it’s kind of the first trial so it’s needed to compare by changing the structure of system. And I used 3 types of fine dust such as HCHO, TVOC and SMOKE. I compared how much fine dust is removed by this system as I change the structure of system.[6]

3. Result and Discussion
I did this experimental under this options of measurement as shown in Table 1.

| Table 1. Options of Measurement          |
|-----------------------------------------|
| **HCHO/TVOC**                          |
| Metrics                                 |
| Measuring range                         |
| 0-1.999mg/m³ (HCHO)                     |
| 0-9.999mg/m³ (TVOC)                     |
| Sample Mode                             |
| Diffusion type                          |
| Density unit                            |
| mg/m³                                   |
| **PM1/PM2.5/PM10**                     |
| Particle diameter test                  |
| 1μm/2.5μm/10μm                         |
| Detection mode                          |
| Density (per liter)                     |
| Detection range                         |
| 0-999 μg/m³                             |

In this study, Smoke, Fine dust, HCHO, and TVOC are measured using an air purifier. This study compares the efficiency of the different type of pipe and the optimal removal time of smoke, fine dust, HCHO, and TVOC. Firstly, the smoke removal experiment is carried out. Smoke contains large dust particles. Therefore, the optimal frequency is determined through the smoke elimination experiment, and the optimal conditions of the other experiment are also examined.

As shown in Figure 6 (a), when the switching frequency is 13 kHz. The circular pipe (A), and the square pipe (B) models are the fastest in removing the smoke. The HCHO, TVOC, and PM 2.5 (particle material) experiments are performed with a frequency of 13 kHz, 40cmx20cmx20cm acrylic box, and input voltage of 30V. Formaldehyde (HCHO) is a flammable colorless gas that has a long-lasting, irritating odor with adverse effects on the human body, such as headache / amnesia and emotional disturbances. If the HCHO density value is > 0.30 mg/m³, the present air is not good. The data are derived by comparing the A and B pipes, and no air purifier only fan(C model) shown in Figure 6(b). The A model showed the fastest purging. The air is purified within 10 minutes by the A and B models, whereas 100 minutes is needed using the C model (Without using an air cleaning system, only fan). TVOC is a precursor of a photochemical reaction and means a substance harmful to the human body / environment by generating secondary pollutants, such as ozone and aldehydes. The experimental results show that the A model takes approximately 4 minutes and the B model takes more than 10 minutes, whereas, the C model takes 100 minutes shown in Figure 6(c).

If the PM 2.5 concentration is greater than 115 μg/m³, the present air is not clean. The experimental results show that the A and B models cleaned the fine dust at the same time. On the other hand, C model clean the fine dust after 100 minutes shown in Figure 6(d). (Table 2) lists the results of the purification. The experimental results of the A model shows excellent results under all conditions. The A model has a uniform surface different from the B model, and it purifies the air the fastest. In the case of the B model, partial discharge occurs in the pointed portion; hence, it is relatively inefficient. In case of the C model it does not have a dust collector, but it has fan function so whenever it operates the air circulates occur inside. As the time passes due to internal circulation the C model parameter gradually decreases.

Follow the experiment, we can find the A model is most effective to remove the fine dust. In case of the A model has uniform surface between (+) pole and (-) pole. But the B model has not uniform surface. Because of the B model has irregular sections like edges of square. So the B model can’t remove fine dust efficiently. Therefore, we can conclude the A model is most effective.

| Table 2. Purification time on A and B |
|--------------------------------------|
| **Type of matter**                  |
| **A Model**                          |
| **B Model**                          |
| Smoke                                |
| 4(Second)                            |
| 5(Second)                            |
| HCHO                                 |
| 4(Minutes)                           |
| 10(Minutes)                          |
| TVOC                                 |
| 4(Minutes)                           |
| 10(Minutes)                          |
| PM2.5(Fine dust)                     |
| 4(Minutes)                           |
| 4(Minutes)                           |
4. Conclusion

In this research, I made a corona discharge system by using a half bridge inverter, step-up transformer and Cockcroft Walton circuit. And I presented here two new types (cylinder, quadrangular prism) for the structure of fine dust removing system. Mainly HCHO, TVOC and SMOKE is measured with two types of electrodes and as a result, the model A was able to remove the fine dust on 30V of input voltage for 4 sec. The HCHO, TVOC and fine dust, all particulate matter was visible but it’s going to be invisible so this type of system by using Li+ batteries and supercapacitor is possible to operate outside properly.

5. References

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