

WORLD FOOTWEAR



Polyurethane is an increasingly vital material in footwear production as noted in the previous article 'Polyurethane today and tomorrow', which looks at overall usage and consumption. To find out more about how the applications for PU could develop, *World Footwear* asked Bayer MaterialScience to identify possible future trends as seen by its various polyurethane business units.

Future applications for **polyurethanes**

PU FOR SOLING

High fashion shoes

High fashion shoes will continue to be characterised by rapidly changing styles—a trend that may well become even more marked. This will benefit PU sole moulders, as mould costs are relatively low compared with thermoplastics. Subject to fashion trends, which are difficult to predict, thick soles and deep treads will continue to be in demand for the foreseeable future. PU is ideal for these types of soles because it is lightweight.

In developed countries, ageing populations and an increasing number of overweight people will lead to an increase in demand for high quality, comfortable shoes as their feet are particularly sensitive to pressure and, in the case of the former, are also sensitive to cold. PU is an ideal soling material because of its optimum shock-absorbing properties, excellent insulation and lightweight. PU soles can also be easily sewn to the upper to produce softer shoes that aid the flexing action of the foot when walking. This will be a key market for shoe manufacturers that continue to operate in high-wage countries.

Transparent PU soles are an important design feature



Sports shoes

Sports shoes will continue to be produced in Asia. However, the labour shortages that are already evident in some regions of China and Vietnam, and increasing wage costs, will force manufacturers to streamline their operations. One option may be to introduce direct injection of PU soles on to the uppers as opposed to producing separate sole units. This technology can be used to mould in inserts and functional elements, and integrate them cost-effectively.

There will be greater emphasis on functionality in future, with the sole playing a key part in maximising an athlete's performance. The possibility of configuring PUs from viscoelastic for extreme resilience, and of varying their density and hardness independently of one another, will be more widely used. For example, it is already possible to manufacture soles that can store energy to aid the runner's next step.

Safety shoes

As international standards for occupational safety become ever stricter, so the demand for safety shoes will continue to increase worldwide. Direct injection of PU soles is economical and allows the use of robots, which means it is usually performed on-site in the industrial nations.

PU can also help manufacturers conform to legal standards that require compliance with certain minimum physical values when producing soles. Bayer has helped PU to take market share from rubber by developing systems with internal release agents, cold-flex-optimised polyurethane, hydrolysis-stable polyester PU, very lightweight midsoles and ESD (electrostatic discharge).

TPU FOR SOLING AND COMPONENTS

Thermoplastic polyurethanes (TPUs) with a Shore hardness ≤ 80 A are mainly used for the outsoles of high fashion and safety shoes. Many still contain plasticisers, some of which contain phthalates (e.g. DEHP (di (2-ethylhexyl) phthalate) that pose a health risk and are suspected of being carcinogenic. Bayer does not use any phthalate-containing plasticisers but is still able to produce soft TPUs down to 60 Shore A. In the medium-term, only TPUs containing completely safe plasticisers, or those that are plasticiser-free, will endure.

These trends are driven by the raw material producers themselves and by global manufacturers of high-quality sports shoes. Although the latter's production is located in countries with less stringent environmental standards, their specifications stipulate that safe, low-emission materials must be used. Environmental and consumer protection organisations in developed countries also have an increasing influence.

Structural elements made from TPU, such as honeycombs, rings and air cushions, are being increasingly integrated into running shoes in place of all-foam soles. There are already examples of this, such as the adidas a³ technology and the shock absorption in Nike Air. The increasing number of shock absorption systems used reflects the lightweight trend: they are lightweight and they look it. Moreover, they are transparent. They feature design principles modelled on nature and also enable different zones of the foot to be cushioned differently during running. The demand for transparent materials is also increasing, bringing advantages for the TPU business. However, it is difficult to predict how long this fashion trend will continue.

In the future, sports shoe design and the materials used to ensure correct and healthy running will be increasingly influenced by new findings in sports medicine and orthopaedics. This can already be seen in the heels of many running shoes that used to be made in one piece but now consist of multiple sections. This is a result of the discovery that different regions of the foot need to be cushioned differently.

Sports shoes will also become even more customised, and there are two ways to achieve this: firstly by developing 'intelligent' shoes, and secondly through the introduction of modular construction. Intelligent shoes adapt to the wearer, the surface and the running scenario. This is achieved by means of a chip that controls the adaptable sole. Modular systems enable the retailer and his customers to put together a customer-specific, 'made-to-measure' shoe. Examples of intelligent and modular shoes are already on the market.

Plans under discussion to increase the use of synthetic playing surfaces may be a critical factor in the development of soccer boots. These surfaces change the requirements of the boot, particularly with regard to shock absorption.

TPU is extensively used for soccer shoe soles



TPU is primarily used in sports shoes, as it allows simple processing and offers generous scope for design and excellent physical properties. It also has excellent abrasion resistance and tensile strength, and can be made UV and hydrolysis-resistant. The soles and studs of soccer boots for instance, are often produced from TPU. It can also be used to make heel counters, torsion bars and lacing fittings, and can even be sprayed on to textiles as a reinforcement.

It is used to a lesser degree in safety shoes, where outsoles made from TPU are bonded to PU midsoles using direct injection to provide good grip, anti-static properties and electrostatic dischargeability. TPU is seldom found in high fashion shoes except as top pieces on ladies' heels, where its excellent abrasion resistance is an advantage.

PU FOR UPPERS

Synthetic leather is used as an upper material in all three sectors: high fashion, sports and safety shoes. Today, synthetic shoe upper materials are mainly produced using solvent-based processes, some of which employ recirculating systems. Unfortunately, solvents such as dimethylformamide are toxic and, moreover, the statutory requirements governing the ►

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PU textiles are increasingly used in sports shoes



concentration of emitted volatile organic compounds (VOC) will tighten further. The demand for materials that are produced without using solvents, and that can therefore be classified as eco-friendly, will increase sharply. Bayer develops ecologically compatible polyurethane systems of this kind, which are either water-based or consist of 100% polymers.

In the past, men's dress shoes were supposed to be rigid and hard to protect the feet. Now, the demand is for lightweight shoes. The trend for lighter, softer, more comfortable shoe upper materials will continue in all market sectors. There is no way of predicting if or when the trend will begin to swing back in the opposite direction.

A potential future development is the 'intelligent' shoe featuring upper material systems with properties that can be 'adjusted'. One possibility would be upper materials whose moisture permeability changes depending on weather conditions. It may also be possible to develop systems that change to meet different requirements. For example, a shoe configured to be soft and comfortable in the town might turn into a shoe that provides firm support for the foot during a walk in the woods.

Both genuine and synthetic leathers will both be available on the high fashion or city shoe market in the future. In Europe and North America in particular, real leather will continue to be looked on as a natural, organic and luxurious material. In other regions of the world, particularly Asia, synthetic leather is preferred because of its superior properties, such as better

washability and abrasion resistance. Either way, design will continue to play a very important role, as it is the most obvious way for a shoe manufacturer to make their products stand out from the competition.

ADHESIVES

In the future, solvent-containing adhesives will increasingly be replaced by more ecologically friendly alternatives, in both PU and polychloroprene (CR)-based adhesives. This development has already begun in Asia, where aqueous adhesives are being

PU adhesive peeling test



used primarily to comply with the strict specifications of global brands. Large retail chains and producers of high fashion shoes are likewise committed to using only solvent-free adhesives in shoe production. In Europe, this trend is driven principally by statutory requirements such as VOC directives. However, the reasons for switching to solvent-free adhesives are also economic. Aqueous systems can now be more cost-effective than solvent-based adhesives, as the price of solvents has risen sharply—a trend that is expected to continue.

Bayer develops raw materials for all major types of adhesive for the shoe industry. These include both solvent-based and solvent-free systems. Concern about the use of solvents has put the spotlight on aqueous dispersions, among other things, because they can replace solvent-based adhesives in shoe production without the need to invest in new equipment. The one-component PU dispersions currently being developed offer additional advantages, such as removing the need for complicated and error-prone mixing with a crosslinker before application. They also have no pot life restrictions. These systems are now being introduced in the shoe industry and offer excellent potential for the future.

PU-based adhesives are extensively used in the manufacture of soles whose construction, particularly in the case of sports shoes, can be very complex and involve a large number of

individual components that must be pre-assembled before being bonded to the upper in a subsequent production step. Aqueous PU dispersions are already widely established in this area of application.

Hot melts, which are currently being introduced into the market, are 100% PU systems that are supplied in solid form. Before they can be used in shoe production, they have to be melted and kept warm, and the melted mass is then applied at high temperatures. Bayer is working to further develop hot melts and improve them in areas such as initial strength and processing properties.

In the field of aqueous (CR)-based adhesives, the intensive research work carried out in recent years has led to the development of aqueous adhesives systems whose properties are equal to traditional solvent-based adhesives and in some respects superior to them. CR adhesives are mainly used in uppers, where they can facilitate the sewing together of component sections.

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