Well-being indoors is becoming more and more important. Textiles can improve the indoors climate substantially. In home textiles, Lenzing Lyocell® is particularly suitable to generate comfortable sleeping conditions in beds, and to balance the room climate. Also in clothing textile applications, Lenzing Lyocell® contributes to well-being by its properties of cool, smooth and dry feeling, and the natural ability to minimise growth of microbes. Even for persons with sensitised skin, Lenzing Lyocell® offers improved comfort.

**Keywords:** fibre, home textiles, lyocell

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**A Healthy indoor environment AS an important well-being factor**

More people than ever spent most of their time indoors. Therefore, the indoors environment is of increasing importance for quality of living. Formerly, natural materials like wood, clay and natural fibres were used a lot in building, often helping to produce a comfortable room climate. Today, unnatural building methods and the excessive use of artificial materials can lead to an extremely unhealthy climate in our homes and offices. Therefore, the factors influencing the well-being of dwelling become more and more important, as studied in the new science discipline “biology of housing” or “physiology of dwelling”.

Not only building materials and furniture can add to a healthy housing environment, but also textiles influence strongly our indoors well-being, i.e. on

- micro-climate, room-climate (temperature, humidity)
- sensorial comfort
- hygiene (dust mites, mildew, bacteria, pollutants)
- optical appearance (design, colours...)

**Feelgood factors for the indoor environment**

Most of us spent about one third of their lifetime in bed. Therefore, the “physiology of the bedroom” is a major well-being factor. The textile components for bedding play an important role in this context. For this purpose the complete Lenzing Lyocell® bed derived from wood is available:

- Duvets - Filling and covers
- Pillows - Filling and covers

**Figure 1. Duvets - comfort votes (Umbach, 2003)**

- Bed linen, fitted sheets
- Mattress tickings and mattress fleeces
- Pyjamas
**Lenzing Lyocell®: In Summer Cool and Dry, in Winter Warm?**

Lenzing Lyocell® as a filling fibre offers a very broad comfort range in duvets (Umbach, 2003). Compared to a goose down (90%) filled duvet, the range of comfort in a lyocell/polyester (50%/50%) filled duvet is larger not only in the in a warm climate, but also in a cold climate. So, Lenzing Lyocell® filled duvets are good to very good in summer and winter. The comfort votes (1 – very good, 5 – poor) were calculated from textile physiological measurements. We approach here an explanation for this outstanding behaviour.

**Textile Physiological Measurements**

<table>
<thead>
<tr>
<th>Filling</th>
<th>µCL</th>
<th>CLY</th>
<th>CLY/ PES</th>
<th>Wool</th>
<th>Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imt (mm)</td>
<td>0.70</td>
<td>0.58</td>
<td>0.53</td>
<td>0.36</td>
<td>0.58</td>
</tr>
<tr>
<td>Rct / mm</td>
<td>30.5</td>
<td>25.2</td>
<td>23.0</td>
<td>15.8</td>
<td>21.5</td>
</tr>
</tbody>
</table>

**Table 1.** Water vapor permeability (Imt) and thermal resistance (Rct) of duvets with various fillings (Measurements at the Hohenstein Institutes, Germany)

Table 1 shows for Lyocell Fill® better water vapour transport properties than PES fillings. Fibre blends like CLY/PES and CLY/PLA (polylactate) show fairly good performance. Lyocell Micro® even excels the natural materials wool and goose down. At comparable thickness of duvets, Lyocell Fill® has better thermal insulation properties than PES, wool and even goose down.

**Micro-climate in Bed Tested with Test Persons**

A comparative study was done in 3 different beds using various fibre materials (Helbig, 2003) with test-persons who tend to sweat more than the population average. Lenzing Lyocell® exhibited the driest climate in the sleeping cave and close to the body (Table 2). When the temperature-humidity index (NWS–USA, web) is calculated as a measure for the apparent (felt) temperature, taking into account that humid air is felt warmer than dry air in this temperature range, the apparent temperature in a Lenzing Lyocell® bed is lower and closer to the body temperature due to the lower humidity.

**Water Vapour Absorbing Lenzing Lyocell®**

**Water Vapour Absorption of Lyocell**

The water vapour absorption of Lyocell is similar to wool over the whole range of relative humidities, and clearly exceeds cotton (Figure 2). In comparison, polyester shows a very poor moisture absorption capability. This feature will have a great influence on the room climate when Lenzing Lyocell® textiles are used.
Effect of Home Textiles on the Room Climate
Especially modern “low energy – high insulation” building techniques can lead to humidity problems. Human water vapour production is not a negligible factor in cool rooms (e.g., sleeping rooms), if no water absorbent material is present.

Too high air humidity in a cool sleeping room may lead to an uncomfortable sleeping climate, water condensation on cold surfaces and therefore can cause mildew growth, and enhanced growth of dust mites. An example for the development of humidity in a closed room over night is given in Figure 2. At a low air exchange rate, the humidity exceeds the comfort zone after only a few hours. Later, the humidity reaches 100 %, leading to condensation somewhere in the room.

Lenzing Lyocell® beds can help to prevent this problem (Figure 3): A complete Lyocell bed contains about 4 kg of textile material, which can absorb the respective amounts of moisture. In case of Lyocell, the increase in absolute humidity is easily buffered by the absorption capacity of the bed. A polyester bed is not able to absorb the excess moisture.

When the bedroom is equipped with a Lenzing Lyocell® containing carpet, the moisture buffering in the room will further be improved.

Heat of Sorption as a Feel-Good Factor?
Why are Lenzing Lyocell® duvets in summer cool and in winter warm? A key may be found in the heat of sorption of water vapour. For wool, it is well described that heat of sorption plays a major role in the heat buffering capacity of textiles (Morton et al. 1962). Literature data suggest this also for Lyocell (Mizutani et al., 1999).

We measured sorption isotherms at two temperatures (20 °C and 36 °C). The difference in vapour sorption at a certain relative humidity is a direct measure for the heat of sorption. In medium humidity, for Lyocell the difference is similar to wool, at high humidity even higher.
From these data, the differential heat of sorption can be calculated (Morton et al. 1962). The overall heat released when a fabric is transferred from low to high humidity air includes the heat of condensation of the respective amount of moisture. The total heat released correlates roughly with the moisture regain. However, there are exceptions; some Lyocell types show very high heat of sorption.

A hypothesis can be formulated:
In winter, in cold conditions at low starting humidity the fibres recycle latent heat from moisture by absorption of water vapour released from the body. The cooling effect of de-sorption mainly takes place in the upper region of the duvet, therefore it does not affect the body temperature very much (direction of convection is upwards).
In summer, in warm conditions and at high starting humidity the body is cooled by the energy needed for desorption of water in the lower region of the duvet. The high water vapour permeability index of Lenzing Lyocell® results in permanent good cooling by insensitive (not noticable) perspiration.

Feelgood factors in clothing textile applications
Cool Feeling
The well-known “cool” feeling of Lenzing Lyocell® can be quantified by the Alambeta method (Hes, 2002). The measured values of thermal absorptivity correlate with a cool feeling or touch of textiles; a higher thermal absorptivity means a cooler feeling of the fabric. Lyocell feels cooler than cotton. This is explained in a first approach due to the higher moisture content of Lyocell at a given relative humidity.

Bacterial Growth and Odour
It is generally accepted that unpleasant odour of worn textiles is mainly produced by decomposition of sweat by bacteria. Therefore, a reduction of bacterial growth on a textile will lead to lower odour development. One approach to this problem is antibacterial finishing of textiles. In a comparative wearing trial, test persons wore T-Shirts sewn together from halves of commercial T-Shirts of varied materials. The exercise was 4 hours fast walking at moderate temperature (15 to 18 °C). The T-shirts halves were analysed for bacterial growth by extraction and DNA analysis.
Lenzing Lyocell® T-shirts showed lower bacterial growth than corresponding polyester and polypropylene sports wear, leading to less odour formation. 4 of the 5 synthetic materials samples were pre-washed (5 times at 95 °C); the exception is the non pre-washed PP material, indicating that this contains a antibacterial finishing, though this was not declared on the package. The antibacterial activity of the commercial shirts was confirmed by the challenge tests.

**Lenzing Lyocell®: Smooth, Cool, and Dry Relief for patients suffering from neurodermitis and psoriasis**

A clinically supervised study was conducted by Prof. T. Diepgen, University of Heidelberg/Germany. 60 Patients suffering from Neurodermitis and Psoriasis tested commercially available Lenzing Lyocell® textiles: 100% Lyocell bedding (duvets, covers, bedlinen, sheets), and clothing from 70% Lyocell / 30% Cotton (T-shirts, Polo-shirts, Pyjamas). As a control, patients used their own clothing and their own bed textiles. A generally accepted “objective standard” is not available, as neurodermitis and psoriasis are complex syndromes with individually differing symptoms. Adult patients have individually optimised their textile use for decades, providing the toughest possible control.

<table>
<thead>
<tr>
<th>Patients with</th>
<th>Total</th>
<th>Worse</th>
<th>Equal</th>
<th>Better</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurodermitis</td>
<td>14</td>
<td>0</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Psoriasis</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>17</td>
</tr>
</tbody>
</table>

*Table 3.* First results of wearing trials with lyocell textiles, as compared to the patient’s usual textiles

The test period were conducted over one week for each set of textiles. Development of the symptoms was evaluated by initial and final diagnosis, and daily protocols.

The preliminary results of 33 patients show that the Lenzing Lyocell® textiles help nearly 90 % of the patients to a great improvement in the symptoms. Details of the study have been published in the meantime by Diepgen and Schuster (2004)

*A fibre structure model for Lyocell*

From the results of earlier structure characterisation approaches, and the water swelling and vapour sorption behaviour of Lyocell, the individual fibre can be it can be considered as a hygroscopic nano-multifilament: It consists of countless hydrophilic, non swelling, highly crystalline micro- or nano- fibrils. Swelling occurs in the non-crystalline but highly ordered regions, capillaries and voids between the fibrils.

**Conclusions**

- Bedding materials of Lenzing Lyocell® lead to pleasant micro climate in bed and exhibit a very broad comfort range: dry and warm in winter, dry and cool in summer
- Home textiles made of Lenzing Lyocell® derived from wood can add to a dry, comfortable and healthy room climate
- Regulation of air humidity restricts growth of dust mites and mildew
- Lenzing Lyocell® brings hygiene into our homes: Less growth of bacteria and less odour formation
- Clothing textiles made of Lenzing...
Lyocell® have extremely good sensorial properties: cool, smooth and dry

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