

# Fabrication of Filter by Using Natural Fiber and Its Potential Application as an Additional Filter on Cooker Hood

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**Abstract:** *Luffa spp.* exists abundantly in Asia and is a rich source of natural fibers for composite development. Previous studies have proven the efficacy of luffa fiber for separation of oil from seawater, extraction of pollutants from water, organic solvent absorption etc. This study emphasized the use of luffa as additional filter to increase the efficiency of the cooker hood. The characteristics of luffa fiber which is hydrophilic make it less effective to act as additional filter for cooker hood. To overcome this, luffa fiber is treated with stearic acid by using immersion method. Oil control film was used to determine the capability of untreated luffa fiber and SA treated fiber to be used as efficient additional filter on the cooker hood. From this study, it was found that untreated luffa fiber and treated luffa fiber has the capability to be an efficient additional filter to the cooker hood. The treated fiber is proven to be most effective as additional filter for the cooker hood, followed by untreated luffa fiber in comparison with no additional filter on the cooker hood (as a control set of the experiment). The fabricated filter also has the capability to absorb pollutants or contaminants as depicted from increased ppm count detected by TDS meter for the used fabricated filter. Among the dissolved substances, sulfite and nitrate show a prominent presence as indicated by the 14 in 1 Reagent strips.

**Keywords:** *luffa; filter; hydrophilic; hydrophobic; stearic acid; cooker hood.*



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## 1. INTRODUCTION

The existing cooker hood system that is usually used in the kitchen is designed and constructed based on prominent specifications such as width of cooking area, mounting height, suction power, recirculating/ventilated air type, type of filtration, noise, maintenance, aesthetic aspect etc. In terms of suction power, it is measured by how much air it can move in a given time and the fan needs to be powerful enough to suck in all the pollutants. Higher rate of airflow corresponds to a more powerful fan motor performance in the kitchen which in turn will contribute to increment in electricity consumption.

In general, the speed of fan motor is adjustable depending on the intensity of cooking method and cleanliness of the cooker hood filter. If the filter in the cooker hood is not cleaned regularly, the pores will be clogged with grease and the fan has to work harder to maintain the airflow which will increase the electricity consumption. Generally, the filter has to be cleaned once a month, depending on the usage frequency and type of filter used. However, this kind of tedious task is often being ignored and we only bothered to do the task when the fan motor in the cooker hood started to make unusual loud noise. Eventually, this practice will jeopardize the efficiency of the cooker hood system.

Various hazardous pollutants such as carcinogenic polycyclic aromatic hydrocarbons (PAHs) and particulate matter (PM) were released through household solid fuel burning and by the heating of cooking oil and food to high temperature (Li, 2003; Sugimura, 2004; Straif, 2006; Gao, 2013). Apart from PAHs (Wallace, 2000; Kuo et al. 2006), high temperature cooking such as deep frying, stir frying and grilling would also release fine (<2.5 mm) and ultrafine (<0.1 mm) particles (Abt et al. 2000; Long et al. 2000; Afshari, 2005). Deposition of those fine and ultrafine particles in human lungs has been proven to cause respiratory and cardiovascular diseases, oxidative stress induced DNA damages inflammation, impairment of phagocytosis and thrombosis (Oberdoerster et al. 1995, 2005; Renwick et al. 2001; Nemmar et al. 2003; Stoelzel et al. 2006; Scapellato et al. 2007; Brook, 2008). Moreover, there's also strong correlation that has been found between the exposure to air pollution from cooking and occurrence of lung cancer (Ko et al. 2000; Lee & Gany 2013; Pallis & Syrigos 2013; Sun et al. 2007).

Therefore, it is gravely important to ensure the efficiency of cooker hood systems for the sake of our health and well-being. Most importantly, the present study accommodates to the UN sustainable development goals (UN-SDGs), by including directly or indirectly goals numbers 7, 11 and 12 which are to ensure access to affordable, reliable, sustainable and modern energy for all, make cities and human settlements inclusive, safe and sustainable and to ensure sustainable consumption and production patterns.

The additional features of the existing cooker hood system in the kitchen have been studied comprehensively by various researchers which provide concrete database on modifications such as implementation of column vortex, air curtain, jet-assisted ventilation systems such as push-pull ventilation systems and Aaberg exhaust systems etc. to increase the efficiency of the exhaust hood in controlling pollutants and reduce the flow rate of the exhaust hood by using meticulous techniques and state of the art equipment. Majority of these studies focused on the modification of mechanical features of the cooker hood system. To the best of the author's knowledge, other modification features such as implementation of additional filter on the surface of cooker hood have not been explored extensively on scientific level.

This kind of modification is usually associated with do-it-yourself (DIY) enthusiast, where they usually attach non-woven fiberglass fabric for walls on top of existing mesh cooker hood filter and dispose the fiberglass to the bin after it becomes filthy to skip the tedious task of cleaning the original mesh filter. However, this is not a sustainable approach since fiberglass does not decompose. Moreover, the direct exposure of fiberglass to the food on the stove which releases harmful pollutants makes it improbable.

In this project, a study will be carried out to fabricate additional cooker hood filter by using luffa fiber. The justification of the materials selection for this project is derived from consideration of certain factors such as cost, availability of resource and sustainability issue. On top of that, the justification is also based on the promising prospects of the raw luffa properties and at the same time exploiting the potential of modified/functionalized luffa through inexpensive treatment method.

## 2. METHOD & MATERIAL

### 2.1 Preparation of Luffa Fiber

The natural fiber that was used in this project is luffa fiber which was purchased through online shop. The luffa is in unbleached and dried form. All of the samples were cut and trimmed into rectangular shape by using scissor, cutter and cutting mat. Then, it was boiled in hot water for 30 minutes to remove impurities. After that, the luffa fiber was left to dry on table top at room temperature.

### 2.2 Compression of Luffa Fiber by Using Steam Iron

A few samples of the dried luffa fibers prepared previously were then compressed by using steam iron to flatten it. A cloth was used to cover the top of the fiber before it is pressed with steam iron. Compressed and uncompressed luffa filter were prepared to test whether the compression of fiber will jeopardize the functionality of the fiber in terms of grease and pollutants absorption. In general, it is preferable to use the compressed fiber since it provides maximum surface attachment on the cooker hood.

### 2.3 Modification of Luffa Fiber Through Treatment with Stearic Acid

In this project, luffa fibers were treated with stearic acid by using the immersion method. This method was adapted from the research done by Gomez et al. (2021) which has successfully fabricated a sustainable hydrophobic luffa sponge for efficient removal of oils from water with  $133 \pm 4.0^\circ$  contact angle through 2% SA concentration. Stearic acid was chosen due to its supreme characteristics such as non-toxic (obtained from animal and vegetable fats), exist abundantly, economical, thermal stability, appropriate melting temperature and renewable (Chen et al. 2017).

Firstly, 70% ethanol was prepared through the dilution of the 95% ethanol. Then, 2% concentration of stearic acid in ethanol solutions was prepared by dissolving 60 g of stearic acid in 3000 ml of 70% ethanol at 80 °C for approximately 10 minutes until it dissolves completely. Next, the luffa fibers were immersed for 6 hours in the stearic acid/ethanol solution. After that, the luffa fibers were removed and left to dry on tabletop at room temperature

### 2.4 The Attachment of Additional Filter Onto the Surface of Cooker Hood

The performance of luffa fiber as additional cooker hood filter was tested by attaching it to the surface of cooker hood by using magnetic tape and cooking routine was continued as usual for 15 days. In the beginning, the mesh filters were cleaned thoroughly and dried. On the first 5 days, there will be no additional filter attachment on the surface of the cooker hood to monitor the performance of the original filter which served as control set. On the 6th day, the original filters were cleaned thoroughly and dried. After the filter dried, the additional untreated luffa filters were attached to the surface of cooker hood by using magnetic tape and its performance were tested for 5 consecutive days. On the 10th day, the additional untreated filters were removed, and the original filters were cleaned thoroughly and dried. After the filter dried, the additional treated luffa filters were attached to the surface of cooker hood by using magnetic tape and its performance were tested for 5 consecutive days. On the 15th day, the additional treated filters were removed, and the original filters were cleaned thoroughly and dried. Similar steps were repeated by using the compressed luffa fiber. Since the surface of cooker hood is made of metal, it is easier to use magnetic tape to attach and detach the additional fibers.

### 2.5 Determination of Oil Absorption Capabilities to Assess Absorption Effect by Using Oil Control Films

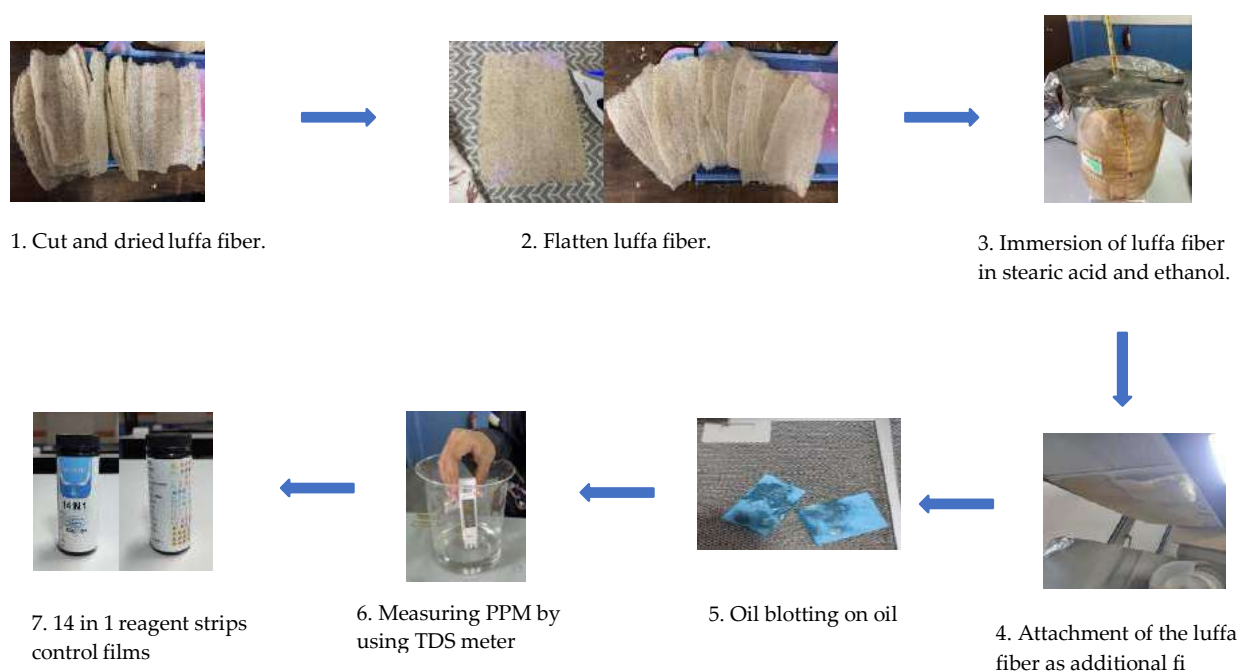
The assessment of oil absorption capabilities was conducted by using oil control films. The oil control films were wiped on the surface of the additional filter and original filter on the 5th, 10th and 15th day before filter cleaning was conducted. The determination of oil absorption capabilities was assessed by observing the oil blotting area on the oil control films.

## 2.6 Parts Per Million (ppm) Measurement by Using TDS Meter

A TDS meter is used to determine the amount of dissolved particles in the water, usually in parts per million or ppm. Thus, to utilize the TDS meter, the used and unused fabricated luffa fiber were soaked in distilled water to test the amount of dissolved particles in the soaked water. This data represents estimated amount of pollutants absorbed by luffa.

## 2.7 Detection of Contaminants by Using 14 In 1 Reagent Strips

14 in 1 reagent strips is usually used to test the quality of water in terms of total alkalinity, pH, hardness and the presence of certain substances such as lead, copper, iron, chromium, sulfite, free chlorine, bromine, nitrate, nitrite, mercury and fluoride. Thus, to utilize this strip, the used and unused fabricated luffa fiber were soaked in distilled water to test for the presence of any of those substances in the soaked water. This can help to identify the type of pollutant absorbed by the luffa fiber.



**Figure 1.** Summary of preparations, treatment and efficiency analysis of luffa filter.

### 3. FINDINGS

The efficiency of the fabricated luffa filter in terms of oil absorption capabilities, amount of pollutants absorbed, and the substance(s) absorbed were assessed by using oil control films, TDS meter and 14 in 1 reagent strip respectively.

#### 3.1 Oil absorption assessment

**Table 1.** Observation of oil blotting area on the oil control film

| Type of additional filter     | Area of oil blotting on the oil control film                                        |
|-------------------------------|-------------------------------------------------------------------------------------|
| Without any additional filter |   |
| Untreated luffa fiber         |   |
| Treated luffa fiber           |  |

#### 3.2 Parts per million (PPM) measurement by using TDS meter.

**Table 2.** PPM Reading of used Luffa filter

| Filter                               | PPM Reading |
|--------------------------------------|-------------|
| SA-treated uncompressed Luffa filter | 26          |
| Untreated uncompressed Luffa filter  | 53          |
| SA-treated compressed Luffa filter   | 39          |
| Untreated compressed Luffa filter    | 66          |

#### 3.3 Detection of contaminants by utilizing 14 in 1 Reagent strips.

**Table 3.** 14 IN 1 Reagent Test for the presence of dissolved substance(s) in fabricated filter

| CONTENT       | UNCOMPRESSED /<br>UNTREATED /<br>UNUSED | UNCOMPRESSED /<br>UNTREATED /<br>USED | UNCOMPRESSED /<br>TREATED /<br>UNUSED | UNCOMPRESSED /<br>TREATED /<br>USED | COMPRESSED /<br>UNTREATED /<br>UNUSED | COMPRESSED /<br>UNTREATED /<br>USED | COMPRESSED /<br>TREATED /<br>UNUSED | COMPRESSED /<br>TREATED /<br>USED |
|---------------|-----------------------------------------|---------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
| Lead          | X                                       | ✓                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Copper        | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Iron          | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Chromium (VI) | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Iodine        | X                                       | ✓                                     | X                                     | ✓                                   | X                                     | ✓                                   | X                                   | ✓                                 |
| Free chlorine | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Bromine       | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Nitrate       | X                                       | ✓                                     | X                                     | ✓                                   | X                                     | X                                   | X                                   | ✓                                 |
| Nitrite       | X                                       | ✓                                     | X                                     | ✓                                   | X                                     | X                                   | X                                   | X                                 |
| Mercury       | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |
| Fluoride      | X                                       | X                                     | X                                     | X                                   | X                                     | X                                   | X                                   | X                                 |

## 4. DISCUSSION

Table 1 shows the image of the oil control film that was wiped on the original mesh filter. Without any additional filter, it can be seen that the oil/grease content is more as depicted from the larger oil blot area on the film. The amount of oil on the original mesh filter after the treated additional filter were taken off were significantly reduced as shown by the less intense oil blot area on the film that was wiped on the original filter. This implied that the treated additional filter soaked up more oil, leaving behind less amount of oil to be filtered by the original mesh filter. In comparison with the treated filter, the untreated filter soaked up lesser amount of oil which makes the original filter had to filter out more oil as depicted from the more intense oil blot area. However, the amount is not as much as the one with the absence of additional filter.

The ppm count for used fabricated filter (treated/untreated/compressed/uncompressed) is generally higher when compared to blank water as shown in Table 2. Meanwhile, the ppm count for used and treated (compressed & uncompressed) is less than the untreated filter. This may be due to the filter being hydrophobic after it is treated with stearic acid, therefore, the impurities in the filter are not able to be dissolved efficiently to reveal the absorb pollutants. Based on Table 3, sulfite, nitrite and nitrate shows a prominent presence among the dissolved substances in the soaked water, as indicated by the 14 in 1 Reagent strips. Those substances primarily originated from the combustion of fuel in cooking stove.

## 5. CONCLUSION

In conclusion, the additional filters which are made of luffa fibers that are treated and untreated are capable of filtering grease/ pollutants when it is being used as an additional filter in kitchen cooker hood. Moreover, we have successfully fabricated a filter by using luffa fiber which has higher capability to remove grease from airflow of kitchen cooker hood through the implementation of immersion method with stearic acid treatment in comparison with the untreated form. Apart from that, the fabricated filter also has the capability to absorb pollutants or contaminants as depicted from increased ppm count detected by TDS meter for the used fabricated filter. Among the dissolved substances, sulfite, nitrate and nitrate shows a prominent presence as indicated by the 14 in 1 Reagent strips.

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