

# Influence of hydrophobic surface treatment toward performance of air filter

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**Abstract.** This study investigated the performance of hydrophobic surface treatment by using silica aerogel powder via spray coating techniques. Hydrophobic properties were determined by measuring the level of the contact angle. Meanwhile, performance was evaluated in term of the hydrogen gas flow and humidity rejection. The results are shown by contact angle that the microstructure filter, especially in the upper layer and sub-layer has been changed. The results also show an increase of hydrophobicity due to the increased quantity of silica aerogel powder. Results also showed that the absorption and rejection filter performance filter has increased after the addition of silica aerogel powder. The results showed that with the addition of 5 grams of powder of silica aerogel have the highest result of wetting angle 134.11°. The highest humidity rejection found with 5 grams of powder of silica aerogel.

## 1. Introduction

Nanostructured thin film has been extensively study because they exhibit better structural, optical, and electrical properties[1]–[7]. A continuous evolution of the mechanical properties is expected due to the easy tuning of the initial organic or inorganic composition, the chemistry and the processing conditions [8]–[17]. Air filter is a device composed from fibrous materials which are removed solid particular such as pollen, dust, mold and bacteria come from the air. Chemical air filter consists of an absorbent or catalysts. According to Irwin et al. (2016) in the Handbook of nonwoven filter media (second edition), the applications of air filter usually used for HVAC systems, high-efficiency air filtration (HEA, HEPA, and ULPA), industrial air filtration, respirators and gas masks, turbine air filtration, and household air filtration such as vacuum, air purifiers, and cleaners [18].

The air filter industry has been proved that its share of changes over the last decade. All air filter manufacturers have created a new product that has improved indoor air quality and also reduced the cost of installing and operating air-filtration equipment in commercial and institutional facilities [19]. Beside that the technology has been developed, industry organization has adopting, guideline and requirement that promote healthy by indoor air quality. As for maintenance, it was focus on indoor air



quality (IAQ) and its impact on their facilities and occupants. The manufacturer provides them with more efficient high voltage alternative current (HVAC) systems and components, including air filters.

Air pollution defined as a control mechanism that supplies clean air realizes bright space through HEPA filter placed at the air supply terminal, which were the largest difference for cleaning air conditioner between the concept and general air conditioner. The biggest problem in air filter media is leakage. However, in order to solve this problem, it is not effectively with sealing and make leakage stoppage. If this issue cannot address early, it can increase particle concentration or bacteria concentration for air filter media.

Theoretical interest in hydrophobic interactions and wetting has also been stimulated in several ways [20]. Work on designing superhydrophobic surfaces has led to renewed interest in the theories of heterogeneous wetting due to Wenzel and Baxter [21][22]. Various surface reflectivity measurements have been interpreted as evidence for a layer (albeit thinner than the diameter of a water molecule) of depleted water density next to extended hydrophobic surfaces, and different techniques have been adopted to investigate the boundary conditions of flow next to both smooth and structured hydrophobic surfaces and the relationship to rewetting. Based on M.khayet et al., (2005) they had discussed the properties of hydrophobic/hydrophilic porous membrane and was proposed for application in this membrane distillation [23].

## **2. Experimental**

### **2.1. Materials and procedure**

The preparation process of hydrophobic silica aerogel with acetone and tetraethyl orthosilicate (TEOS) as the raw material. The process can be divided into two major step, including preparation of filter, synthesis of aerogel silica. For this experiment, we use a particular HEPA filter from company salutary avenue to make a hydrophobic treatment. The purpose of using this filter is because of this filter is very suitable for an environment with moisture contain and humidity. Silica aerogel will be obtained from Merogel Company.

### **2.2. Spray coating**

In this research, the hydrophobic coating will be prepared using spray coating technique to deposit on the filter. Spray coating method is a process solvent solutions, molten powder and dispersions are atomized by the action of air, the pressure and inert gas of the solution itself and deposited on the substrate.

The first step that we make for this experiment has we fabricated the spray technique so that it becomes static, where we make it 90 degrees to get a uniform spray coating. Figure 1 shows that the spray machine that we fabricated.

#### **2.2.1. Parameter**

The coating process has many types, but in this study hydrophobic coating was prepared by using spray method. There are several parameters considered which is substrate aerogel silica and Tetraethyl orthosilicate (TEOS)/acetone, the speed of dipping and interval time between dipping.

### **2.3. Membrane Evaluation**

The preparation of hydrophobic coating was characterized for surface morphology was studied by using SEM (JOEL JSM6380LA).

## **3. Result and Discussion**

### **3.1. Permeability**

Figure 1 shows the nitrogen (N<sub>2</sub>) permeability as a function of different filter prepared at a different silica aerogel composition. Sample 1 was filter before treatment and sample 2 have 3g silica aerogel,

sample 3 with 4g, and sample 4 with 5g silica aerogel. This method was using to measure the gas permeability.

Based on the result, the permeability for nitrogen gasses comes out through the filter are decreased because due to increase of silica aerogel composition from 3g to 5g. Furthermore, it shows the permeability order was nitrogen (N<sub>2</sub>). The permeability shows the lowest reading from sample 4 because the surface of the filter has been treatment from silica aerogel and also from the treatment which can block some of the size pores of the filter. According to Zoran Novak et al., (2008) Silica aerogels are nanostructured materials with an open foam-like structure having a low density, high surface area and high porosity (> 95%) so that the aerogel can block the pore on the filter, but it still can be porosity because of the properties have a high porosity. Thus, the result obtains and the past review was in line with the porosity analysis that an increase of weight density which can result the decrease percentage of porosity [24].

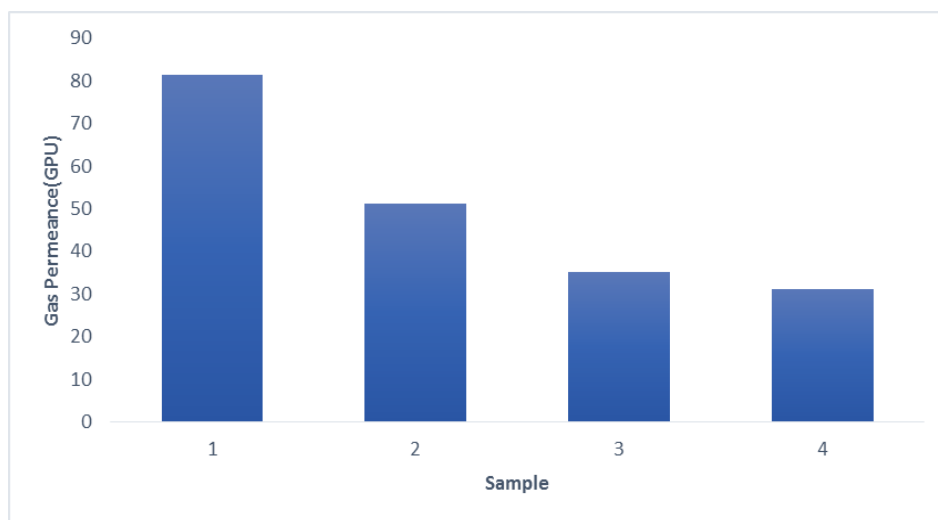


Figure 1: The graph of Gas Permeability

### 3.2. Humidity

Humidity are the amount of water in the vaporous state contained in a gas usually characterized in term of absolute or relative humidity. Absolute humidity is defined the weight of water present in a given volume gas. Relative humidity defines as the ratio of the actual weight of water vapor to the gas capacity to keep water at a specific temperature. Humidity testing one of the most common method used to measure the percent of absorption humidity into the filter surface. Figure 2 shows the percentage of rejection of humidity result from each sample. The result show the value of percent humidity rejection which increased with the addition of 3 g of 5 g of silica aerogel. Sample 1 shows the lowest reading (55%), followed by sample 2 (68%), sample 3 (69%) and sample 4 (72%).

The percent rejection of humidity shows that sample 4 has the highest percentage of rejection because of has high hydrophobic properties compared with other samples. This result was in line with Melin et al., (2013) that state the high hydrophobic properties, it can reduce the absorption of humidity in the air. This result show the parallel with contact angle result which addition or more silica aerogels will decrease the percentage of absorption humidity at the hydrophobic filter.

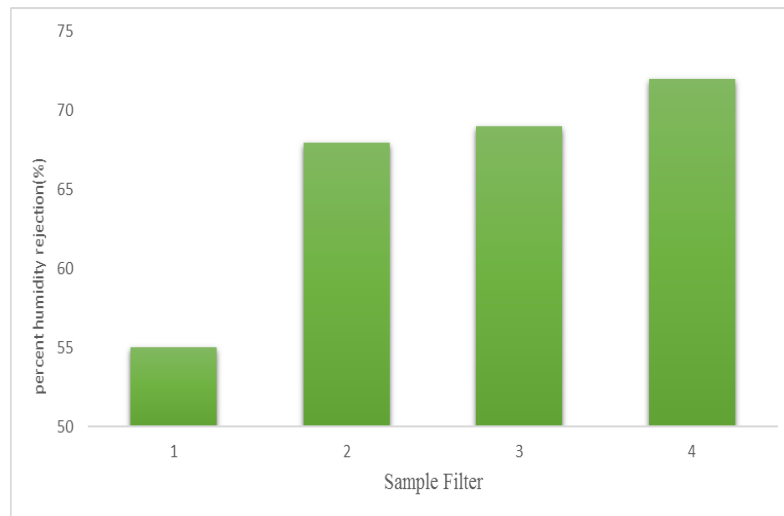


Figure 2: Graph Percent Humidity Rejection

### 3.3. Contact Angle

Hydrophilic are caused by the decreased contact angle and the hydrophobic are caused by increased of the contact angle [25]–[28]. Table 1 and Figure 3 shows the result data obtained after contact angle test. Based on the Figure 2, it was clear that the sample filter 1 shows the lowest reading of the contact angle at  $85.93^\circ$  follow by sample 2, sample 3 and sample 4 with contact angle of  $123.92^\circ$ ,  $128.69^\circ$ , and  $134.11^\circ$  respectively. Lower contact angle readings by sample filter 1 show that the sample filter 1 has hydrophilic properties while the sample filter 4 which has a high contact angle readings have less hydrophilic properties. Furthermore, the results show that untreated sample possesses hydrophilic characteristic. Treatment with silica aerogel shows that filter contact angle increases up to 35.93% as compared to the untreated sample. This result shows due to the addition of silica aerogels can improve the hydrophobic properties of the filter.

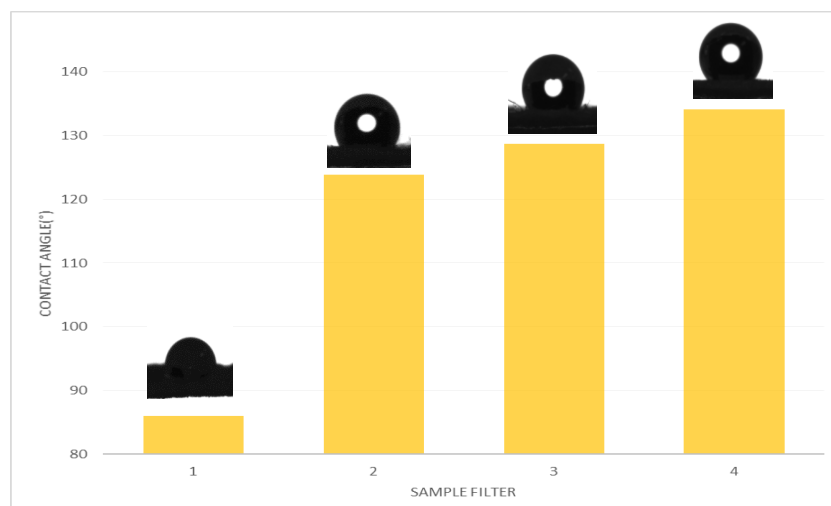


Figure 3: Graph for Contact Angle

### 3.4. Density and Porosity

There are differences in the type and concentration of additives of aerogel silica that is sprayed onto the filter samples. The result difference has changed the level of porosity and density of the filter are shown in Table 1, Figure 5 and Figure 6. Based on result, it shows the level of porosity filter where it was clear the decrease in porosity the level off with the addition of aerogel silica into the filter. The

maximum value of level of porosity of the filter samples 1 which were not included aerogel silica has 22% of porosity follow by sample 2, sample 3 and sample 4 which decreasing it porosity to 7.1%, 8.15% and 13.17% respectively. Due to the filter, has been immersed in acetone while using density and porosity machine and make the particle of aerogel silica fall from the filter surface. In addition, it was clear that acetone is miscible with water and serves as an important solvent in it is own right, typically for cleaning purposes.

However, when compared to the sample membrane 2 and 3, where the sample 2 which contains silica aerogel of 4g, has a level of porosity decrease by 7.1%, compared to sample 3 that contains silica aerogel of 3g have a level of porosity 8.15%.

Regarding weight density filter, it was apparent in Figure 6 that the sample filter 1 having the lowest average density ( $0.4119\text{g/cm}^3$ ) over all samples. While the sample filter 4 has an average density higher ( $0.9077\text{g/cm}^3$ ) than the weight of the samples of others filter. The filter has an average density that caused by the addition of silica aerogel in each sample as shown in Table 5. This result might be clear due to prove by porosity result shows that the increase of density filter it will decrease the percent of porosity [29]–[31].

Table 1: Density and Porosity Analysis

Sample	Aerogel silica(g)	Porosity (%)	Density( $\text{g/cm}^3$ )
1	0	22	0.4119
2	3	7.1	0.8859
3	4	8.15	0.8957
4	5	13.17	0.9077

#### 4. Conclusion

This study is aimed to identify the effects of silica aerogel added to the filter. Four filter composition was produced. There is a change in the properties of the filter when the silica aerogel powder coating on the filter surface. Filter samples 2, 3 and 4 in the silica aerogel coating additive powder. The hydrophobicity of filter samples 2, 3 and 4 which were coated using silica aerogel powder and filter all samples have been proved by the wetting angle on the surface of the filter increases through contact angle experimentation. Filter sample 4 shows the rate with a high wetting angle  $134.11^\circ$  reading angle while sample 1 showed the lowest rates angle of  $85.93^\circ$ . It is clear that the presence on the surface of silica aerogel has increased hydrophobic filter on the filter. Besides that, the addition of silica aerogel powder additive on the surface of the filter had increased the rate of rejection of air humidity on the filter. The decision to reject air humidity indicates that the sample filters 2, 3 and 4 show the highest rejection humid air. However, the sample filter 4 records a higher against the rejection decision filter samples 2 and 3. This shows that the addition of silica aerogel powder additive has increased the level of rejection of humid air into the filter. Humidity rejection of filter sample stage 4 is the highest due to the hydrophobic properties the sample filter five a higher. Hydrophobic character of sample 4 proved through the high level of contact angle. Percent rejection is based on the resistance level filter. Filter 4 shows the rejection of humidity level was the highest compared to other filter samples. This result was reported with Melin et al., (2013) where they found that when high hydrophobic properties, it can reduce the absorption of humidity in the air. Conclusions be made from this research was the addition of silica aerogel powder additives has increased hydrophobic filter, the rejection of and the wetting angle.

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