

## **Experimental procedure**

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### **3. EXPERIMENTAL PROCEDURE**

The experimental procedure pertaining to “**A Study on Nano Finishing of Multifunctional Properties in Herbs on Cotton Fabric**” is discussed under following headings:

- 3.1 Selection of Material**
- 3.2 Pretreatment of Fabric**
  - 3.2.1 Desizing of cotton fabric
  - 3.2.2 Bleaching of cotton fabric
- 3.3 Selection of finishing**
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  - 3.3.2 Selection of binder
- 3.4 pilot study**
  - 3.4.1 Selection of suitable solvent
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- 3.6 Optimization of finishing parameters**
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### **3.10 Product development**

#### **3.1 Selection of Fabric**

Cotton fabric was selected due to its excellent absorbency, strength, and comfort properties. Five meters of 100 percent, plain woven, 40 count cotton fabric was purchased from kadhi shop in Coimbatore for this study. One meter of this was kept aside as original fabric, remaining four meters of cotton material was used for finishing.

#### **3.2 Pretreatment of Cotton Fabric**

The raw cotton consisted of 90-94 percent cellulose, 9-9 percent moisture and the natural impurities such as nitrogenous matter-1-2.9 percent, mineral matter- 1-1.9 percent, oil, wax, and\ fats-0.5-1.0 percent, and natural colouring matter. Most of the impurities present in cotton are hydrophobic in nature which makes cotton fabric non-absorbent until it has been given a cleaning treatment also known as pretreatment. Unless the cotton subsequent wet process like dyeing, printing, and finishing cannot be expected to be uniform Kandhasamy (2004).

### **3.2.1 Desizing**

Desizing is a process of removing sizing in order to remove the hydrophobicity offered by these materials, which hinders the subsequent dyeing and printing process. The following ingredients are used for desizing process

Weight of the fabric	-	994 grams
Material to liquor ratio	-	1:40
Detergent	-	25 grams
Temperature	-	90°C

The detergent powder was mixed in water. The fabric was immersed in this solution and stirred gently for 60 minutes at 90°C. Then the fabric was taken out and rinsed thoroughly with running water and dried.

### **3.2.2 Bleaching**

Bleaching is a chemical process that eliminates unwanted coloured impurities and prepares the cloth for further finishing process. The removal of natural coloring matter from the selected fabric was done using the following ingredients.

Weight of the fabric	-	990grams
Material liquor ratio	-	1:40
Hydrogen per oxide	-	20 grams
Temperature	-	90°C
Time	-	60minuties

The desized fabric was treated with 20grams of hydrogen peroxide in water and stirs thoroughly and heat at 90°C for 60 minutes, then removes the fabric from the vessel and washed thoroughly with warm water and dried.

### **3.3 Selection of finishing**

According to Kannaian (2009) a major factor that has stimulated interest in antimicrobial and mosquito repellent finishing using natural herbs has been the vogue that promotes natural and eco- friendly life style. The consumer is now increasingly aware of the hygienic life style and there is a necessity and expectation for a wide

range of textile products finished with functional properties such as anti bacterial, mosquito repellent, and fragrance says Srivastava (2010).

### **3.3.1 Selection of Herbs**

For special finishes the following herbs have selected from nature. Eucalyptus (PLATE-I) is a member of myrtaceae family. Eucalyptus leaf has terrific cleansing properties and also anti infections against bacteria, virus and fungi. It was investigated in order to evaluate the suitability of functionalized textiles with antimicrobial and anti allergic effects Sarsaparilla root (PLATE –II) has Saponins, its compounds help to destroy fungi and Bacteria. This could be one of the possible reasons that Sarsaparilla has antimicrobial properties Profound Joshi (2009). Both Eucalyptus and Sarsaparilla have Anti microbial properties and Sandal wood (PLATE-III) has very good fragrance. Hence the above herbs were selected for this study.

### **3.3.2 Selection of Binder**

The binder is a film forming agent made up of long chain macro molecules which when applied to the textile together with the pigment produces a three dimensionally linked network. The binder should be colorless, odorless, evenly thick, smooth and good adhesion says Khoja (2003). Citric acid serves to revive and raise certain colors and also used to carry out pH adjustment as it destroys the effects of alkalies. Hence citric acid was selected as binder for this study.

## **3.4 Pilot study**

For this study pilot study was conducted for the selection of solvent for extraction.

### **3.4.1 Selection of solvent for extraction.**

An experiment to identify the most suitable solvent for the extraction of finishing agent from herbs was carried out. The solvent such as water, Ethanol, and Methanol, were used for extraction. 10 grams of grinded Eucalyptus, and Sarasparilla herbs were added in 100ml of the solvents separately. The compounds were kept into the Shaker incubator for 9 hours at 1000rpm. After extraction the solution was filtered by using filter paper and the same filtered solution were evaporated at room

temperature for 24 hours. Among the extracts ethanol extract shows good antimicrobial activity and fragrance. Hence the ethanol extraction was selected for the study.

The 5cm×5cm pretreated fabric samples were finished with herbal extraction into extracted solutions such as Eucalyptus leaf, Sarsaparilla root and Eucalyptus and Sarsaparilla mixed solutions for 12 hours. Among the samples, Eucalyptus and Sarsaparilla mixed sample showed the most significant properties (Plate – V). From the pilot study, Eucalyptus, and Sarsaparilla mixed solution was taken for this study. Sandal wood powder was added for fragrance effect.

### **3.5 method of extraction**

#### **3.5.1 Soxhelt extraction**

Soxhelt extractor (PLATE – IV) was used to extract the natural finishing agent from Eucalyptus leaves, Sandal wood powder and Sarsaparilla root. Ethanol was used as a solvent. 50grams of grinded herbs were refluxed in the apparatus separately with 500ml of ethanol. The temperature was maintained at 50°C. The process was continued till to obtain pale color of the solution. The extract was stored in round bottom flask. The extracted solution was filtered with watermen filter paper. The solution was evaporated at room temperature for 24 hours.

### **3.6 Optimization of finishing parameters**

Following are the optimization of Concentration, Proportion, Time, and Temperature

#### **3.6.1 Optimization of concentration**

The selected herbs were taken in the optimized ratio and soaked in ethanol for four days. After four days the ethanol was evaporated for the extraction of finishing agent. The extracted solution was diluted with water in three proportions 50, 75 and 100 percent. The 100 percent extracted solution shows good antimicrobial activity in the pilot study. Hence 100 percent concentration was chosen for this study after pilot study.

**PLATE – I**  
**EUCALYPTUS GLOBULES**



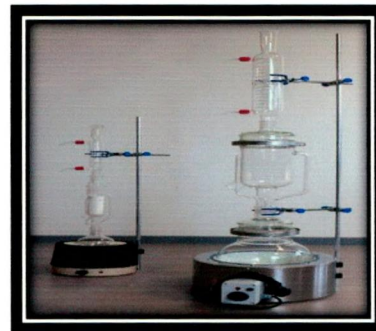
**PLATE – II**  
**HEMIDESMUS INDICUS**



**PLATE – III**  
**SANTALUM ALBUM**



**PLATE - IV**  
**SOXHLET EXTRACTOR**



**PLATE – V**  
**HERBAL SOLUTION**



**PLATE - VI**  
**CITRIC ACID**



**PLATE - VII  
PILOT STUDY  
SELECTION OF SOLVENT AND HERBS**



**PLATE - VIII  
DYE BATH**

**PLATE - IX  
ULTRASONIC ATOMIZER**



**PLATE - X  
NANO SPRAY DRIER**

**PLATE - XI  
NANO PARTICLES**



### **3.6.2 Selection of binder and herbal extract proportion**

Citric acid is (PLATE -VI) considered as an important aspect in binding of herbs in the fabric in the finishing process. Thilagavathi (2010) suggested that citric acid gives good results as a mordant. In this study 100 percent extracted solution and 100 percent concentrated citric acid in the ratio of 9: 1 was selected for the study.

### **3. 6.3 Optimization of time and temperature**

The finishing samples of the time for finishing were selected after the sample was processed in different time intervals such as 30 minutes, 45 minutes and 60 minutes. From the pilot study 60minutes gives the better results than 30 and 45minutes.

To optimize the soluble temperature for the finishing fabric samples when treated with equal ratio for 60 minutes in different temperature such as 60<sup>0</sup>c, 90<sup>0</sup> and 100<sup>0</sup>c from the pilot study, 60C which gives better finishing than the other temperature. Hence the investigator selects 60<sup>0</sup>C for the final study. The optimization parameters are given in the table.

**TABLE-I**  
**OPTIMIZED PARAMETERS**

S. No	Name	Concentration (%)	Temperature (°c)	Time (minutes)
1	<i>Eucalyptus globulus</i> (Eucalyptus)	100%	60	60
2	<i>Hemidesmus indicus</i> (Sarsaparilla)	100%	60	60
3	<i>Santalum album</i> (Sandal wood )	100%	60	60

From the table – I it is clear that the herbal extract was mixed with water and one percent citric acid was added. The temperature was maintained at 55°C for 60 minutes. Thus the above parameters were selected for the study

### 3.7 Methods of finishing

#### 3.7.1 Conventional method

The following parameters were used for finishing

Material: liquor ratio	-	1:10
Temperature	-	60°C
Time	-	60 minutes

50cm× 50 cm cotton was treated with 500 ml of optimized herbal solution at 60°C for 60 minutes of 1: 10 material liquor ratio. After the finishing process the fabric was taken out from the bath (PLATE – VIII) and dried thoroughly. The finished fabric was evaluated by visual inspection, evaluation of antimicrobial, fragrance and mosquito repellent evaluation.

### 3.7.2 Ultrasonic atomizer

The ultrasonic atomizer (PLATE –IX) uses only ultrasonic vibrational energy to generate a gentle, low-velocity spray. Over spray is practically eliminated, resulting in substantial material savings and reduction in airborne pollution. A wide variety of coating, chemicals, lubricants, and particulate suspensions can readily be atomized; however, factors such as viscosity, miscibility, and solid content deserve consideration. For optimum atomization, the viscosity should be under 50 cps and the solid concentration kept below 30 percent. Although lower frequencies are capable of atomizing higher viscosity liquid film into motion, typically the higher the viscosity the lower the flow rate and the more difficult the application. The ultrasonic power supply converts 50/60 HZ to high frequency electrical energy. This electrical energy is transmitted to the piezoelectric transducer within the converter, where it is changed to mechanical vibrations. The ultrasonic vibrations are intensified. By the probe and focused at the tip where the atomization takes place. Drop size is primarily a function of frequency, and the higher the frequency, the smaller the drop diameter. With water, the median drop size at 20KHZ is 90 microns, and 50 microns at 40 KHZ.

The pretreated cotton fabric in the dimension of 50cm in length and 50 cm in width was placed in the plastic tray for finishing process using ultra sonic atomizer. The 500 ml of herbal solution was taken in the beaker. 9 percentage of citric acid was added in the solution as a binder. The solution was dispensed to the atomizing probe (nozzles), by small low- pressure metering pump. The size of the pump was 4 mm. the one end of the pump was fixed with sucker, and the another end was fixed with probe. Two types of atomizing probes are available for processing volumes up to 20 liters per hour. A duel inlet atomization probe and a wide dispersion atomizing probe operates at 20KHZ or 40 KHZ Wide dispersion probe was used in this study. The probes are fabricated of Titanium alloy.

The following parameters are used in this study

Volume	-	300ml
Tube size	-	4mm
Flow rate	-	10 ml per min
Repetition	-	5
Direction	-	clock wise

The solution was sucked by the sucker and travels through the pump, and reached the probe. The solution passed through a probe and spread out a thin film on the atomizing surface. The oscillating tip disintegrates the solution into 50µm micro droplets, and ejects them to produce a gentle, low velocity spray on the fabric. The Ultrasonic atomized fabric was evaluated by visual inspection, Antimicrobial test, and Mosquito repellent test

### **3.7.3 Nano Spray Dryer B-90**

The Nano Spray Dryer B-90 (PLATE – X) is characterized by a piezoelectric nozzle for atomization, laminar flow of drying gas and electrostatic particle collection for nanoparticles enabling high yields. Major benefits are the high separation efficiency; simple particle collection and the protection of the user and the environment due to the integrated gas filter. The droplet generation is based on a piezoelectric driven actuator, vibrating a thin, perforated, stainless steel membrane inside a small spray cap. This membrane (spray mesh) features an array of high-precision, micron-sized holes (4.0, 5.5 or 9.0 µm). The actuator is driven at an ultrasonic frequency, causing the membrane to vibrate, ejecting millions of accurately sized droplets per second with a very narrow droplet size distribution.

#### **3.7.3.1 Spray drying parameters**

The right selection of the process parameters has an influence on the success of the spray drying process. The parameters were kept as stable as possible to enable reproducible results.

##### **3.7.3.1.1 Temperature**

The inlet and outlet temperature proved to have a valuable impact on the drying process and on the quality of the dried powder. Raising the inlet temperature increased the evaporation energy at a constant drying gas flow rate. The inlet temperature was kept constant at a maximum level of 120°C. The outlet temperature varied between 45°C and 52°C depending on the selected spray cap size and the given spray rate. The spray head temperature remained constantly at between 125°C to 129°C, indicating a stable vibration performance in the piezoelectric crystal inside the spray head.

### 3.7.3.1.2 Feed rate

The spray rate selected indicates the activation of the mesh vibration. 100% setting is typically applied resulting the highest possible. Throughput In this investigation the throughput increased from 20 ml/h (4.0  $\mu\text{m}$  spray cap size) to 50 ml/h, (5.5  $\mu\text{m}$ ) and 95 ml/h (9.0  $\mu\text{m}$ ) at 0.1% solid concentration. At higher viscosity (e.g. higher solid concentration) the feed rate decreased. Drying air flow rate and air humidity .The laminar drying gas flow and piezoelectric atomization of the Nano Spray Dryer B-90 offer a gentle way of evaporation. The gas flow rate was constantly kept at 140 L/min, which resulted in rapid drying. The final moisture content in the spray dried powder was within the range of 4% to 5%.

### 3.7.3.1.3 Inside pressure

In this application, the drying air flow rate of 140 l/min resulted in a constant inside pressure of 60 mbar. The gas pressure correlates with the drying gas flow rate. Certain inside pressure are required to ensure good spray performance. It also indicates tightness.

Yield Depending on the selected spray cap size, the yield varied from about 60% (5.5  $\mu\text{m}$  spray cap size) to 90% (9.0  $\mu\text{m}$ ) and reaches up to 90% (4.0  $\mu\text{m}$ ).

The selected spray drying parameters were

Spray cap	-	4.0 $\mu\text{m}$
Gas flow rate	-	126 per min
Inlet Temperature	-	120°C
Spray head Temperature	-	129°C
Outlet Temperature	-	52°C
Spraying time	-	12 hours
Feed rate	-	25ml/h
Spray rate	-	100%
Pressure	-	42 mbar
Yield	-	90 – 90%

### **3.7.3.2 Nano Spray drying procedure**

The 500ml of extracted herbal solution was taken in a beaker. The solution was converted into nano particle using Nano Spray Dryer B-90. The spray drying process started with the preheating of the spray dryer to the preset inlet air temperature. Oil-free compressed air of 1.5 bars was used as a drying gas. A drying air flow rate of 126 L/min was applied. In this investigation, the inlet temperature was constantly kept at 120°C. After reaching the set inlet temperature, distilled water was pumped by inlet tube and sprayed until a stable outlet temperature had been obtained after the herbal solution was sprayed through the 4 micron probe into the chamber. The sprayed solution was dried inside the chamber by electrode. The process was then continued for 12 hours in selected parameters

### **3.7. 3.3 Powder collections**

After spray drying, the cylinder with the particles (PLATE- XI) collected was left to cool down until it reached room temperature. The resulting powder was collected manually by applying a rubber spatula, weighed and filled into an air tight container, and then it was kept into the Deep freezer in -40°C.

### **3.7.3. 4 Application of nano particles on fabric**

The collected nano particles were mixed with 100ml distilled water and 9 percent citric acid was added with the solution as a binder. The solution was sonicated using ultra sonic bath for dissolving particles, after the solution was applied on Cotton fabric by using Ultra sonic atomizer. The ultra sonic atomizer procedure was already mentioned in 3.6.2.

### 3.9 Nomenclature

The following nomenclatures was used in the Results and Discussion

**TABLE-II**  
**NOMENCLATURES**

<b>Name of the samples</b>	<b>Nomenclatures</b>
Control sample	A
Conventional finished sample	B
Ultra sonic atomized sample	C
Nano finished sample	D

### 3.9 Evaluation of the Sample

The evaluation is very important in research. In this study selected raw Cotton fabric was pretreated, and finished with Exhaustion method, Ultrasonic atomizer and Nano spray dyer. The above mentioned four samples such as original, Conventional finished sample, Ultra sonic atomized sample, and Nano finished sample were evaluated by visual inspection, Antimicrobial test, Mosquito repellent test, physical properties test, mechanical properties test, comfort properties test and wet ability.

#### 3.9.1. Sensorial Evaluation

The samples B, C , and D were analyzed visually by elected 50 judges from post graduate students from Textiles and clothing department in Avinishilingam University. who are having textile knowledge for this rating scale was used to evaluated general appearance , evenness, texture and fragrance this was evaluated Performa was compared with this original to find out the difference after finishing.

#### 3.9.2 Physical properties test

##### 3.9.2.1 Fabric weight

The weight of a fabric can be described in the two ways, weight per unit area in terms of ounces per square yard or grams per square meter, weight per unit length in terms of ounces per yard or grams per meter. Weight of the fabric was determining using G.S.M cutter (PLATE – XII). It is a device to cut circular specimen of the 100

square cm of fabric. The samples were cut using GSM rotating the handle with pressure. This was done for 5 samples, to get a correct value. The cut sample was weighted using digital balance. The values obtained directly from the reading on the balance. The value in grams multiplied by 100 gives to final value mechanical properties. The weight of the samples was evaluated by using Electronic Weighing Balance and the results were given in Table – III.

### **3.9.2.2 Fabric thickness**

Fabric thickness is an important property that adds to the insulating effect. Two thin layers of fabric are more than one thick layer because there is extra dead air space between the two layers. Finer fabrics fill up spaces in fabric layers and increase insulating effect. Thickness gauge (PLATE – XIII) is the instrument used for measuring fabric thickness. It consists of a flat metal surface. The anvil and the presser foot, both are circular but presser foot is smaller than anvil. Anvil provides gradual lowering of presser foot onto the anvil in order to get reading nearest to 0.0001. A randomly selected specimen, of size twenty percent larger than the presser foot is placed on anvil and the presser foot is lowered into contact with the top surface of the fabric. This was done in five samples randomly to get the correct value. The thickness is read from the dial of the instrument suggests Arora (2010). By using Thickness gauge the selected sample were tested and the results were given in Table-IV.

### **3. 9.3. Mechanical Property Test**

#### **3.9.3.1 Tensile strength of the fabric**

Tensile strength is defined as the force or load per unit area required to rupture a material. The British standard for fabric tensile strength involves extending a strip of fabric to its breaking points by a suitable mechanical means which can record the breaking load and extension. Fabric samples are extended in a direction parallel to the warp and parallel to the weft. The specimens are cut to size of 60mm\*300 mm and then frayed down in the width equally at both sides to give samples which are exactly 50mm wide. The rate of extension is set to 50mm per minutes and the distance between the jaws is set of 200 mm. the mean of 5 samples were found out for

**PLATE - XII**  
**GSM CUTTER**



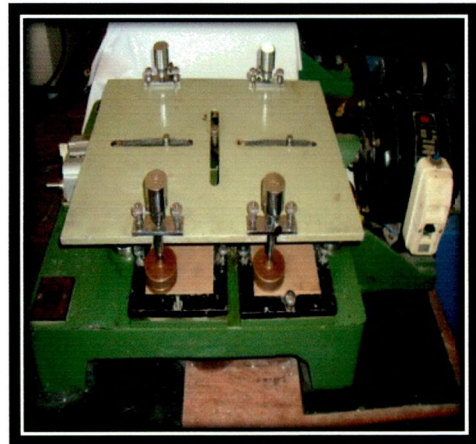
**PLATE - XIII**  
**THICKNESS GAUGE**



**PLATE - XIV**  
**TENSILE STRENGTH TESTER**



**PLATE - XV**  
**MARDINDALE ABRASION TESTER**



**PLATE - XVI**  
**STIFFNESS TESTER**



**PLATE - XVII**  
**CREASE RECOVERY TESTER**



breaking force and mean extension as a percentage of initial length are reported explains Saville (2004). Hence Tensile strength tester (PLATE – XIV) was used to find the strength of samples and the results were given in Table – V

### **3.9.3.2 Abrasion Resistance**

Abrasion is one aspect of wear it is rubbing away of the component fibers, yarns of the fabrics Abrasion is measured by subjecting to specimen to rubbing motion in the form of geometric figure that is a straight line, which becomes gradually widened ellipse, until its forms another straight line in the opposite direction and traces the same figure again under known conditions of pressure and abrasion action cities ASTM standards (2005). By using Martindale abrasion tester (PLATE – XIV) the samples were tested and the results were given in Table – IX

### **3.9.4. Comfort Property Test**

#### **3.9.4.1 Stiffness of the fabric**

Stiffness is an important characteristic of fabric. The stiffness is important elements on the end use of the fabric. The most commonly used instrument for measurement of stiffness of a fabric is shirly stiffness tester (PLATE – XVI). A rectangular strip of fabric, 6 inches \* 1 inch is mounted on a horizontal platform in such a way that it over hangs, like a cantilever, and bends downward. From the length '1' and angle @ number of values are determined views Booth (2004). The stiffness of samples was tested and results were given in Table - X

#### **3.9.4.2 Crease recovery of fabric**

Creasing of a fabric during wear is not a change in appearance that is generally desired. The ability of fabric to resist creasing is in the first instance dependent on the type of fibre used in its construction. The basic principle of this test is that a small fabric specimen is folded in two and placed under a load for a given length of time to form a crease and it is then allowed to recover for a further length of time and the angle of crease that remains is measured. The magnitude of this crease recovery angle is an indication of the ability of a fabric to recover from accidental creasing. By using the Eureka crease recovery tester (PLATE – XVII) the selected samples were tested and results were given in Table - XI

### **3.9.4.3 Fabric drape**

According to BIS-9359/1999 the drape is defined as the extent to which a fabric will down deform when it is allowed to hang under its own weight. According to BS-5059/ 1993.it is defined as the percentage of the total area to an annular ring of fabric obtained by vertically projecting the shadow of the draped specimen. A circular fabric specimen is held concentrically between smaller horizontal disc and an annular ring of fabric is allowed to drape into folds around the lower supporting disc. The shadow of the draped specimen is cast onto an annular ring of the paper of same size as the unsupported part of the fabric specimen. The outline of shadow is traced onto the ring of paper, the mass of which is then determined. The paper is then cut along the trace of shadow and the mass of inner part representing the shadow is determined, the drape co-efficient is calculated from two masses. The drape meter was used to analyze the drape co-efficient of selected samples and the results were given in Table - XIV

### **3.9.5. Wet ability and Absorbency test**

The wet ability and absorbency tests included drop test, sinking test and capillary rise test.

#### **3.9.5.1 Drop test:**

The ability of fiber or a fabric to take up moisture is termed as absorbency, according to Skinkle [1999]. Wettability is the time taken in seconds for a drop of water to sink into the fabric, if any fabric takes more than 200 seconds to absorb water the same is considered to be UN wet table. Drop of water is placed on the fabric surface from a height of 2.5cm with the help of pipette (PLATE – XVIII). A stop watch is started as soon as the drop falls on the fabric and stopped when water drop is completely absorbed by the fabric. This is termed as drop absorbency time.

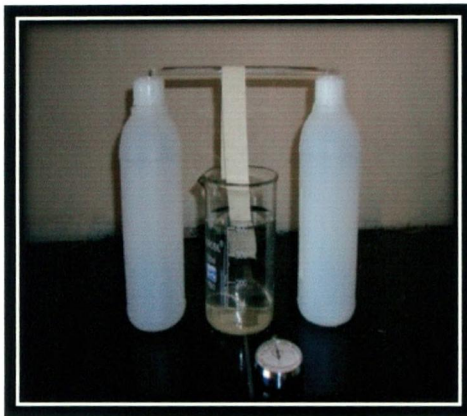
**PLATE -XVIII  
DROP TEST**



**PLATE - XIX  
SINKING TEST**



**PLATE - XX  
CAPILARY TEST**



**PLATE - XXI  
NANO UV DROP**



**PLATE - XXII  
PILLOW CASE**



### **3.9.5.2 Sinking test:**

In this test, a small square sample of size “X” is cut and drops it to the surface of the water in a beaker (PLATE – XIX). The time taken for the specimen to sink below the surface is observed. The shorter the time, the greater the wet ability remarks Booth (2005). Five samples of the size 1”x1” are cut, each samples kept on the surface of water taken is 500ml of glass beaker. Time taken by the piece to sink just beneath the water surface is measured. Absorbency about 5 seconds is generally considered satisfactory for well prepared cellulosic materials. Using this method, the absorbency of selected samples were evaluated and results were given in the Table - XVI

### **3.9.5.3 Capillary rise test:**

Paul (2000) points out that the capillary travel method measures the rapidity of absorption. The sample was cut into the size of 15cm length and 2.5cm width. One end of the sample was plated with a glass rod and on the other end, two grams. Weight was attached to keep the sample straight both the ends of the glass rod were placed in heavy wooden block. At the weight ends two of the same fabric was allowed to immerse in a tray of distilled water the rate of the distilled water level in the sample was measured after 5 minutes (PLATE – XX). Using this method, the absorbency of selected samples were evaluated and results were given in the Table - XVI

## **3.9.6 Assessment of functional properties**

### **3.9.6.1 Evaluation of Antimicrobial activity**

The antimicrobial activity of control sample (A), finished samples (B, C, D) were evaluated by AATCC 149 Test method. The AATCC plates were prepared by pouring 20ml of sterilized broth solution in to sterile petri dishes. The broth contains peptone, Beef extract, and Agar. The dishes were allowed to solidify for 5 minutes, after solidification the selected Bacteria was swabbed uniformly. It was allowed to dry for 5 minutes. The samples such as A, B, C, D were placed on the surface of medium and the dishes were kept for incubation at 40°C for 24 hours. At the end of

the incubation, zone of incubation was formed around the fabric was ensured in centimeter and recorded

### **3.9.6.2 Evaluation of Mosquito repellent property**

#### **Cage Test**

Cage test is the easy and effective method of determines the mosquito-repellent property of treated materials. A box of 30 x 30 cm made out of transparent glasses with 30°C + 2°C temperature and 60 to 90 per cent humidity was maintained. In the glass box the finished and unfinished fabric was placed. Mosquitoes were collected during evening around 5pm and used for mosquito repellent test. 15 mosquitoes were put inside the cage. Mosquitos' movement in the cage was observed for 10 minutes. Movement of mosquitoes in cage towards the opposite side to the treated fabric was considered as better repellent property. Note down the anti-mosquito effectiveness by counting the number of mosquitoes which will rest on the unfinished and finished samples.

### **3.9.6.3 Evaluation of fragrance finishing**

Concentration of the fragrance was measured using Nano UV/ visual spectrophotometer (PLATE – XXI). Fragrance was extracted from 1gram with ethanol for 3 min at 40°C and ensured complete evaporation of ethanol. Extracted fragrance was dilute to 1:10 with distilled water. Absorbency was measured on UV/ visual spectrophotometer at  $\lambda_{max}$  295 by calibrating it with ethanol, which was then converted according to Beer Lambert's Law. This was done for all unwashed samples after 3 days of application. To test the release rate of fragrance with ethanol and concentration was calculated. Evaluation was done on next day after application to ensure evaporation of fragrance. Same process was repeated twice with interval of 4 days. Release rate was measured using following formula;

$$\text{Release rate of fragrance} = \frac{(\text{Immediate concentration} - \text{concentration after 4days})}{(\text{Immediate concentration})} \times 100$$

### **3.9.9 Wash durability test**

The treated samples such as B, C, and D were analyzed for their wash durability by subjecting the samples to washing and testing their antimicrobial efficiency and concentration of fragrance.

### **3.10 Product Development**

The finished fabric was developed into pillowcase (Plate-XXII) for home textile application