



Colourful microfibres from Lorica. CREDIT: LORICA

Footwear Fundamentals

UPPER MATERIALS

Despite all efforts made to replace it, leather remains number one choice for shoe uppers. Most attempts to produce synthetic alternatives have failed on a lack of foot comfort with DuPont's Corfam being a classic example. The only ones that have come anywhere near are PUCF (polyurethane coagulated fabric) and microfibre, which is the closest yet that any substitute has come.

STANDARD LEATHERS

Bovine – leather is a by-product of the meat industry, so with beef being the one consumed in the greatest volume, bovine hides are the most readily available for leather production. Bovines include ox, cow and calf. Ox and cow yield the largest surface area and greatest thickness followed by heifer and steer. All are usually cut neck to tail to create sides and then split (see Footwear Fundamentals January/February 2008 for more details). Calf comes from immature animals and is generally processed as a whole skin.

The fibre structure is compact and provides both good tensile and tear strengths. Up to three splits can be obtained from a hide; the grain split has the characteristic pattern of the hair follicles and is used for uppers, the flesh split is used to produce suede, while the middle split is sometimes

used as a low-cost lining.

Buffalo – is similar and usually either vegetable or semichrome tanned. Adult hides tend to be thicker, more wrinkled across the shoulder and looser textured than ox. Buffalo calf, on the other hand, makes excellent linings and can also be used in uppers for fashion shoes.

Ovine – skins from sheep are smaller, thinner, of looser fibre structure and the finished leather has a much lower tear-strength. Skins are often tanned with the wool left on the grain and the flesh side sueded for use in slippers and 'Ugg' boots where the wool acts as an integral lining. Skins can also be split in thickness to give a grain split or skiver and a flesh split, which is oil-tanned to produce a substitute for chamois leather.

Caprine – goatskins are generally smaller than sheep and have a much tighter structure, providing greater strength at the same thickness. They are mostly chrome tanned and glazed to produce glacé kid women's shoes. Hair sheep skins come from crossbreeds of sheep and goats which grow hair rather than wool. The skin structure is similar to goat and makes excellent quality linings.

Porcine – the skin of the pig has a unique fibre structure where the bristles go right through the skin. It has a very compact and strong fibre structure which enables strong, durable splits and a very fine sueded surface to be produced. The grain is also very attractive and can be further accentuated in processing.

Equine – less available as it is not widely eaten. Only the back portion or ‘crup’ of a horse hide is used to make Cordovan leather for top grade men’s shoes. Its fibre structure is very tight and the finished leather extremely tough and water-resistant.

EXOTIC LEATHERS

This covers a wide range of skin types some of which are mainly used for their decorative effect due to a general lack of physical strength.

Deer – these skins are similar to bovine calf. The fine grain coupled with good strength and low weight makes them ideal for uppers with the traditional suede ‘Buckskin’ used in the best men’s welted shoes being a good example.

Kangaroo – this has a unique fibre structure giving high tensile strength. It has been traditionally favoured for use in sports shoes, although other highly specialised leathers are now also being produced.

Bird – only the largest have skins suitable for footwear. The best known is ostrich with its characteristic grain pattern generated by the feathers. Despite quite extensive farming for both meat and skins, the finished leather is expensive.

Snake & Lizard – these reptile skins are small, thin and not very strong. Each, however, has its own distinctive pattern or scale structure, the effects of which can be enhanced by dyeing. Tensile strength is usually increased by lamination to a woven or non-woven backer. Lizard skins are normally sold in pairs that have as close a grain pattern match as possible so that one is cut for the left foot and the other for the right.

Crocodile & Alligator – this has more substance and greater strength. The belly region has a fairly uniform scale pattern and is the part used to make leather. Crocodilians are protected so all skins must have a CITES certificate from the country of origin and a tail tag which remains throughout the tanning process. Needless to say, the finished leather is extremely expensive.

Bony Fish – the only types commercially processed into leather are carp, catfish, salmon, eel and Baramundi, which is often referred to as Emperor Leather. Fish skin is surprisingly strong although it lacks elasticity. Eel produces beautifully soft and shiny leather that can be used for footwear provided it is carefully sectioned and seamed.

Shark (cartilage instead of bones) – this on the other hand is thick enough to produce good upper leather. The surface is covered in small protuberances which make it very rough to the touch and these are softened prior to tanning.

Tripe – believe it or not, this internal bovine organ can be tanned to give a quite unique sculptured surface which can be used in decorative panels or, if laminated to a substrate and further reinforced, in ladies dress shoes.

Leather is without doubt the most versatile upper material available. The colours, textures and special effects that can be achieved are virtually without limit. It is however a natural material and will therefore always vary from skin to skin in terms of quality depending on that of the original skin.



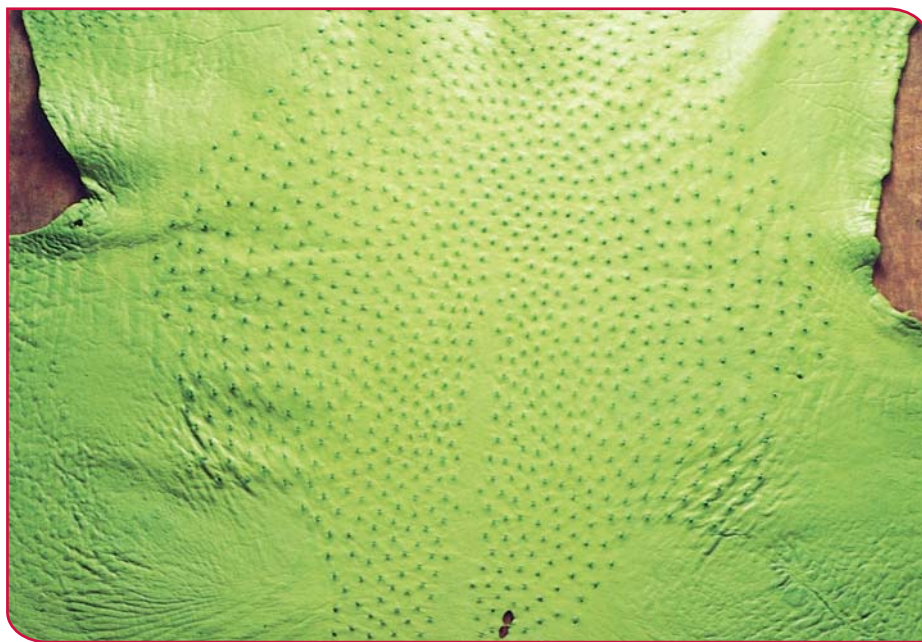
Cross-section of grain layer of calf hide after hair removal. (Section sampled from the butt area, 20 microns magnification 140 diametres.)



Cross-section of grain layer of sheep skin after hair removal. (Section sampled from the butt area, 20 microns magnification 140 diametres.)



Cross-section of grain layer of pig skin after hair removal. (Section sampled from the butt area, 20 microns magnification 140 diametres.)

Drum dyed and polished ostrich skin.

PUCF

While not strong or thick enough for men's shoes, PUCF probably accounts for over half the uppers used in women's footwear. It is essentially a PU surface layer combined to either a woven or non-woven substrate and the way this substrate is made has a profound effect on the finished material.

Substrates – the type selected depends on the end use. For instance, absorption rates can be controlled in inorganic non-wovens, whereas organic wovens such as cotton may absorb too much solution during coating. The substrate also affects the final hand or feel of the finished product so, by and large, wovens are used for cheaper PUCFs and non-wovens for the better quality. By carefully controlling the properties of the fibres used, a substrate can be made to precisely cohere with its coating.

Coating – PUCF can be made by a dry coating process in much the same way as PVC coated fabrics. Liquid PU is applied to an embossed casting paper which imparts the grain finish. This PU skin is combined to a substrate using adhesive. While this produces a vastly superior material compared to PVC coated fabrics, it lacks the smoother hand and lustre of a coagulated PUCF and, unlike the latter, can fray at its selvedge. It also lacks the degree of breathability that wet coagulation provides.

In the coagulation process, a woven or non-woven substrate is immersed in a viscous PU solution that permeates and coats the fabric. This contains 25% PU dispersed in a 75% solution of dimethylformamide (DMF) which converts the PU into a film solution that penetrates the substrate. Excess PU is removed before it passes through further successively weaker immersions to a final one consisting purely of water. Coagulation occurs as DMF leaches out of the PU into the successive baths. The process

can coat one or both sides of a substrate but it is usual to coat only one to a thickness of between 0.025mm to 0.05mm.

The 'breathability' is introduced by the use of silicon cell regulators that minutely control cell density and rearrange the molecular size of surface cells in the PU. If these are allowed to become too big, too much air circulates and feet become cold. The aim is to make them small enough to allow only an insulating cushion of air to circulate. While not as good as leather or microfibre, it is a vast improvement over other synthetics. After coagulation, the material is heated to remove any solvent traces and a grain pattern applied by embossing rollers.

PUCF has proved very successful in ladies shoes which tend to be open and so breathability is less of an issue than in a closed boot or shoe. It also has one great advantage over leather due to its uniformity and can be cut automatically—even in multi-layers—and every piece will be exactly the same in terms of strength and elongation.

MICROFIBRE

A microfibre is a material of less than 0.1 denier determined by weighing 9,000 metres of the fibre used. An ultra-microfibre falls below 0.01 denier and, generally speaking, the finer the fibre the better the microfibre. It can be produced from nylon, polyester or nylon/polyester blends. Nylon is best for footwear. Polyester is an alternative but is generally confined to upholstery.

Nylon fibre is particularly light and hard-wearing, being typically only one third the weight of an equivalent thickness leather. Furthermore, when wet, it loses no more than 15% of its strength and is also fast-drying. It can be dyed in a wide variety of colours and has good colour-fastness. PU coating also works very well on nylon. Its main weaknesses are a tendency to yellowing after prolonged exposure to UV rays and a loss of mechanical strength at high temperatures. Its characteristics do however make it very suitable for footwear, which is where it is most

“...technically speaking...”

TANNAGES

Chrome is the most common method used for footwear leathers. It provides a lightweight material that is easily softened, is light fast and can be easily dyed, despite its original pastel blue/green colour. It also yields good strength and excellent heat resistance to shoe manufacturing processes.

Vegetable tannage is the oldest method of tanning and the resulting leather can vary from pale cream to dark red brown. The leather is firmer, but easy to mould to shape, which it then retains. It can be

combined with chrome to yield leather with improved sueding characteristics, better stand and added thickness.

Aluminium zirconium and titanium are used as pretannages to give a wet-white. This improves splitting, shaving to substance, the disposal of shavings and flexibility for the main tannage. Resins and syntans are added to chrome leather to tighten the grain and improve colour and sueding. They also improve colour and light-fastness in vegetable tannages.

commonly used.

Sea-island – this is the preferred method for producing ultra-microfibre. In this process, nylon or polyester material (the island) is immersed in a copolymer of polyester (the sea). The structure is treated with caustic soda until the copolyester—converted into sodium salt and soluble in water—is completely washed away. All that remains are the inner fibres that make up the islands. For example, if the initial denier of the islands in the sea was 2, and the islands were 21, each island—once freed from the sea—represents a microfibre below 0.1 denier.

Split microfibre – in this method, nylon and polyester are held together in an unstable state as they are extruded simultaneously from a spinneret, which keeps them separate. This means there is a greater volume of material, as unlike the previous method, there is nothing to eliminate. The problem lies in the dyeing process as there are two different but co-existing fibres. The structure that comes out of the spinneret is star-shaped or divided into alternate polyester and nylon segments. These are separated with a water jet. If the original fibre is one denier and has 10 equal segments, the resulting microfibre will be 1 denier.

CHARACTERISTICS

Microfibre has a very soft feel which is useful in footwear as consumers associate this with comfort and quality. It is also good in terms of tensile, elongation, needle strength, flexing and abrasion resistance. In addition, it also offers a high degree of resistance to external moisture while at the same time providing high water vapour permeability and absorption. It is also generally resistant to hydrolysis.

It also looks very much like leather, particularly when made as suede, nubuck or natural softie type material where there is no indication at all of a ‘synthetic’ grain break. Even the reverse side looks and feels like leather, so with its excellent abrasion properties, it can be used for unlined shoes. Suede and nubuck look particularly good as



Sports shoe in Giardini sueded microfibre.

they can also be consistently and evenly dyed to any colour, offering tremendous manufacturing advantages as it can again be cut automatically using CAD/CAM systems. Smooth grain surfaces however tend to have a slightly artificial looking surface break.

As ever, the choice of upper material will always depend on the type of shoe being produced and its price point. Meat is in ever increasing demand as world living standards rise so, while hide prices inevitably rise and fall, supply is assured for the foreseeable future. PUCF clearly has a place in terms of price and ease of manufacture for women's shoes. The exciting development is microfibre which has already replaced leather in many sports shoes and, when suede finished, offers a sensible alternative to variable suede splits. 