Talk to any cyclist, runner, walker, climber, football player, or cross-country skier about the smell of his or her thermals and you will always hear the response, "It can be awful." If you went into more detail, you'd most likely hear that some athletes consider certain brands to be 'smellier', while others seem to be more 'socially acceptable'. In the last issue of *WSA*, we looked at different substances that are used to prevent, mask, or absorb unpleasant odours in performance fabrics. Yet where do these smells come from? How do we sense them? And how can they be measured?

# Kicking up a stink

Starting with the basics: unpleasant smells are mainly generated through human sweat, the result of perspiration, which is a means of maintaining our core body temperature at a level that is deemed 'comfortable' (approximately 37°C). In reality, the human body permanently perspires, although we only notice it when our body's sensors indicate that our core temperature is higher than the optimum. Once we begin to sweat, the pores in our skin pass more perspiration (sweat as vapour), providing a cooling effect. If this does not provide sufficient cooling, sweat is dispersed as liquid over the skin's surface, from where it can evaporate and provide additional cooling (phase change). The major component of human sweat is water; however, it also contains various minerals, fatty acids, toxins, and other by-products. The actual composition depends primarily on the individual's metabolism and what food is eaten (just think of garlic)...

When this personal 'sweat cocktail' arrives at the skin, it meets bacteria. It is suggested that up to two kilogrammes of the human body are made up of bacteria, which live in or on the body in a symbiotic relationship. The human skin is naturally populated by a number of different kinds of bacteria which feed on the fatty acids that are expelled along with perspiration. The skin, at a humid 35°C or so, is a paradise for these bacteria and being well fed with fatty acids their numbers begin to increase. They decompose sulphur and nitrogen compounds and once the leftovers of this decomposition process have dried, they begin to smell. This odour consists of small, volatile molecules that 'float' in the air, which our noses then catch and 'smell'. This may sound simple but the human body's sense of smell is a highly complicated system. To make it even more complicated, it is also linked to our sense of taste.

## A sense of smell

The first step of sensing smell is the arrival of a smelling molecule on the nasal mucosa, located high up the nose. The surface is as small as 5.5 $cm^2$ in each nostril (about the size of a €2 coin) and contains approximately three million odour sensing cells. These consist of 347 different types,

*Small, volatile molecules 'float' in the air, which our noses then catch and 'smell'.*

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with every single one able to detect only one specific smell. The smell of coffee, for example, consists of a blend of more than 200 different components; however, a mere 15 will be enough to make your brain sense 'coffee'. As smelling components arrive on the nasal mucosa, they activate the exact smell sensing cells that are sensitive to them. All others remain unaffected. Activated cells then convert the message into an electrical impulse, which is conducted by the olfactory nerve into the brain, more precisely into the *bulbi olfactorii*. Of course, different parts of the human brain are all interconnected and a simple odour stimulus will also be linked with other impressions, emotions, memories, etc. In the case of coffee, this means that the mere activation of 15 coffee smell detecting cells, together with the memory of coffee that we have enjoyed some time earlier in our lives, actually makes us think, 'Smells like coffee'.

A recent study from K. Franks and J. Isaacson* also proved that the sense of smell of a newborn baby is actually 'calibrated' by its mother's smell within the first few weeks after birth. The smell of your mother is your first-ever olfactory impression and her odour is the calibrator for everything that follows later. Additionally, men and women generally sense smell differently.

## Machine versus man

Considering all of these variables, it is no surprise that athletes might consider one particular base layer brand to be 'stinkier' than another and, from the scientist's point of view, this poses a real problem.

Dr. Paul Raschle, microbiologist and senior scientist at the Swiss research institute EMPA, says, "Sensing smells is an extremely complex and subjective topic. There are people who are able to distinguish many more different odours than others. Here at EMPA, we have a colleague who is able to distinguish immense numbers of different smells, and describe them in detail. His sensory abilities are simply much better developed than other people's."

In the past, EMPA has worked with several test people, or professional 'sniffers'. One reason for this was that machines had not yet been developed that were sophisticated enough, whilst it also wanted to record the 'individual's

impression'—something that will probably never be replaced by machines. However, when it comes to simply detecting smells, modern testing apparatus, such as gas chromatography, can do this faster and more precisely than any human nose.

Getting back to 'smelly' first layer garments, the means of preventing unpleasant odours is either by absorption, masking, or simply preventing them from forming. From a logical point of view, the latter would seem to be most appropriate. Jordi Lopez, marketing manager, AdvanSA Europe explains, "Bacteria's excretions do not arrive at our noses while still inside liquid perspiration. To avoid being too technical, let's say that these excreted particles float in the air when perspiration evaporates. When a fabric is not wet, but humid or dry, millions of these particles are passed from the fabric to the air. It is then that our nose catches them and we perceive perspiration smells. This is why we only perceive smells after there has been an evaporative process in the garment. The more efficiently a garment evaporates perspiration, the more easily and sooner smells will appear, caused by the bacterial excretions being exposed to air. Therefore, if you eliminate the bacteria, you eliminate the smell. It is that easy."

This is where we arrive at a point where scientists smile. The task sounds simple: 'Measure bacterial growth'. As a matter of fact it isn't that easy, as Dr. Raschle knows, "My opinion is that there are various test set ups that do not deliver fully satisfying and realistic results, i.e. the shake flask test. If you put some bacteria plus a piece of fabric in a sealed bottle to find levels of bacterial growth, you can easily detect antibacterial properties. Sooner or later, bacteria will simply die from starvation. For me, the key thing of all theses tests is a test in a growth-enhancing environment."

A growth-enhancing environment includes: high humidity – an ideal temperature is 30-40°C – and sufficient nourishment (in the case of textile testing this will usually be some kind of nutrient broth).

Dr. Raschle points out, "Such a test set-up should always be carried out in parallel with a treated and an untreated sample. From our point of view, you can only talk about antimicrobial properties when there is significant growth on the untreated sample and none on the treated one."

But as long as there are some living bacteria—and sooner or later, conditions in any first layer will allow them to survive and to grow—odour will appear. And there is a certain grey area of personal opinion where you can decide whether you think it smells good, agreeable, tolerable, or simply awful.

There was no doubt about terrible smells on the final day at the recent Outdoor Retailer show, when the Milliken booth packed up its comparative tests. Normally the company would run tests for bacteria, the fixation of silver to the fibre, and the kill rate of the bacteria in a laboratory, but for the show they went straight to the nose. Four shirts were washed five times, one containing its VisaEndurance product (a microfibre polyester that is embedded with silver ions that control odour for the life of the garment whilst also providing moisture management)—then half a cup of milk was poured over each and left to sit for three days at 73°C. This proved an effective and clear demonstration throughout the show of the effectiveness of the VisaEndurance. When it came to packing up, the term 'smell' quickly moved to 'stink', and there was no argument about the definition.

*As the body temperature rises perspiration is produced as liquid to create a cooling effect.*
*Craft*

** Kevin Franks and Jeffry Isaacson, University of California, San Diego, "Neuron" Vol. 47.*

## 'Smelly' terms

Reading some marketing brochures from textile suppliers and certain articles in magazines, it seems there is a need to explain certain terms.

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| ***Antimicrobial:*** | Works against bacteria and fungi |
| ***Antibacterial:*** | Works against bacteria |
| ***Microbicidal:*** | Kills bacteria and fungi |
| ***Bactericidal:*** | Kills bacteria |
| ***Bacteriostatic:*** | Inhibits the growth or reproduction of bacteria. |