MAPP® MERINO FIBRE ATTRIBUTES AND BENEFITS

TEMPERATURE INTELLIGENT

MAPP Merino Fibre is temperature intelligent and assists the wearer in maintaining a comfortable temperature in many conditions. In brief, MAPP Merino Fibre:

- Buffers the body's micro-climate in changing conditions
- Releases heat as it absorbs moisture
- Effectively dissipates body heat and enhances the body's natural cooling system

This document provides background and scientific grounding on the above attributes and benefits of Merino fibre. The concepts discussed in this paper include:

- Water absorption and the structure of the wool fibre
- Heat of sorption
- Cooling by evaporation
- Water-vapour transmission
- The interaction of fabric and its wearer

Water Absorption and the Structure of the Wool Fibre

The chemical building blocks of the wool fibre, amino acids, are hydrophilic (water-liking), meaning that they attract and absorb water molecules into the chemical structure of the fibre. Water binds within wool's structure through the action of hydrogen bonds in a process known as absorption (Leeder, 1984). The water enters the amorphous region of the intercellular cement and the matrix of the fibre within the fibre cortex (see Figure 1), where pore diameters are as small as 4 nm (Kerr, Dawley et al., 1995).

Wool has the highest water absorbing potential or 'regain' of all the natural fibres although this can vary depending on the chemical treatments the wool has been subjected to, for example chlorination (Onions, 1962). The ability to absorb moisture is an important functional attribute of wool, but perhaps more important is wool's ability to shed moisture. This arises as the hydrogen bonds that bind the water molecules are reversible; water can be shed in a process known as desorption.

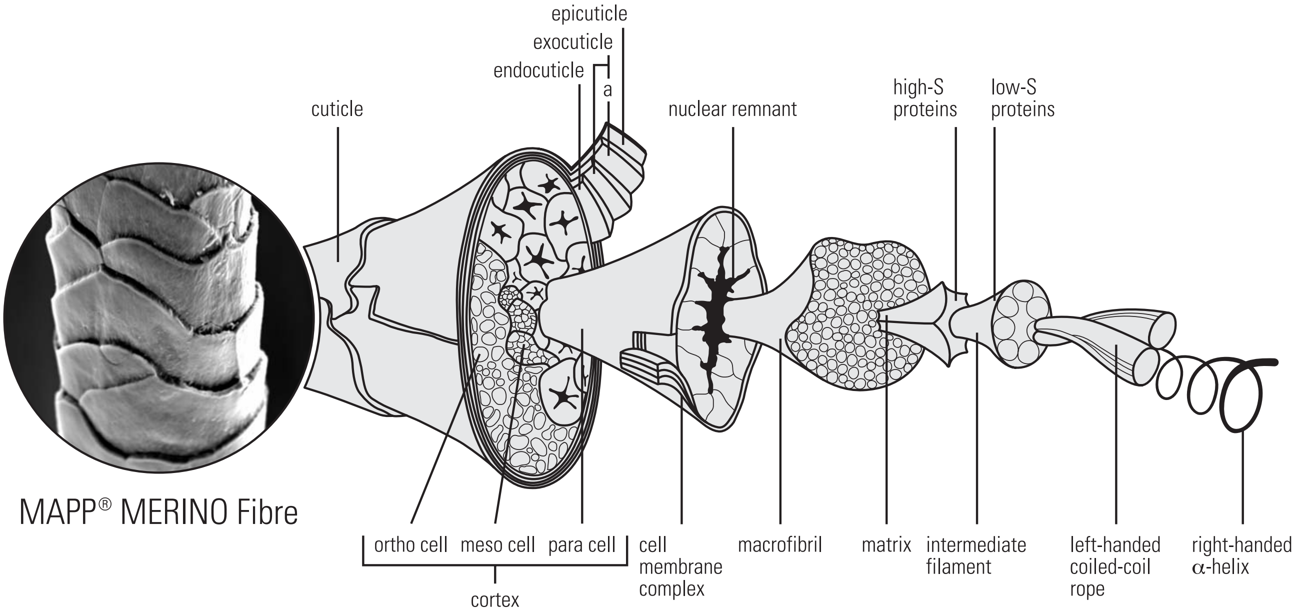

Figure 1. Exploded view of the various structural units of the wool fibre (Source: WRONZ, 2001).

Heat of Sorption

The hydrogen bonds that bind water within wool's structure have another important practical function within the context of wool garments; the interaction of hydrogen bonds with water is a chemical reaction. This reaction generates heat when water is bound (absorption) and takes up heat during moisture loss (desorption) (Leeder, 1984). This ability to absorb the water into the chemical structure of the fibre prevents the fabric from feeling wet or clammy (Leeder, 1984). In comparison, man-made fibres may only absorb moisture up to 5% of their weight at the same humidity (Leeder, 1984).

These moisture absorption and desorption characteristics provide important functional characteristics to wool garments. For example, when a wool fabric experiences a sudden change in the environment associated with its wearer, such as increased activity leading to sweating, wool acts as a buffer, absorbing the extra moisture quickly and dissipating it gradually (Leeder, 1984). The same occurs for the external environment where wool acts as a buffer to changes in atmospheric humidity (Onions, 1962). As a result, wool can prevent the 'clamminess' that can occur in environments of high humidity (Collie and Johnson, 1998).

All fibres do this to some degree but wools performance is superior (see Figure 2) and in typical winter conditions can provide real benefits to the wearer (Collie and Johnson, 1998).

Another practical example of the absorption/desorption characteristic is that in cold climates the relative humidity indoors in winter is generally lower than outdoors. Wool garments conditioned (equilibrated) to a drier indoor environment immediately begin producing heat when taken outdoors, buffering the wearer against the sudden temperature drop they experience (Anon). On exposure to a saturated atmosphere, the heat produced by a kilogram of dry wool as it takes up 35% water vapour is about 960 kJ, equivalent to the heat output from an electric blanket over 8 hours. This effect occurs quite quickly, typically in the first 2-5 minutes and then decreases until the moisture content of the wool reaches equilibrium with the higher relative humidity of the atmosphere (Anon).

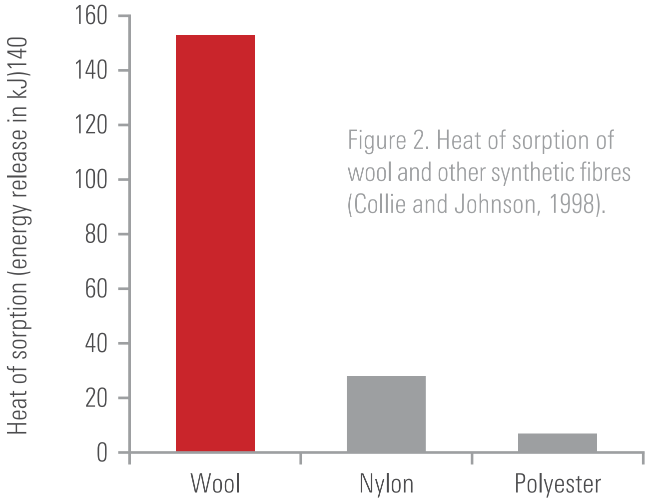

Figure 2. Heat of sorption of wool and other synthetic fibres (Collie and Johnson, 1998).

Cooling by Evaporation

Human performance can potentially be affected by the extent to which sweat is vapourised and the vapour released from the garment microclimate (and hence the effectiveness of body cooling) (Laing and Sleivert, 2002).

When water evaporates from a surface the surface cools, as heat is expended from the surface to the water to change the water from a liquid into a vapour form. The latent heat, that is the heat absorbed by the water as it changes state, contains a considerable amount of energy and carries away more heat than if the same temperature liquid was simply removed physically (Benisek et al., 1987).

We all experience cooling by evaporation every day. The human body utilises cooling by evaporation, through the evaporation of sweat from the skin surface, to cool itself – it is not the sweat itself that cools us, but the action of the sweat being evaporated from our skin. As sweat evaporates from skin, the skin temperature is lowered as heat energy is transferred from neighbouring tissue to the sweat to allow it to change state from liquid to gas (vapour); the water molecules in the sweat draw energy, in the form of heat, from the body tissue. The majority of the heat energy in this process is drawn from the body as the thermal conductivity of human tissue is much better than that of the surrounding air.

To provide its maximum cooling efficiency evaporation should occur within or at the skin surface and perspiration transferred through clothing in vapour form only (Benisek et al.,1987). The structure of wool fibre assists in the body's natural cooling mechanism of perspiration evaporation at the skin surface by preferentially encouraging the transmission of perspiration in vapour rather than liquid form (Benisek et al.,1987).

Heat transmission or dispersal can be scientifically assessed by measuring fabric surface temperature. In the study by Pessenhofer et al., (1991), fabric surface temperatures were higher for wool, indicating improved heat dispersal characteristics, while measures of retained heat were significantly lower for wool than for polypropylene. When assessed subjectively, subjects involved in the investigation gave more positive responses to garment comfort questions with respect to wool than they did for polypropylene (Pessenhofer et al.,1991).

Water-Vapour Transmission

With respect to the control of body temperature, a fabric's ability to allow moisture to pass through it is critical to maintaining comfort, especially when the wearer is participating in athletic activity. For example, under resting conditions the body may lose 0.5 litres of water through perspiration each day, however during strenuous exercise, this can increase to up to 1 litre per hour. As a result, if free transmission of moisture is not allowed, moisture builds up against the skin creating wetness or clamminess for the wearer. However, wool has similar moisture absorption capacity to skin and so can act as a buffer. In comparison, synthetic fibres absorb water less effectively and keep moisture against the skin (Leeder, 1984), reducing garment comfort.

Additionally, wool fabrics are porous/lofty/bulky, and hence provide an improved physical avenue for moisture transmission. This can be further enhanced by movement of the wearer which causes a 'pumping' of air close to the skin through to the outside of the garment both through the fabric itself, but also through openings at collars and sleeves etc (Leeder, 1984).

The Interaction of Fabric and its Wearer

To enable prolonged efficiency in sporting activities, two factors are important (Pessenhofer, Kohla et al. 1991);

- Energy supply (which can be optimised by appropriate training); and,
- Emission of heat to the surroundings (which must be ensured by suitable sportwear).

One of the main tasks of sportswear is to support the thermoregulation of the athlete by promoting evaporative heat transmission (Pessenhofer, Kohla, et al. 1991). The heat budget of the wearer during physical activity can be balanced only by the evaporation of sweat, the most efficient form of evaporative heat transmission. Prevention of heat emission causes a build up of heat in the athlete, leading to rises in core body temperature and contributing to the cessation of physical activity due to exhaustion.

The temperature of clothing fabrics is typically between that of the environment and that of the skin. As a result, if fabric touches skin, a momentary drop of temperature will occur. The skin has nerve endings that will detect even minute or brief temperature changes, and the intensity of the coolness felt by the wearer will depend on how well the fabric conducts heat away from the skin (Anon.).

Achievement of higher stress by athletes in wool garments than by those in polypropylene garments indicates that aerobic performance capacity, that is the supply of energy through the oxidation of nutrients, is available to a greater extent in the wool clothing. The cumulative result is that the body can shed more heat when wearing wool than when wearing nonhygroscopic

Fibres such as polyester (Li Holcombe et al. 1994). This can be important in sporting competition, where only slight differences in time and performance can be extremely important in terms of outcomes (Pessenhofer, Kohla et al. 1991).

Wool also exhibits favourable dynamic adaptation to the flow of heat from the athlete to the environment. This is possibly due to the loading of the fibre with moisture from the massive generation of sweat that takes place following the commencement of high-load activity (Pessenhofer, Kohla et al. 1991)

References

Anon. Wool for Comfort. Benefits of moisture absorbency in wool knitwear.

Benisek, L., Harnett, P.R. and Palin, M.J. (1987). The Influence of Fibre and Fabric Type on Thermophysiological Comfort. 13th Joint Meeting of the Textile Research Insitutues, Aachen.

Collie, S. R. and N. A. G. Johnson (1998). The benefits of wearing wool rather than manmade fibre garments. Lincoln, Christchurch, New Zealand, WRONZ.

Kerr, N., C. Dawley, et al. (1995). A Comparison of the effects of microorganisms and freezing on the degradation of wool. Biodeterioration and Biodegradation 9. A. Boucher, M. Chandra and E. G. Edyvean, Institute of Chemical Engineers: 96-100.

Laing, R.M. and Sleivert, G.G. 2002. Clothing, textiles and human performance. Textile Progress, 32(2): 1-132

Leeder (1984). Comfortable Wool. Wool - Nature's Wonder Fibre, Australasian Textiles Publishers. Chapter 5: 24-31.

Li, Y., B. V. Holcombe, et al. (1994). "Wool for Comfort. The influence of fibre hygroscopicity on the dynamic comefort performance of clothing." Textile Asia(June): 57-60.

Onions (1962). Wool. An Introduction to its Properties, Varieties, Uses and Production., Interscience Publishers: 46-63.

Pessenhofer, H., B. Kohla, et al. (1991). Influencing energy readiness and thermal regulation of humans during physical stress on a bicycle ergometer by clothing made form various textile materials. Graz, Austraia, Physiologiches Institut, Karl-Franzens Universitat.

WRONZ (2001). Wool fibre structure and function (Module 1). Introduction to wool and the wool industry. Lincoln, New Zealand, WRONZ. Module 1.