# Odour and Toxics Absorption

**Wool's unique structure and moisture absorption properties make it naturally resistant to the build up of body odours. Its complex chemical structure also allows it to bind harmful toxic agents from air such as those associated with sick building syndrome, with little or no re-emission of the vapours.**

## Odour Absorption

Sweating is a natural way that the human body regulates its temperature in response to hot conditions or strenuous exercise, and some people naturally sweat more than others. The body continuously secretes moisture through sweat glands (about 3,000,000 of them) all over its surface and this sweat would normally evaporate quickly. Sweat itself has no odour, but if it remains on skin for a few hours, bacteria develop and often lead to body odour.

Many extreme athletes with long term uses for clothing such as mountaineering have reported far less odour build-up using wool garments than with man made fibres, especially for wear close to the skin. Companies specialising in active outdoor wear are using the natural attributes of wool such as moisture absorption, comfort and breathability, but also its odour control and absorbing properties to provide a range of high performance layered products that can be used from next-to-skin wear through to outerwear.

Figure 1. Synthetic jumper & woollen jumper.

There are several different ways that wool prevents and controls the development of body odours, and these depend on both the unique chemistry and the physics of the wool fibre.

Natural fibres such as wool, because of their moisture absorbing properties, allow the skin to 'breathe'. This removes moisture from the skin surface, as opposed to synthetics which do not have these moisture absorption properties. This moisture is taken up inside the wool fibre, making the conditions on the skin surface less favourable to bacterial action.

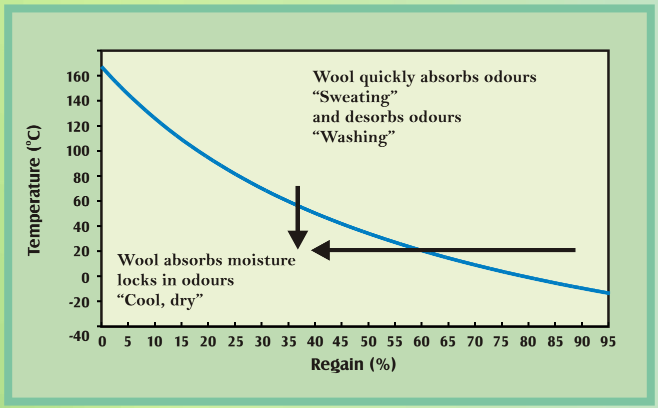
The fibre surface is hydrophobic and cannot be penetrated by bacteria; water bound within the fibre is not available for microbes to utilise, and wool provides a poor environment for growth of bacteria.

The wool scale structure on the fibre surface makes the surface uneven and difficult for microbes to attach to it. There is some evidence that the fibre surface exposed by loss of scale-edge material has an anti-bacterial effect.

The very outer layer of the epicuticle has a high concentration of a unique C21 fatty acid bound to the surface and there is speculation that this bound acid layer has anti-bacterial properties.

Wool has a complex internal chemistry that potentially allows it to bind acidic, basic and sulphurous odours. These are important components of body odour.

In high humidity conditions and in water, wool passes through a glass transition that dramatically increases its rate of absorption and desorption as shown in graph 1. The synthetics do not show these effects in water and under normal wear conditions.




Graph 1. Wool absorption and desorption.

If skin is in a hot and sweaty state, wool absorbs the moisture and this may cause it to exceed the glass until it exceeds the glass transition temperature. At this point the rate of diffusion of small and large molecules into the wool fibre increases and it absorbs odour faster. When the body cools down, and the moisture evaporates, the fibre falls below the glass transition curve and the rate of diffusion slows. The fibre effectively 'traps' the odours. When the garment is laundered, even under mild conditions, the temperature of the wash water will be sufficient to allow the fibre to again pass through the glass transition, increasing the rate of diffusion and releasing the odour molecules from the fibre into the water. The odour components are washed away.

Even before washing, wear trials have shown that wool socks were preferred for lack of odour after wear, especially when compared with synthetics, in conditions ranging from sedentary to sporting activity. Odours are prevented from developing, and when they do form, they are trapped in the fibre. After washing, wool socks also were perceived to retain fewer odours even though the wash conditions were cooler than for other fibres. The water sensitive glass transition ensures release of trapped odours.

Figure 2. Wool Socks

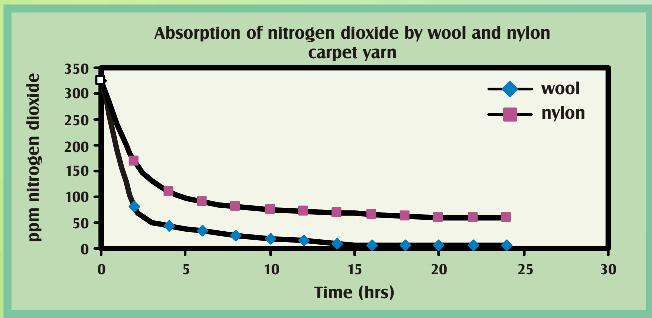
## Absorption of indoor air pollutants

Indoor Air Quality (IAQ) is affected by many things including outdoor air quality, people and their activities, heating and ventilation, building materials, finishes, furnishings and floor coverings. Air contaminants, particularly VOC (Volatile Organic Compounds), can be generated by many indoor sources.
Wool is a natural protein made up of 18 amino acids. It has a complex physical and chemical structure, and 60% of the amino acids have reactive side chains. This complex chemistry provides wool with the ability to bind with several toxicants in air.
Three important pollutants cited as health hazards in air are sulphur dioxide ($SO_2$), formaldehyde and nitrogen dioxide ($NO_2$). Sulphur dioxide and nitrogen dioxide are by-products of combustion processes involving fuels such as petroleum products and coal, and are produced by domestic appliances, open fires and vehicle exhausts.

## Nitrogen dioxide

Studies have shown that the presence of wool carpet can have a significant effect in reducing concentrations of nitrogen dioxide. Comparison of wool and nylon carpets showed rapid initial absorption of nitrogen dioxide, with the wool showing improved uptake at varying concentrations. However, upon heating, the nylon carpet re-emitted twice as much $NO_2$ as the wool carpet.

Testing using the carpet yarn only, removing any absorption effect from backing materials, found the sorption by the wool carpet yarn resulted in a 12 times lower concentration of $NO_2$ when compared with nylon yarn.



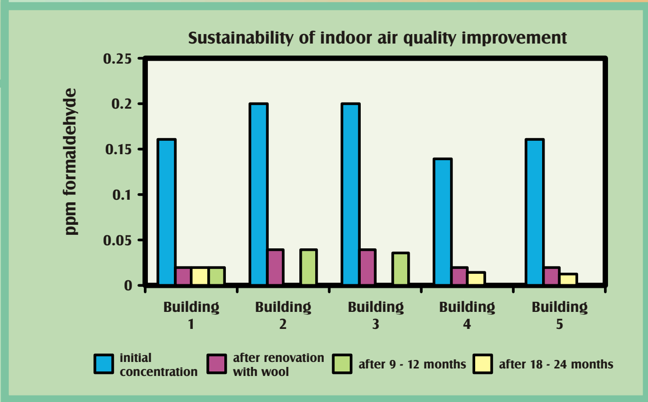

Graph 2. Absorption of nitrogen dioxide by wool and nylon carpet yarn.

## Sulphur dioxide

Studies comparing the rate of sorption of $SO_2$ by wool, cotton, viscose rayon and nylon fibres found that nylon and rayon became saturated very quickly, and together with cotton had an absorption rate of almost zero after 90 minutes, where wool reached a steady state at a low level of sorption at this time. The prolonged beneficial effect by wool carpet was considered to be due to the high acid-combining potential of wool. In addition, $SO_2$ is a reducing gas and sulphitolysis reactions at the disulphide bonds in wool may be possible under some circumstances. Because the sorption of sulphur dioxide by wool is a chemical reaction, the uptake is irreversible, with less than 1% of the absorbed $SO_2$ on an exposed carpet being released over a 2 hour period.

## Formaldehyde

Formaldehyde levels in indoor air can often exceed recommended levels, as formaldehyde is commonly used in resin-based wood products such as chipboard. The formaldehyde is slowly released as the resin hydrolyses, and emissions increase with temperature and humidity. Formaldehyde has a high reactivity to proteins such as wool, it reacts irreversibly with reactive side chains on the protein chains and reemission does not occur. Wool is able to effectively and permanently remove formaldehyde from indoor air. If the temperature and humidity increase, and increase the rate of emission of formaldehyde, wool becomes more reactive and absorbs the formaldehyde even faster.
Research has shown a rapid sorption of formaldehyde by wool at both high and low concentrations. Practical trials involving the use of wool as indoor furnishings such as carpet or wall coverings in contaminated buildings have demonstrated the reduction of formaldehyde concentration to less than 0.05 ppm (lower than WHO recommendations).




Graph 3. Sustainability of indoor air quality improvement.

## Further reading:


John D. Leeder. (1984. )*Wool Nature's Wonder Fibre*, Ocean Grove, Vic.: Australasian Textile Publishers and J.D. Leeder

*Comfort Advantages of Wool Socks.* IWS publication

Johnson, N.A.G. et al, (2003) Wool as a Technical Fibre, in *J. Text. Inst.*, V. 94 Part 3, pp.26-41.

Causer, S.M., McMillan, R.C and Bryson, W.G. (1995) The Role of Wool Carpets in Controlling Indoor Air Pollution, in *Proceedings of the 9th International Wool Textile Research Conference, Vol. 1: Plenary lectures Ecology*; June 28 July 5, pp155-161.

Crawshaw, G.H. (1978) The Role of Wool Carpets in Controlling Indoor Air Pollution. in *Textile Institute and Industry*, January, pp12-15.

Wortmann, G., Swiener, G., Sweredjuk, R., Doppelmayer, F. and Wortmann, F.J. (1999) *Sorption of Indoor Air Pollutants by Sheep's Wool: Formaldehyde as an Example.* IWTO Technology & Standards Committee, Commercial Technology Forum, Florence Meeting, June, Report CTF3.

Wortmann, G., Thome, St., Sweredjuk, R., Swiener, G., and Wortmann, F.J. (2005), *Chemisorption of Protein Reactive Indoor Air Pollutants by Wool.* IWTO Technology & Standards Committee, Commercial Technology Forum, Hobart Meeting, May Report CTF03.