Performance Evaluation of Mini-Mesh Fabric

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Objectives:

The main objectives of this study were to test the Polar skin ice sheet Mini Mesh, hereafter referred to as Mini Mesh. Main focus was to evaluate its permeability, wettability, drying characteristics as well as thermal comfort. The wettability and related characteristics were evaluated for water as well as the special Polar skin solution provided by PVL. For comparison purposes another fabric, that is the current industry standard, also referred to as the 'Sheet" was also evaluated. The results are summarized in the following sections.

Experiments and Evaluation

The following tests were run under the listed conditions.

Air Permeability: 10 tests were run for each sample using the Textest FX3300 Air Permeability Tester. Tests were conducted in accordance to INDA 70.1 in the laboratory conditions of 69.6 F and 24% Relative Humidity.

Thickness: 10 tests were run for each sample using the TMI Model 49-70.

Basis Weight: 10 circular samples with an area of 0.01 m^2 of each were taken to determine the basis weight. These were tested in accordance with INDA/WSP 130.1. Laboratory conditions during testing were 69.6 F, and 24% Relative Humidity.

Hydrohead: 5 tests were run from each sample using the Textest FX3000 Hydrostatic Head Tester. The first set of samples was run using deionized water and the second set of mesh samples were done using the supplied Arctic Aqua. Tests were conducted in accordance with INDA/WSP 80.6. The laboratory conditions were 69.6 F, 24% Relative Humidity.

ATS Absorption: 5 tests were run for each sample using the Sherwood Instruments ATS-600 with deionized water, in accordance with the suggested Test methods. The laboratory conditions were 69.6 F, 24% Relative humidity.

Absorptive Capacity: Measured in accordance with INDA/WSP 10.1 were liquid absorptive capacity of fabrics. The laboratory conditions were 67.9 F, 51% Relative humidity.

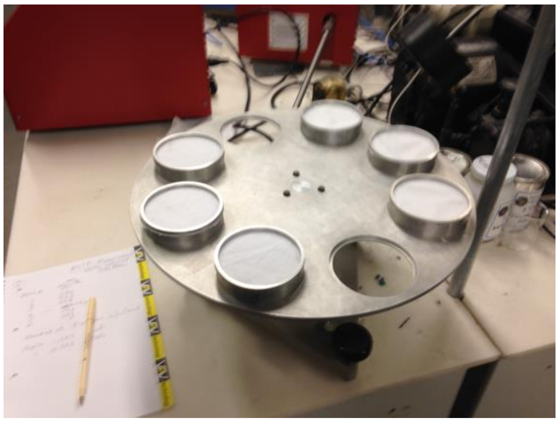
Drying Rate was tested in accordance with the military standards. Measured the sample dry weight and maximum liquid absorptive capacity (INDA WSP 10.1), then spread samples on glass plate in the lab fume hood. The weight of the samples was determined at set time intervals and the loss in water mass was plotted with respect to time.

Capillary Wicking: Tested in accordance with INDA/WSP 10.1 by measuring vertical capillary wicking of fabrics. Food coloring was added for visual reference.

Cooling rate was measured by using thermocouples placed under the wet fabrics in an environmental chamber at a set temperature.

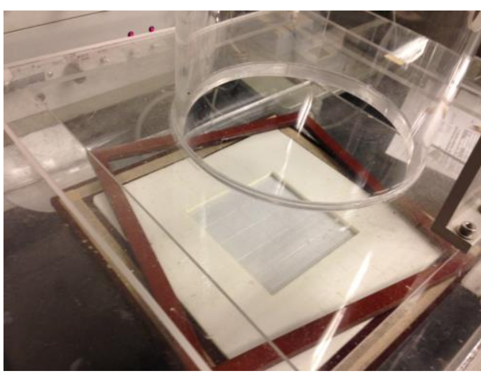
Moisture Vapor Transmission Rate (MVTR)

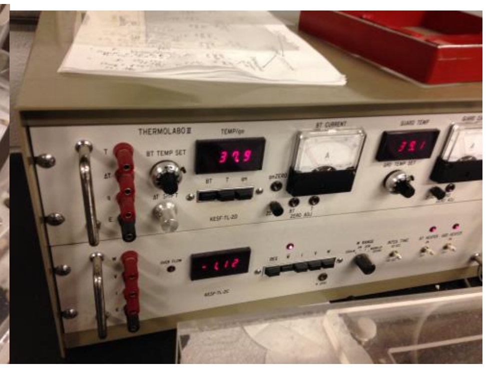
Evaporative dish method based on the British standard BS7209 was used to determine the MVTR of the two fabrics. The test specimens are sealed over the open mouth of test dishes that contained water. The adjacent figure shows the set up. We used three samples for each fabric. All the dishes are placed on a turntable, which slowly turns. The instrument was in a conditioned testing lab. The water in the dish was weighed before the start of the test and after 24 hours. The MVTR was calculated and reported as moisture vapor transmission in grams per square meter per day.



Thermal Resistance of Fabrics

Thermal resistance of fabrics was determined using a hot plate according to ASTM test method D1518-14. The figure below shows the sample on the hot plate and the control panel.





This procedure measures the rate of heat transfer from a warm dry constant-temperature horizontal flat-plate up through the layer of the fabric to a relatively calm cool atmosphere. To get a comparison under actual use conditions, samples were also tested with ice water saturated fabric and the mesh with aqua that was kept in the freezer for two hours.

Results

Some of the basic properties of the two fabrics, Cotton sheet and the Per Vivo Mini-mesh are listed in Table 1 and then compared in the following graphs. Both the fabrics have same basis weight of about 2oz per sq. yd. However the properties that determine comfort and specific performance are significantly different due to their unique construction and compositional differences.

The air permeability of the minimesh is more than three times higher than that of the cotton sheet because of the more porous construction (Figure 1). Also, the thickness of the minimesh fabric is about twice that of the sheet. The hydrohead, the pressure required to allow water permeation is comparable with only small differences.

Table1. Summary of results from Air permeability, Weight, Thickness and Absorbency.

Test		**130 TC Cotton Sheet**	**Mini Mesh**	**130 TC Cotton Sheet with Water**	**Mini Mesh with Water**	**Polar skin Ice sheet Mini Mesh**
Air Perm, Avg ± SD	(cfm)	150.3 ± 3	518.4 ± 26	-	-	-
Thickness, Avg± SD	(mm)	0.265±.01	0.601 ± 01	-	-	-
Basis Weight	(gsm)	77.6	72.8	-	-	-
Hydrohead, Avg± SD	(mbar)	-	-	4.1 ± 0.2	3.6± 0.4	5.3 ± 0.3
Max ATS Absorption Avg	(m/in^2)	-	-	0.037 ± 0.05	0.539 ± 0.05	-
ATS Absorption Rate Avg± SD	(g/s)	-	-	0.050 ±.0.03	0.013 +/-0 .01	-
Absorptive Capacity	%			116.5%± 2.2%	368.1%± 7.4%	377.8%± 5.8%

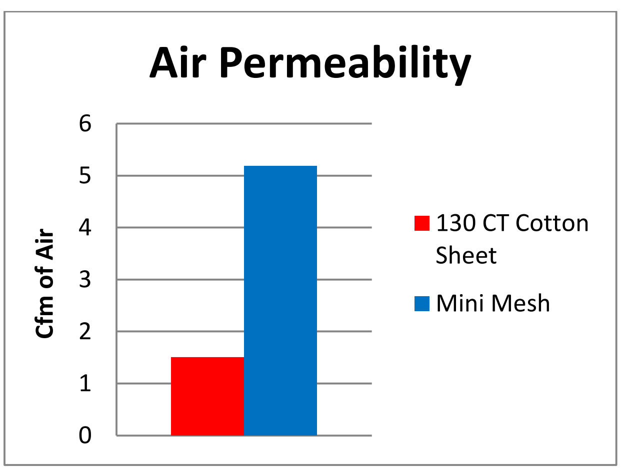


Figure 1. Comparison of Air Permeability of Cotton Sheet and Mini Mesh.

Absorption, Drying and Cooling Performance

Liquid absorption capacity measurement clearly showed that minimesh picks up about 250% more moisture than that absorbed by cotton sheet. Although initial absorption rate is slower with minimesh, the overall moisture absorption is very high. The absorption capacity of minimesh with arctic aqua is also high comparable to that of water absorption (Figure 2). The wicking rate is very high for minimesh compared to that for cotton sheet as seen from the data in Figure 3. This is due to the highly porous structure of the minimesh fabric.

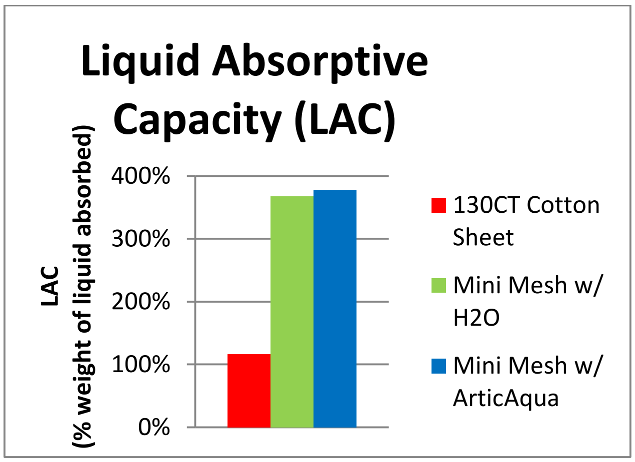


Figure 2. Liquid Absorption Capacity of Different Fabrics.

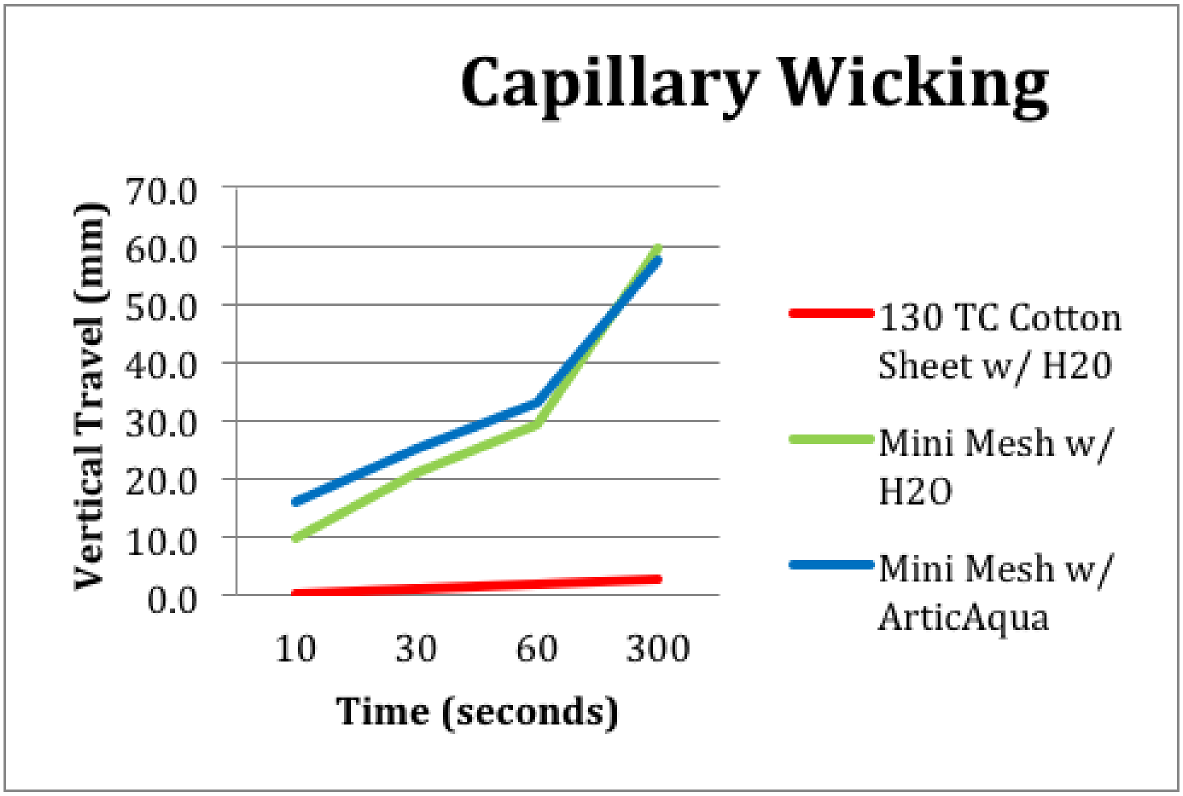


Figure 3. Capillary wicking rate of different fabrics.

Drying rate and cooling effect due to drying of wet fabrics are shown in Figures 4 and 5. Whereas overall drying rates are comparable for the two fabrics initially, the cotton sheet seems to lose all the moisture in a short time, whereas minimesh, probably due to higher moisture content to start with, continues to lose moisture in a controlled rate for a long time, even for two hours.

Cooling rate was measured by thermocouples placed on a glass plate and then placing the wet fabrics on them. The initial temperature in the chamber was ~41 C. As soon as the wet fabrics were placed on the plate the temperature dropped immediately by about 10 C (Figure 5). However, after about seven minutes, the temperature of the surface started going up with set sheet. The temperature was also increasing with minimesh saturated with water, although at a slower rate than that for sheet. The minimesh saturated with arctic aqua shows continuing cooling effect and even after 10min, the temperature does not go back up.

Similar measurements were done with samples chilled with ice water or in a freezer and the results are shown in Figure 6.

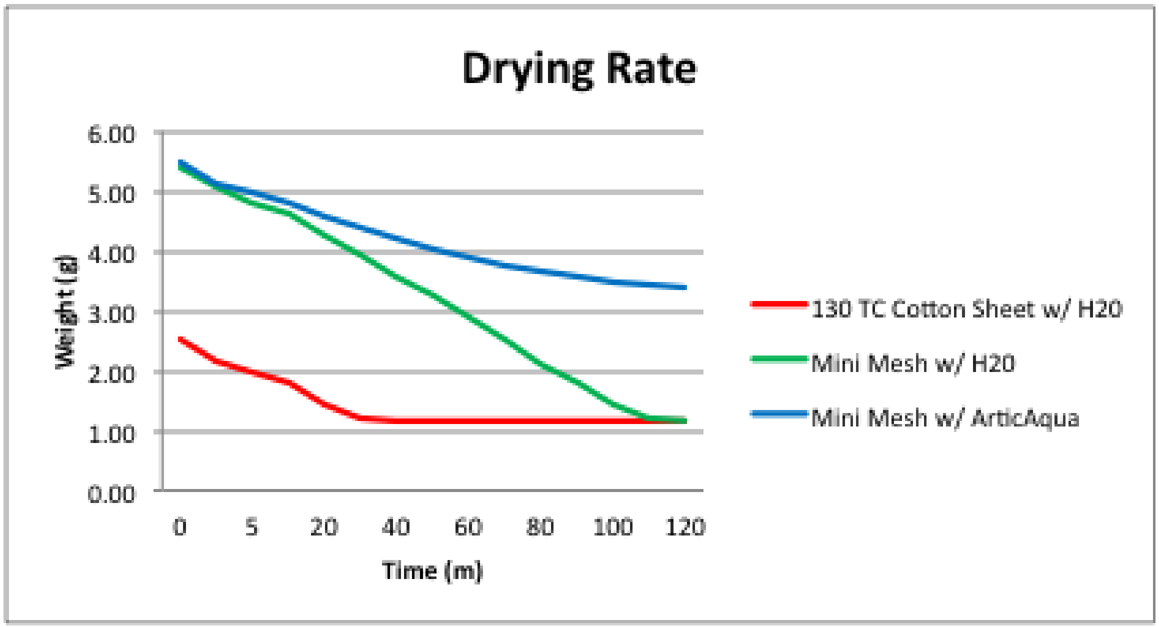


Figure 4. Comparison of drying rates of the samples.

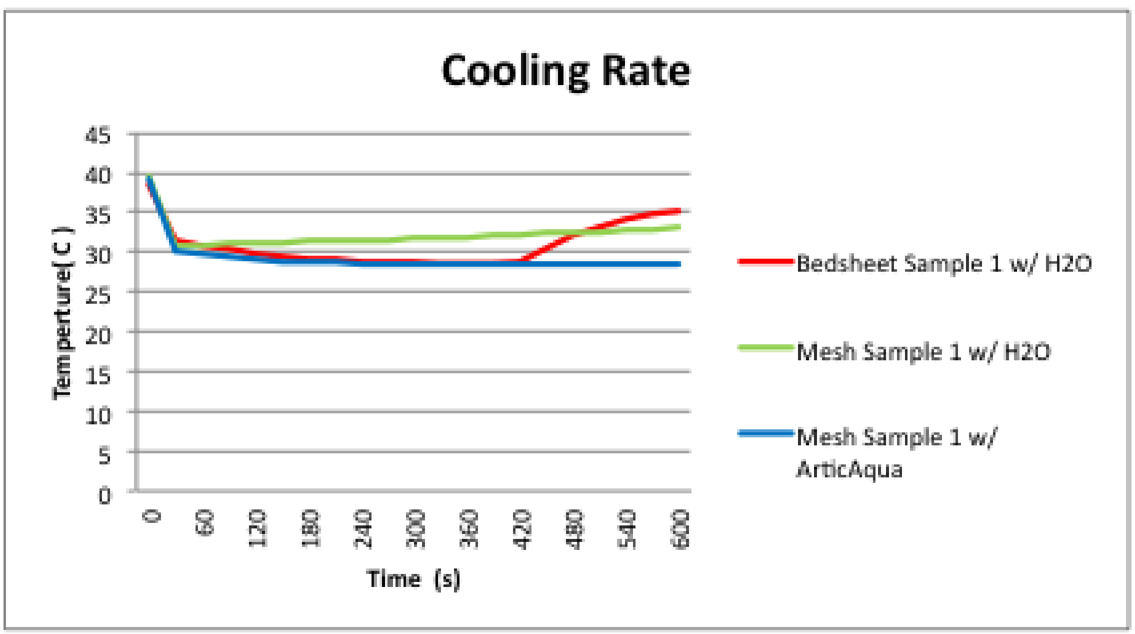


Figure 5. Cooling rate due to wet fabrics.

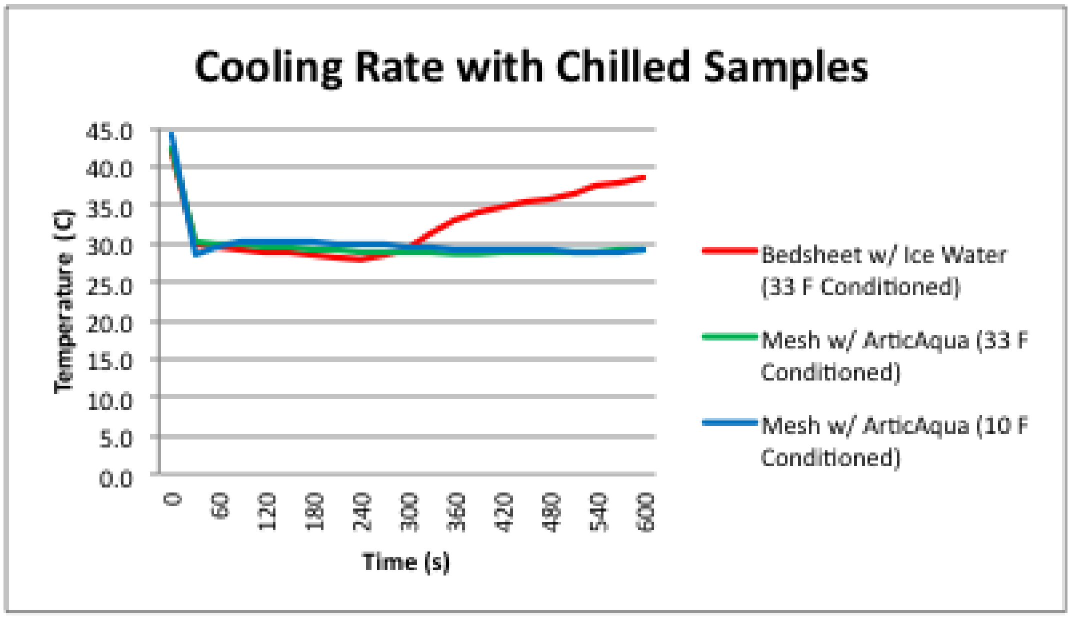


Figure 6. Cooling rate measured using chilled fabric samples.

MVTR Results

Results from MVTR are shown in table below. Mini Mesh shows about 15% higher MVTR values. This is consistent with the other observations and the structure of the two fabrics.

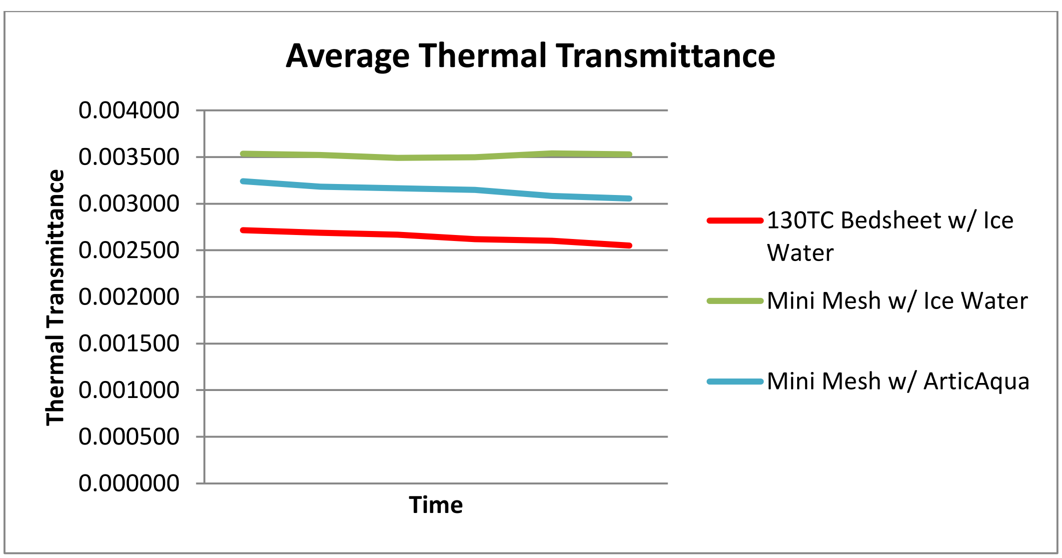
132 TC Sheet	1296
Mini Mesh	1480.8

Thermal Properties

Average Thermal transmittance for the fabrics are shown in the table below. The difference in thermal transmittance values between that of the sheet and mini-mesh are minimal when they are dry. However, the wet fabrics show a much higher difference between the two, with the minimesh showing significantly higher values.

Test	130 TC Cotton Sheet	Mini Mesh	130 TC Cotton Sheet w/ Water	Mini Mesh w/ Water	Mini Mesh w/ Artic Aqua
Thermal Transmittance W/m2· K	0.000968	0.000924925	0.0026450	0.0034890	0.0030380

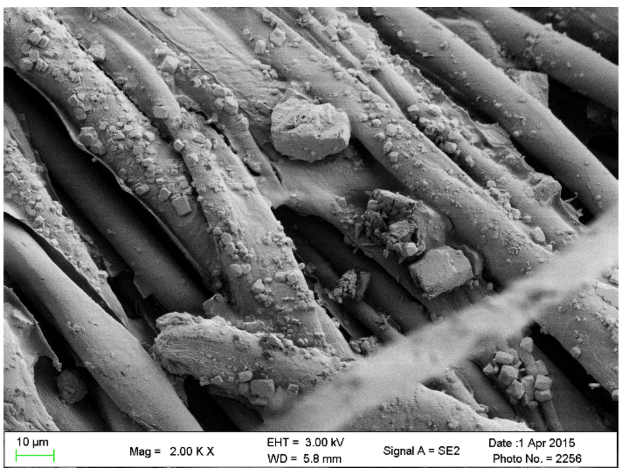
Further, thermal transmittance change with time during comparable use conditions are shown in the figure below. In this case the values were measured for a minute with a gap of 15 seconds in between. The graph reflects the changes taking place in the first 10 minutes. Since the fabrics were wet, it took ~2-3 minutes for temperatures to stabilize. After that, data were collected.



Structural differences between the fabrics

IT is understandable that the differences in the observed properties are due to some structural differences in the fabric. In addition to the differences in the materials used, the yarn and fabric structures contribute to the observed differences in the properties. To elucidate these SEM photographs of the tow fabrics were taken and are shown below. The images clearly show that the minimesh has porous structure with a lot of capillaries for liquid uptake and holding capacity, and the cotton woven fabrics have relatively tighter yarn structure.

Cotton Woven Sample SEM images at different magnifications.



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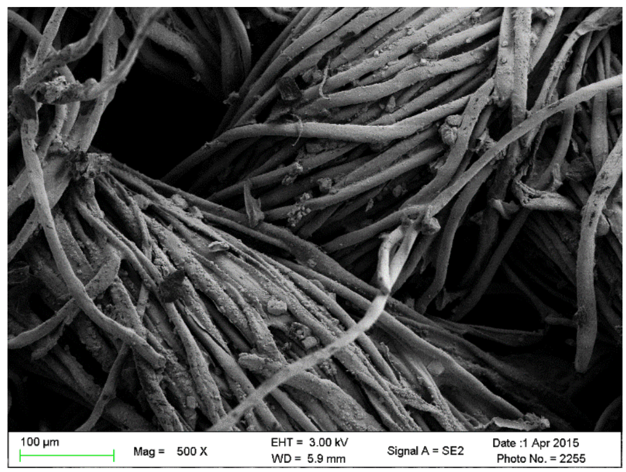
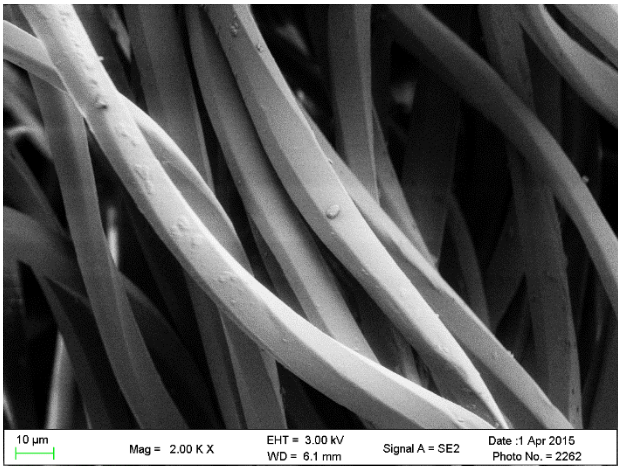


B

C

D

SEM Photographs at different magnifications for Mimi Mesh sample.



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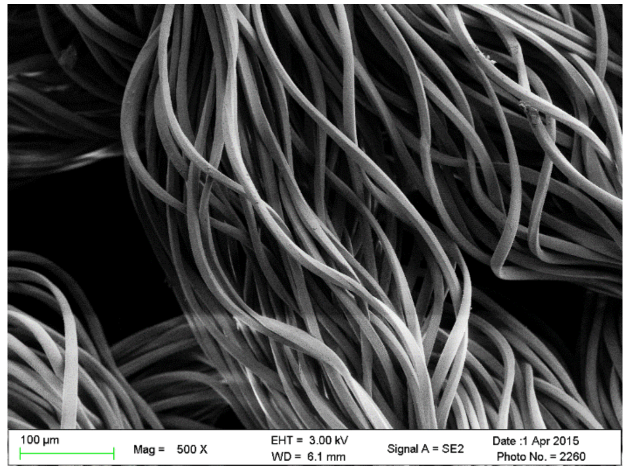

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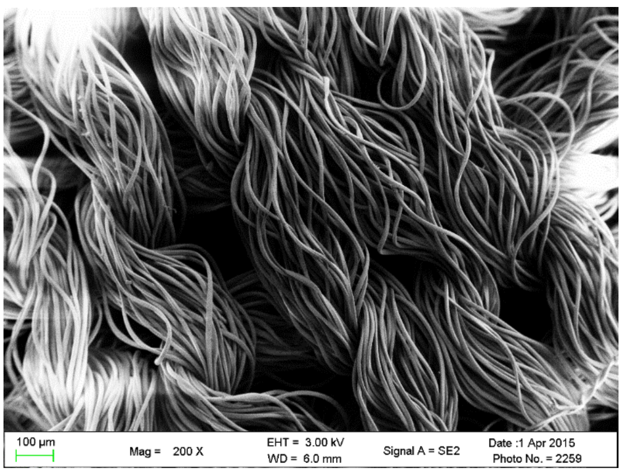

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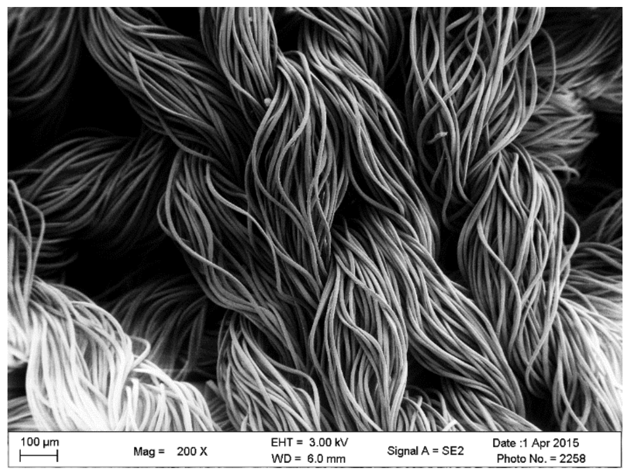

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