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Moisture management finish on woven fabrics

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Moisture management behaviour of four different woven fabrics, such as cotton, polyester/cotton blend, microdenier polyester and nylon, has been studied. A wetting agent of ethoxylated alcohol blend and moisture management finishing agents, such as amino silicone polyether copolymer and hydrophilic polymer, have been prepared and used. Moisture management finishes with wetting agent and without wetting agent are imparted onto woven fabrics. The effect of moisture management finishing process parameters on the comfort properties of woven fabrics has been studied. The optimization of comfort level by varying the moisture management finishing process parameters in order to achieve suitability for making sports wear is done. It is found that the type of fibre and linear density of yarn affect the comfort properties of woven fabrics which include wicking, wetting, water absorbency and moisture vapour transmission characteristics. Based on the test results, microdenier polyester fabrics and cotton fabrics exhibit good wicking, wetting and water absorbency characteristics than the polyester/cotton blend and nylon. It is found that the combination of ethoxylated alcohol (wetting agent) and the recipe containing amino silicone polyether copolymer and hydrophilic polymer in the ratio of 1:2 with *p*H of 5.5 at 60^0-70^0 C temperature is the optimum finishing process than the other two combinations so as to attain better comfort properties for sportswear.

Keywords: Cotton, Ethoxylated alcohol, Microdenier polyester, Moisture management finish, Nylon, Polyester, Water absorbency, Wicking, Woven fabrics

1 Introduction

Moisture management property is an important aspect of any fabric, which decides the comfort level of that fabric[1]. Every human being sweats during different kinds of activities. An important feature of any fabric is, how it transports water out of the body surface and makes the wearer feel comfortable. So moisture management can be defined as the controlled movement of water vapour and liquid water (perspiration) from the surface of the skin to the atmosphere through the fabric[2]. Wetting, wicking and moisture vapour transmission properties are the critical aspects of performance of products with moisture management finishes. Hence, wetting and wicking behavior of clothing have a practical significance in clothing comfort. The most important factor is fabric thickness, since it determines the amount of water (or perspiration) that can be absorbed. The drying time is thus dependant mainly on how much water is absorbed by a fabric; the thickness of fabric being one of the affecting factors[3]. Consequently, the drying time and the energy required to evaporate water from a wet garment depend on the amount of water absorbed and not on the fibre type. Knitted fabric has higher pores in its structure because of lower cover factor and hence shows good liquid transmission, better than the woven fabric. Yarns having more inter-fibre spaces (less twisted yarns) give wider diameter capillary. This will result poor wicking action[4]. A woven or knitted fabric can have desired properties such as insulation and fashion. Often these properties are not enough for daily use in bad weather conditions. Consumers have become much more demanding when it comes to the properties of clothing, particularly those of leisure and sportswear[5]. Nowadays, the fashion aspects play an important role in selection. Consumers also increasingly want clothing to be comfortable and fashionable. The fact is that there is an increasing demand for highly comfortable and fashionable modern sportswear clothing[6-8].

Wang *et al*.[9] showed that the moisture management property of fabrics are significantly affected by the moisture diffusion and temperature distributions. Oner *et al*.[10] observed that the polyester fabrics have

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higher overall moisture management content (OMMC) values than those of cellulosic-based fabrics. Bedek *et al.*[11] suggested that the fibre type, together with moisture regain and knitted structure characteristics appear to affect some comfort-related properties of the fabrics. Alam *et al.*[12] studied the moisture management property of hydrophobic micro-denier polyester fabric by applying moisture management chemical. The overall results show that the hydrophilicity was improved for treated fabrics. El Messiry *et al.*[13] studied the effect of surface treated fabric by applying microcrystalline cellulose (MCC) particles. They concluded that MCC particles adsorbed directly on the fabric surface gives superior improved fabric's wettability and moisture management than MCC coating on fabric surface. In this study, the wicking, water absorbency, wetting, moisture vapour transfer and air permeability of cotton, polyester/cotton, microdenier polyester and nylon have been tested and discussed. The effect of washing on moisture management finish to assess the finish stability is also studied.

2 Materials and Methods

Four types of yarns were taken as the raw materials, which were made of cotton, polyester/ cotton, microdenier polyester and nylon. The four types of yarn count (8.9 tex for cotton and polyester/cotton; 80 denier for microdenier polyester and nylon) were woven on power looms to produce fabrics (92 ends/inch and 84 picks/inch) with similar construction parameters.

2.1 Moisture Management Agents and Wetting Agents

Amino silicone polyether copolymer is used as a softener on textile materials giving durable soft handle to fabrics. It gives good water absorbency properties and improves wickability on woven and knitted fabrics. It is light yellow in appearance and has good *p*H stability in acidic regions. Hydrophilic polymer improves the wetting action and moisture absorbency on polyester fabrics thus enhancing wearer comfort. It has good durability and antistatic characteristics and interacts readily with water, imparting a hydrophilic finish to the fabrics. It is white in appearance. A synergetic blend of ethoxylated alcohol consists of fatty alcohol, ethylene oxide and propylene oxide are mixed in equal proportion. It is a medium foaming, scouring and wetting agent and has been designed for the pretreatment of cotton, polyester and blended fabrics. It is used for woven, knitted and terry towel fabrics. Fatty Alcohol is made of stearyl alcohol (1-Octadecanol) with 18 carbon atoms made from natural vegetable oils. It gives a powerful detergent activity during medium foaming. It contains excellent washing property and is non toxic and biodegradable. Ethylene oxide (C_2H_4O) is produced with ethylene and oxygen reacting on a silver catalyst at 200^o-300^oC. It is highly reactive in the presence of water and alcohols. It acts as a intermediate in the manufacture of surfactants and detergents. The process of manufacturing surfactants and detergents from ethylene oxide is called "ethoxylation". Propylene oxide is an organic chemical in a colourless liquid form. It is highly reactive in nature and acts as a useful intermediate in the manufacture of surfactants used in textile fabrics. All the above three chemicals were mixed together in equal proportion to produce ethoxylated alcohol. The process of blending the different chemicals is called "ethoxylation". It is hazy gel in appearance and acts as a powerful detergent.

Four types of woven fabrics were taken as the raw materials which are made of cotton, polyester/cotton, microdenier polyester and nylon. Cotton and polyester/cotton blend fabrics were desized, scoured and bleached, while microdenier polyester and nylon fabrics were hot washed and bleached. The four fabric samples were then coated with a wetting agent (2% concentration) for 30 min at 60^0-70^0 C. After the wetting process the four variety of fabrics were cut to make two sets of samples. Each set of samples was treated for moisture management finish with different recipes. The first set of samples was treated with amino silicone polyether copolymer with a *p*H value of 5.5 at 70^0 C. The second set of samples was treated with a chemical combination of amino silicone polyether copolymer and hydrophilic polymer in the ratio of 1:1 with *p*H value 5.5 at 70° C. The fabrics were padded using a padding mangle and dried in a hot air chamber. After drying, all the fabric samples were tested for wicking, water absorbancy, wetting, moisture vapour transmission rate and air permeability.

2.2 Finishing Treatment

Cotton and polyester/cotton blend fabrics were desized, scoured and bleached while microdenier polyester and nylon fabrics were hot washed and bleached. After the preparatory processes for four types of fabrics, the following two different techniques were adopted for the development of moisture management finish, viz (i) moisture management finish with wetting agent (ethoxylated alcohol) and (ii) moisture management finish without wetting agent.

2.3 Application of Moisture Management Finish with and without Wetting Agent

The four fabric samples were first prewashed and coated with a wetting agent consisting of a synergetic blend of ethoxylated alcohol (2% concentration) for 30 min at 60^0-70^0 C. After this wetting process, the four varieties of fabrics were cut to make three sets of samples. Each set of samples was treated for moisture management finish with different recipes. The first set of samples was treated with a chemical combination of amino silicone polyether copolymer (ASPC) and hydrophilic polymer (HP) in the ratio of 1:1 with a *p*H value of 6 at 70^0 - 80^0 C. The second set of samples was treated with a chemical combination of ASPC and HP in the ratio of 1:2 with *p*H value of 5.5 at 60^0-70^0 C. The third set of samples was treated with a chemical combination of ASPC and HP in the ratio of 1:3 with *p*H value of 7.0 at 90^0 - 100^0 C. Each set of samples was treated in the finishing bath and padded using a padding mangle. The fabric samples were then dried in a hot air chamber.

In the second part of this research work of moisture management finish without wetting agent, the fabrics were taken and devided into three sets. These samples were directly treated for moisture management finish with the three different recipes as mentioned above. The padded samples were dried in a hot air chamber.

2.4 Testing

After drying, all fabrics, (treated with and without wetting agent) were tested for their moisture management properties.

2.4.1 Vertical Wicking Test (BS 3424)

A 10 × 2 cm strip of test fabric was suspended vertically with its lower end (2cm) immersed in a reservoir of distilled water for tracking the movement of water. In this method, the wick-up action of water spreading by capillary action was observed after five min during at which the water moved upward on a strip of fabric.

2.4.2 Water Absorbency Test (AATCC 79:2000)

The water absorbency test was done to measure the ability of the fabric to absorb water by spreading action. A fabric sample of size 20 X 20 cm was taken. A drop of water was allowed to fall on the flat fabric surface. Area has been kept constant for finding out water spreading in seconds. The height of water drop is controlled by a syringe, which contains 1 mL of water. The absorption and spreading of water on any material increases when the resistance to water flow is low.

2.4.3 Wetting Test (Sinking Method)

This property was evaluated by measuring the time required for a piece of fabric to sink completely from the surface layer of water in a beaker. The fabric was measured by cutting a sample of 3 × 3 cm and placing it on the surface layer of water. The time taken for the sample to sink completely in water was measured. The samples were dropped on the surface of distilled water from a standard height and the time taken to sink the specimen in water was noted. This reading varies according to the way and pressure of putting the fabric. So utmost care has been taken for putting the fabric into water in a horizontal form.

2.4.4 Moisture Vapour Transfer Test (ASTM E 96-Cup Method)

Moisture vapour transmission rate (MVT) is the speed or rate at which moisture vapour moves through a fabric. The ASTM E 96 moisture vapour test (open cup test) was used for measuring the moisture vapour transmission rate. The rate of water vapour that passes through the fabric was determined by two different methods (reduction in the height of water in the cup and reduction in the weight of water in the cup).

3 Results and Discussion

The findings for wicking, water absorbency, wetting and moisture vapour transfer tests are discussed hereunder.

3.1 Wicking Characteristics

The rate of water spreading through capillary action for four different woven fabrics through wicking test are shown in Figs 1(a) and (b) for both with and without wetting agent. It is observed that microdenier polyester shows 30% higher wicking rate. The water drop spreading area is more in microdenier polyester than in cotton and polyester/ cotton blend. Nylon fabric exhibits poor wicking. This is due to more number of fibres in the cross-section. The gap between the filaments inside the core of yarn is very less. Due to this, the rate of water spreading by capillary action is more. The same trend is shown by the samples of moisture management finish without the wetting agent. The treated samples show 100% higher test results than untreated samples. The fabrics

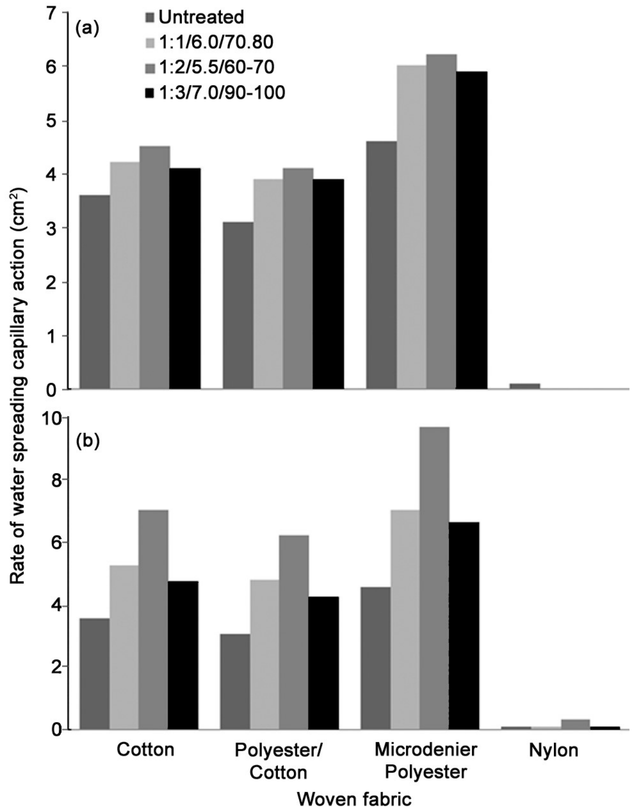

Fig. 1 — Wicking test (a) without wetting agent (b) with wetting agent for different fabrics

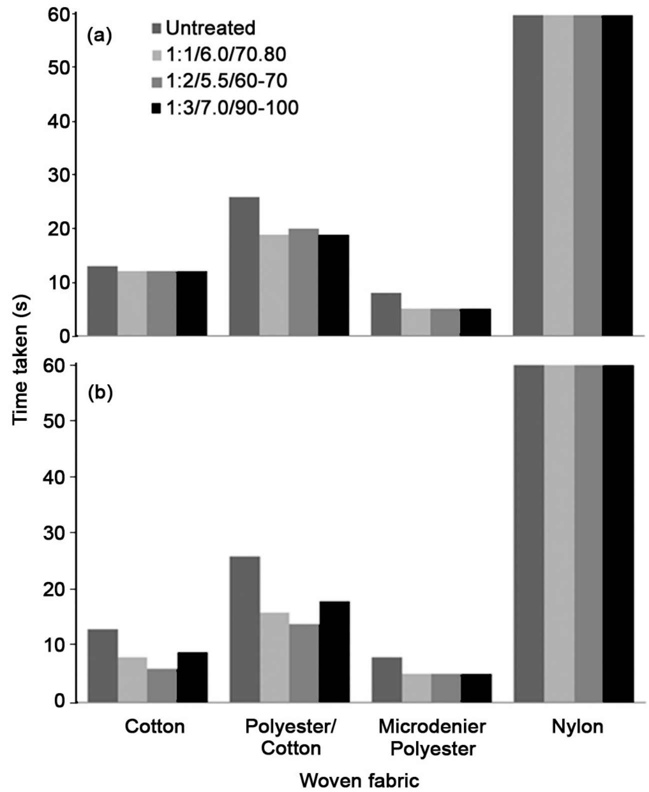

Fig. 2 — Water Absorbency test (a) without wetting agent (b) with wetting agent for different fabrics

coated with wetting agent give 50% higher test results than fabrics treated without wetting agent.

The effects of three different recipe combinations for four different woven fabrics in testing wicking characteristics are shown in Figs 1(a) and (b) for both with and without wetting agent. Among the three recipes used, it is observed that ASPC and HP (1:2) gives 30% higher wicking rate than the other recipe samples. The *p*H range must be kept between 3.5 and 6.5 generally. The middle value of *p*H range (5-5.5) may be the optimum value. Hence, it shows higher value than other two recipes. In both with and without wetting agent samples, the same trend is observed. The fabrics coated with wetting agent gives 15% higher wicking results than the fabrics without wetting agent. This may be due to the detergent activity of the wetting agent.

3.2 Water Absorbency Characteristics

The time taken to sink the fabric samples in water for four different woven fabrics through water absorbency test are shown in Figs 2(a) and (b) for both with and without wetting agent. It is seen that microdenier polyester exhibits 20 % higher water absorbency than cotton. The time taken to absorb water by polyester/cotton blend is found three times more than that by microdenier polyester. When the capillary action is more, the area covered by water drop spreading is also more and hence the time taken is also less. As like wicking behavior, microdenier polyester shows same results. Nylon shows very poor absorbency. In both with and without wetting agent samples the same trend is observed. Compared to untreated samples, the treated samples exhibit 60% higher test result. The same trend is followed by fabrics treated without wetting agent. The time taken to absorb water by fabrics without wetting agent is two times more than the fabrics coated with wetting agent.

On comparing three recipes, it can be seen that ASPC + HP (1:2) gives a 30% faster water absorbency followed by ASPC + HP (1:1) and ASPC + HP (1:3). In the samples without wetting agent, there is no appreciable difference between the three recipes. In the fabrics coated with wetting agent, the absorbency is 60% faster than the fabrics without wetting agent. This is due to the detergent activity of the wetting agent.

3.3 Wetting Characteristics

The time taken to sink the fabric samples in water for four different woven fabrics through wetting test are shown in Figs 3 (a) and (b) for both with and without wetting agent. It is observed that microdenier polyester takes the least time to sink in water. The time taken to sink the other samples is two and five times more in case of cotton and polyester/cotton blend respectively as compared to microdenier polyester. Nylon takes an unduly long time to sink. Even though the construction parameters like EPI, PPI, warp count and weft count are similar, due to more water absorbancy and faster capillary action, microdenier polyester sinks within a short time as compared to other specimens. A similar trend is seen in the fabrics without wetting agent also. Compared to untreated samples, the test results for treated samples show 100% higher results. The fabrics coated with wetting agent take only half the time to sink in water as compared to fabrics without wetting agent. It is observed that among the three recipes samples ASPC + HP (1:2) takes only 30 min time to sink than ASPC + HP (1:1) and ASPC + HP (1:3). This may be due to the *p*H 5.5 and temperature of 60^0 - 70^0C, which act as an optimum value as in wicking results. The fabrics with wetting agent take lesser time to sink than the fabrics without wetting agent.

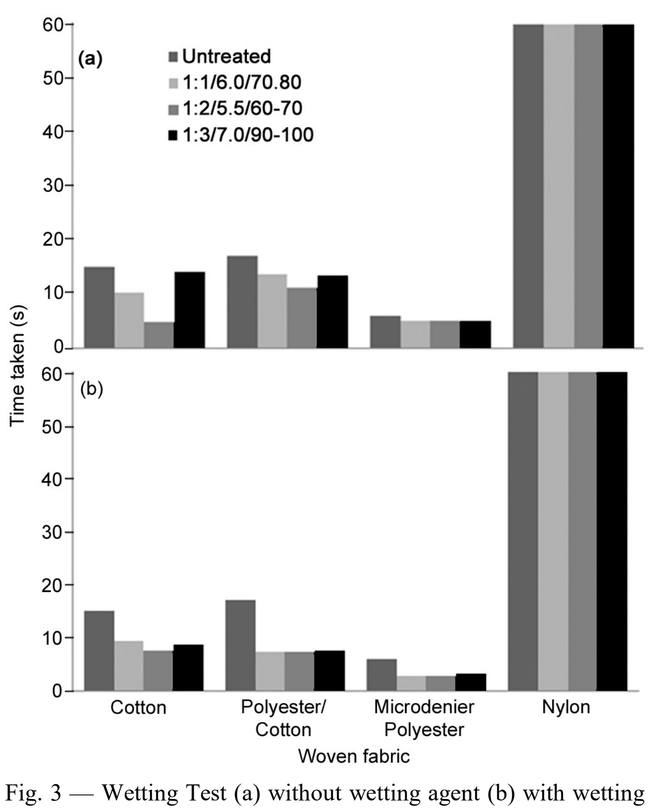

Fig. 3 — Wetting Test (a) without wetting agent (b) with wetting agent for different fabrics

3.4 Moisture Vapour Transmission Rate

The rate at which moisture vapour transfers for four different woven fabrics through MVT height test are shown in Figs 4(a) and (b) for both with and without wetting agent. Figures 4(a) and (b) show that cotton and microdenier polyester have same MVT rate and it is followed by polyester/cotton and nylon respectively. This is due to higher water absorbency of cotton and microdenier polyester. Due to the high porosity nature of cotton and microdenier polyester, the MVT rate is higher. The treated fabrics exhibit 50% increase in height reduction than that of untreated fabric samples. The same trend is followed by fabrics treated without wetting agent. But the fabrics coated with wetting agent give 35% higher water reduction than the fabrics without wetting agent.

The effect of three different recipe combinations for four different woven fabrics in testing MVT rate are shown as a graph in Figs 4(a) and 4(b) for both with and without wetting agent. Among the three recipes, ASPC + HP (1:2) gives 50% increase in height reduction than other two recipes samples. ASPC + HP (1:1) and ASPC + HP (1:3) show similar

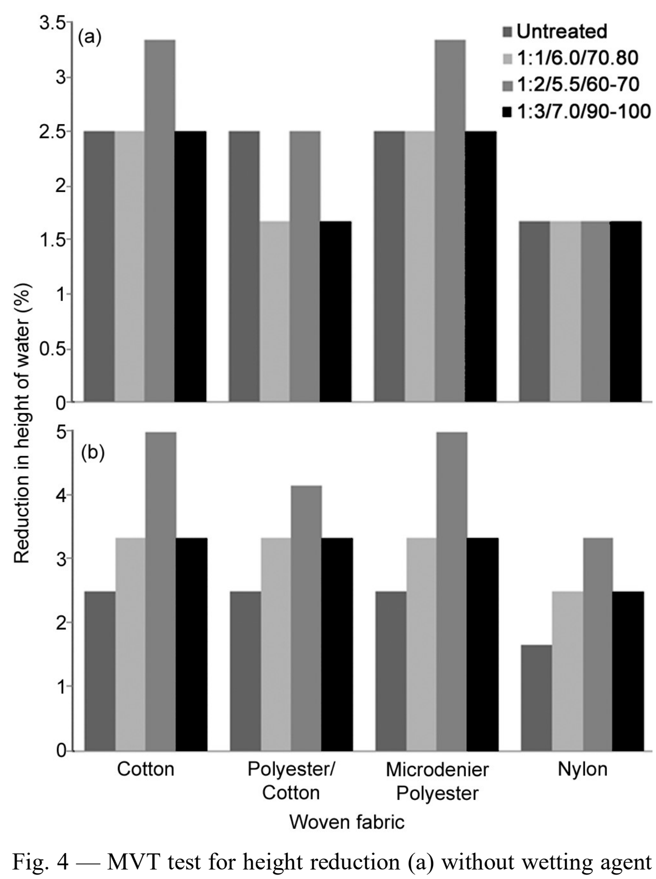

Fig. 4 — MVT test for height reduction (a) without wetting agent and (b) height reduction with wetting agent for different fabrics

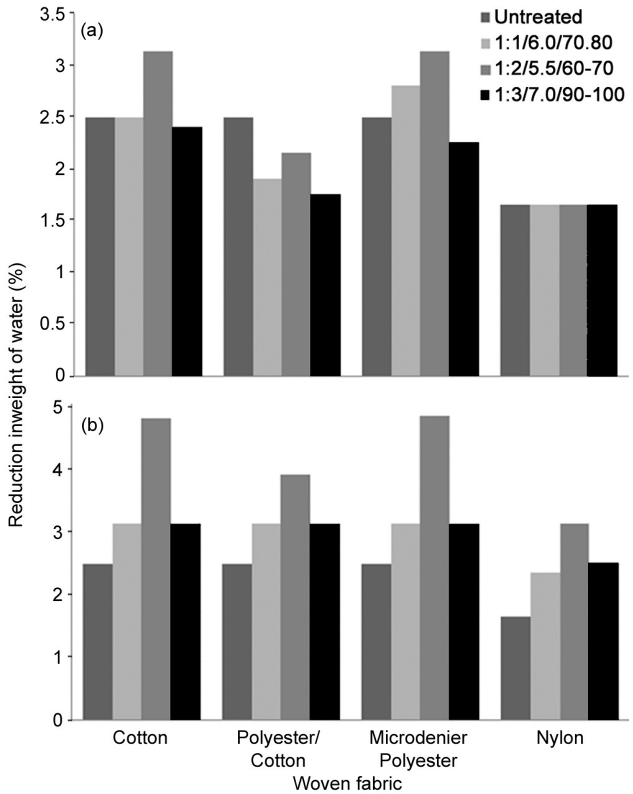

Fig. 5 — MVT test for reduction in weight (a) without wetting agent (b) with wetting agent for different fabrics

readings. This may be due to the powerful detergent activity of the wetting agent. In the height reduction, both the fabrics (with and without wetting agent), show more or less the same trend. The fabrics coated with wetting agent gives 35% more height reduction than fabrics without wetting agent.

The rate at which moisture vapour transfers for four different woven fabrics through MVT weight test are shown in Figs 5(a) and 5(b) for both with and without wetting agent. Cotton and microdenier polyester show same MVT rate and it is followed by polyester/cotton and nylon respectively. This is due to higher water absorbency of cotton and microdenier polyester. Due to the high porosity nature of cotton and microdenier polyester, the MVT rate is higher. The same trend is followed by fabric treated without wetting agent.

Figures 5(a) and 5(b) show that cotton and microdenier polyester show same MVT rate and it is followed by polyester / cotton and nylon respectively. But the fabrics coated with wetting agent give 35% higher water reduction than fabrics without wetting agent.

It is observed that around 50% more MVT rate is observed in ASPC + HP (1:2) than other recipes. This trend is the same in both with and without wetting agent samples. But the fabric with wetting agent exhibits 50% more MVT rate than the sample without wetting agent. This may be due to the powerful detergent activity of wetting agent.

4 Conclusion

The findings obtained from 28 samples treated with and without wetting agent are given below:

4.1 A suitable moisture management finishing agent for textile materials has been developed. Amino silicone polyether copolymer and hydrophilic polymer are used as moisture management finishing agents.

4.2 A suitable wetting agent of ethoxylated alcohol has been developed for the moisture management finishing process.

4.3 Moisture management finish has been imparted to four different woven fabrics such as cotton, polyester/cotton, microdenier polyester and nylon.

4.4 Microdenier polyester and cotton are found good in wicking, water absorbency, wetting and moisture vapour transfer .

4.5 It is also observed that among wicking, water absorbency, wetting and moisture vapour transfer tests, the effect of wetting agent is significantly better than that of fabrics treated without wetting agent.

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