ISSN: 0975-766X
CODEN: IJPTFI
Research Article
Available Online through
www.ijptonline.com

DEVELOPMENT OF DUAL LAYERED NONWOVEN MASK WITH ACTIVATED CHARCOAL FINISH FOR HEALTHCARE

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Received on 07-12-2014 *Accepted on 31-12-2014*

Abstract

Background: In the current scenario the threat to the world is the widespread of serious infections and diseases. A foremost concern for healthcare people is the problem of transmission of pathogens and bacteria from their patients to themselves and the reverse contamination.

Objectives: To develop dual layer needle punched polypropylene nonwoven fabric finished with activated charcoal for improving bacterial filtration efficiency.

Methods: The pore size of the non woven fabric is characterised using a polarised microscope.

Activated charcoal is charcoal treated with oxygen to open up tiny pores between the carbon atoms. The dual layer mask is developed using fusing machine. The mask was evaluated for Bacteria Filtration Efficiency and their mechanical properties.

Results: The polypropylene fabric has a pore size of 0.5 micron, which would block all the bacteria from passing across the mask. The bacterial resistance capacity of the developed nonwoven mask was found 88% which serves the purpose that the product has been designed for healthcare. The developed mask showed a breaking strength of 48.84 lbs and breaking elongation of 48.89%. The dual layered mask was found to have a air permeability of 0.7 $cm^3.cm^2/s$.

Conclusion: The developed mask resistance to bacteria has 88% bacterial filtration efficiency that would keep healthcare people safer.

Key words: Surgical mask, Charcoal finish, Pore size.

Introduction

Nowadays there are many diseases which are spread easily and people are not aware of it. Spreading of diseases can be a serious issue which can take the lives of people. Currently there is a little evidence that wearing a surgical mask provides sufficient protection from all the hazards likely to be encountered in an acute health care .The rationale of wearing masks has shifted from protection of the patient to protection of health care professional wearing the masks. Nonwoven material for medical applications offers numerous advantages both with regard to user requirements and material properties.

Researchers discovered the presence of bacteria in droplets from the nose and mouth and the role these bacteria played in disease transmission. As a result, new mask materials and designs and designs and devices to demonstrate their filtering efficiency are developed[2]. New variations of charcoal therapy have been developed and these modifications include multiple dose activated charcoal (MDAC) therapy, charcoal hemoperfusion, and a new superactive charcoal (SAC). The new SAC has shown to adsorb 1.7 to 4 times the amount of substance tested compared with other activated charcoal preparations[3]. Five commercially available aqueous charcoal products Acta char, Actidose aqua, Insta char, liquid char and super char and their rate of absorption of aspirin is determined. The only statistically significant difference was between super-charand and Acta-char. The most common factor responsible for the difference is surface area[4].

The effect of activated charcoal on the absorption and elimination of astemzole and its metabolities was studied. The absorption of astemizole from the gastrointestinal tract can be effectively prevented with activated charcoal[5]. Nano particles coated face masks, consisting a mixture of silver nitrate and titanium dioxide, protect against infectious agents. A 100% reduction in viable E.coli and S. aureus was observed in the coated mask materials after 48 hour of incubation[6]. Clean surgical gowns, surgical scrubs and masks are worn by operative teams to decrease bacterial contamination and lower surgical site infection (SSI) rates. Bacterial contamination of the operative field has been shown to be decreased by wearing of surgical mask by the operating team[7].

The adsorption behavior of ruthenium ions onto activated charcoal has been studied in relation to time, ruthenium ions concentration and temperature from nitric acid solutions as adsorptive medium. The result indicates that the ruthenium ions adsorption on activated charcoal is physical in nature and change in nitric acid solution concentration does not influence the adsorption process[8]. Single dose activated charcoal (SDAC) may be an effective method of gastric decontamination when administered to patients within an hour of drug overdose. However, few patients who may benefit from this treatment attend an emergency department.[9]. It is predicted that composite materials to continue to have a greater impact owing to the large number of characteristics and performance criteria. Non wove fabrics are utilized in every area of medical and surgical textiles[10].

Intoxications with gamma-hydroxybutyrate (GHB) are occurring more frequently. The treatment of intoxications with GHB primarily consist of supporting respiratory status, the use of activated charcoal (AC) has been suggested[11]. To evaluate the filter performance and facial fit of a sample of surgical masks. Assisted qualitative fit tests and quantitative fit test are performed for the surgical and dental masks[12]. Activated charcoal hemoperfusion is effective in blood purification for removal of various circulating toxic materials and waste metabolities. Chitosan encapsulated activated charcoal (ACCB) beads is used for the removal various toxins such as, creatinine, uric acid, bilirubin[13]. The development of a three – layered cotton based decontamination wipe and its adsorption of 0.1% pinacolylmathylphosphonate in butanol. The adsorption performance of a new cotton-based, non-particulate flexible composite that has a high potential to be used as a portable decontamination wipe[14]. The activated carbon fibres (ACF) pore structure and sulphur dioxide removal performance under dry and humid cinditions were investigated. In dry air, break through capacity of ACFs with sulphur dioxide was found to be proportionately dependent on micropore ratio and pore size distribution[15]. The objectives of current research are to develop and characterization of the dual layered mask treated with charcoal.

Material and Methods

The fabric used in the development of the nonwoven mask was needle punched 100% polypropylene nonwoven fabric. The basis weight of the fabric used is 50 grams per square meter and the thickness is 0.67 mm.

Characterisation of nonwoven pore size

The pore size of the non woven fabric is characterised using a polarised microscope.The sample is mounted at the foot of the microscope. The microscope is adjusted in such a way that the pore of the sample is very clearly seen. The top part of the microscope has a camera which is connected to a computer or laptop. From the image that is captured the pore size of the sample can be determined.

Activated charcoal finishing

Activated charcoal is charcoal treated with oxygen to open up tiny pores between the carbon atoms. They are used to adsorb bacteria. It is highly adsorptive.Here the activated charcoal that is used, is in the powdered form and not in a solid form. First step in the production of nonwoven mask is applying activated charcoal on the non-woven fabric. The activated charcoal is made into fine powder form. It is then applied on the non-woven layer by coating technique. The charcoal paste involved here is Charcoal 50 grams, Metallic gel of 200 grams, Mesh size of 20x20 cm. In this method, the calculated amount of charcoal is mixed with the metallic gel. A mesh is prepared according to the sample size. The sample is placed on a flat and smooth surface above which the mesh is placed. The charcoal mixed with gel is poured on the mesh. Using a screen printing squeezer uniform pressure is applied on all the sides. The nonwoven is cured at 160˚ C.

Development of dual ply mask

The type of fusing machine used here is the roller type of fusing machine which has got two rollers-top and bottom. There are two belts that run over the rollers over which our samples are placed. The sample of size 18x13 cm is placed on the belt whose speed can be adjusted in terms of time taken to come out. Now due to the pressure provided by the rollers and due to the additional heat the fabric sample gets fused. The temperature at which the sample was fused is at 165˚C **.**The speed at which the machine was run in terms of time is 25 seconds. Figure 1 shows the development of dual ply mask.

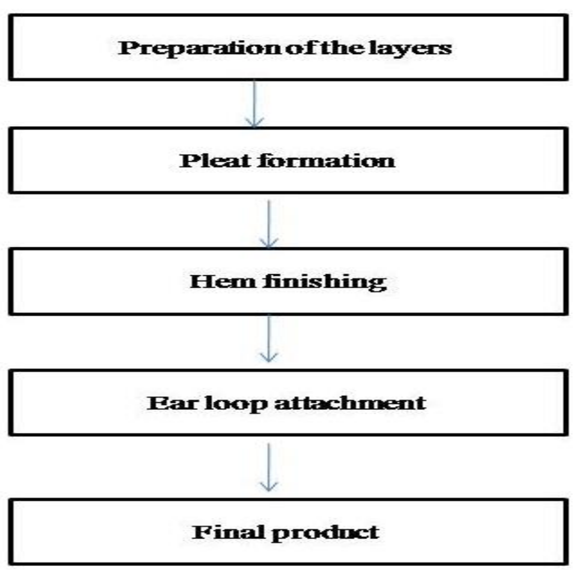

Figure 1: Development of dual Ply mask.

For developing a dual ply face mask, two layers of non -woven fabric is taken. One having finishing with charcoal and the other plain fabric. Here the sample is of dimension 18x13 cm. Now the layers are prepared for the same dimension. After the layers are placed as mentioned above now it is ready for the pleat formation. Here pleats are formed so it allows the user to expand the mask so it covers from the nose and under the chin. First a midpoint is marked along the horizontal direction i.e along 13. Now mark 1 cm above and below the midpoint line. The pleat above is said to be facing upwards and the pleat below is also facing upwards. After the pleats are formed all the four sides of the mask is hem finished. Normal lock stitch is used. It is seen that none of the layers is slipping out and that it is stable. After the hem finish, the ear loop is attached. The strips used as ear loop is the elastic strips. The length of this elastic strip is 17.5 cm. Two strips are prepared for the same length. First the strip is attached on one side from the top to the bottom and in the same way the other strip is attached to the other side. For all this single needle lock stitch having Stitches per inch of 12 is used.

Evaluation of Mask

Bacteria Filtration Efficiency

The procedure was performed to determine the filtration efficiency of the test materials using a ratio of the challenge to effluent to determine % efficiency. This procedure allowed a reproducible aerosol challenge to be delivered to each of the test materials and its capability of resisting it was assessed.

Air Permeability Test

Fabric air permeability is a measure to what extent it gives air passing through the fabric. The principle of the Air Permeability Tester is that air is drawn through a specified area of fabric, which is adjustable to suit specific textiles being evaluated.

Bursting Strength

Bursting strength is the amount of force required to rupture a knit fabric or non-woven fabric. A specimen of the fabric is clamped over an expandable diaphragm. The diaphragm is expanded by fluid pressure to the point of specimen rupture. The force is applied equally in all directions on the specimen. The specimen is placed symmetrically in the jaws of the machine with the short dimension parallel to and the long dimension at right angle to the direction of application of the load. Care should be taken to grip the fabric backing by both pairs of jaws.

Tensile Strength

This test is to determine the tensile characteristics of non-woven fabric. The grab test is a tensile test where the central part of the specimen's width is tested in the grips. Specimens 4 inches (10 cm) wide and not less than 6 inches (15 cm) long are taken for the test. Two sets of five specimens each are required. The distance between the two pairs of jaws on the apparatus is 3 inches (7.5 cm) at the start of the test. The rate of separation of the jaws shall be 12 + 0.5 inches (30 + 1 cm) per minute.

Fabric Stiffness test

Cantilever Test method is the widely used method for testing stiffness of fabric. It works on the principle of cantilever bending. A Sample size of 25±1mm x 200± 1mm was used having a minimum of at least three specimens (lengthways direction) of the fabric and at least three specimens (widthways direction). sample should not contain any folds or creases. Specimens should be left to precondition in an atmosphere of not more than 10%RH and a temperature of not more than 50°C for 4 hours. A rectangular strip of fabric is supported on a horizontal platform of the stiffness tester and extended in the direction of its length, so that an increasing part overhangs and bends under its own mass. When the tip of the specimen reaches a plane passing through the edge of the platform and inclined at an angle of 41.5° below the horizontal, the bending length is read off the scale of the apparatus. From the bending length, the mass and the unit area of the fabric, the flexural rigidity and the bending modulus can be subsequently calculated.

Tearing strength test

Sample is prepared by using a specially shaped template. The sample is mounted on the apparatus and fastened .It is then tested by providing the cut with the knife. The value of the pointer could be noted.

Results

Characterisation of nonwoven pore size

The pore size of the nonwoven mask was analysed using a polarised microscope. From the images obtained from the camera attached to the microscope Figure 2 shows the nonwoven fabric has a pore size of 0.5 micron, which would block all the bacteria and viruses from entering or passing across the mask.

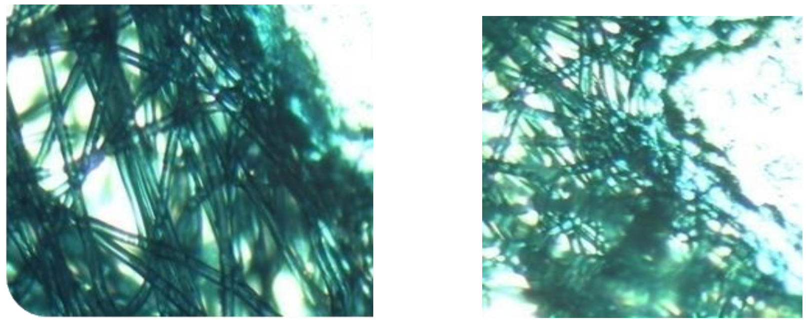

Figure 2: Microscopic image of nonwoven fabric.

Bacteria filtration efficiency

Table 1 shows the results of developed dual layer mask. The bacterial resistance capacity of the developed nonwoven mask was found 88% which serves the purpose that the product has been designed for. The use of surgical mask could be one of the fortifications to the problem of spreading of diseases. It would give primary protection to all the people around and to all the first responders.

Table 1: Results of dual layer mask

PARAMETERS	RESULT
Bacterial filtration efficiency (%)	88
Tearing strength (grams)	480
Breaking strength (lbs)	48.84
Breaking elongation (%)	48.89
Bursting strength (KPa)	509.7
Air permeability (Cm3.cm3/s)	0.7

Tearing strength:

The sample is mounted on a tearing strength tester and the fabric was assessed to tear at a load of 480 grams. Hence it is seen that the mask will not tear at a load less than 480grams which is possible in a mask.

Fabric stiffness test

The sample after being subjected to cantilever fall principled stiffness tester it is assessed to have stiffness within the acceptable level. Hence the mask will give free movement to the wearer and also comfort.

Tensile strength:

The fabric was assessed for tensile strength by grab method and it showed a breaking strength of 48.84 lbs and breaking elongation of 48.89% which means that the fabric has good strength and resistance to longitudinal force or pressure.

Air permeability:

The air permeability of the sample was tested by letting the air pass through the sample at high speed. Finally the sample was found to have a value of 0.7 $cm^3.cm^2/s$.

Conclusion

There has been a habitual spread among enormous amount of people and ultimately taking a levy on their lives. Simple surgical masks protect wearers from being splashed in the mouth with body fluids and to prevent transmission of body fluids from the medical professional to the patient. They also remind wearers not to touch their mouth or nose, which could otherwise transfer viruses and bacteria after having touched a contaminated surface. They can also reduce the spread of infectious liquid droplets carrying bacteria or viruses that are created when the wearer coughs or sneezes. They are not designed to protect the wearer from inhaling airborne bacteria or viruses particles. Here the focus has been on developing a two layered and thin mask with activated charcoal finish that would provide extra filtration of the airborne particles than a normal surgical mask. Activated carbon is essential to improve the air and water environment. Besides powder and granular types, activated carbon fibre has been highlighted due to high absorption speed and process ability. The fabric used was a non woven fabric .The two layers of fabric are joined together by fusing the fabrics. The pleat that was formed further enabled easy air flow and ultimately improving the breathability. The effects of filtration, structural variables, air permeability and mechanical properties of the fabrics were studied by various tests like the tensile strength, tearing strength, stiffness, air permeability, bacterial filtration efficiency and bursting strength. These test results have also shown a positive inclination in favour of the mask. The pore size characterisation a positive response has been brought which is serving the main objective of resistance to bacteria and the activated charcoal mask has 88% bacterial filtration efficiency that would keep healthcare people safer.

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