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Multitalented elastic materials for undercover assignments

When most people think about rubber, the first thing that comes to mind is probably car tyres. After all, we see them everywhere on our streets and roads, and many of us have to ensure that they are regularly inspected and replaced.

About 60 % of the 22millIont of rubber used worldwide every year are processed to make all kinds of tyres. However, rubber can be used for many other purposes, most of which fall under the headings “sealing”, “damping” and “transportation” – three simple words, with a lot more to them than might first appear. This is because many rubber products are used for undercover applications, so that most people are unaware of the real scope of this material’s versatility. Rubber products are used to seal things as small as medicinal ampoules and as large as the roofs of stadiums. They help trains to run smoothly and engines to run quietly, ensure that conveyor belts perform energy-efficiently and wind turbines gain the necessary momentum. They give operating elements their soft-touch feeling, and – in the form of safety clothing – protect people against dangerous substances. As belts in different shapes and sizes, they transmit energy, and as hoses of all kinds they transport fluids, both in the home and in industrial and medical applications.

Since the invention of the first synthetic rubber 100 years ago, this material has been repeatedly provided with new and highly specific properties in an enormous number of different polymers. In just the last ten years, major developments in have included automotive applications in the under-the-bonnet area, where conditions are increasingly harsh. Even simple hoses and gaskets must now be capable of withstanding temperatures of about 150°C for long periods of time. And then there are the associated temperature peaks of up to 180°C, aggressive media such as fuel and motor oil, and the stresses of several million working cycles. All these factors push standard elastomers to their limits. It is true that special grades of fluororubber such as FKM are the usual option for applications requiring high thermal and chemical resistance, but they are often more difficult to process than standard types. A few years ago, **DuPont** achieved a breakthrough with its **Viton-**brand performance elastomers, based on advanced polymer architecture (APA). The flow, crosslinking and demoulding properties of these products are similar to those of standard fluororubber grades, and the properties of the final products correspond to those of the high-performance speciality grades.

As a different approach, suitable materials can be sought on the basis of good processability. Liquid silicones (LSR) are an obvious candidate, but their excellent temperature resistance is accompanied by only moderate resistance to organic chemicals. A more suitable alternative has been developed by **Wacker,** in the form of its fluorosilicone liquid rubber grades (FLR), which are characterised by good resistance to motor oils, even at high temperatures. This trend has been taken even further by **Momentive Performance Materials,** which has developed fully fluorinated liquid silicone elastomers (FFSL). Like FLRs, FFSLs are resistant to diesel fuel and hot oils. Moreover, their resistance to a wide range of chemicals is similar to that of FVMQ peroxide-crosslinking fluorosilicones. These are used for all applications which require excellent high temperature flexibility in environments where they are exposed to fuels, oils and blow-by gas.

Fluoroelastomers are also in demand for applications involving biodiesel. Despite its environmentally friendly properties, this fuel is extremely aggressive towards traditional seal and hose materials. A flexible polyolefin elastomer (FPO) developed specially by **Dyneon** for such applications was subjected to long-term testing at 150°C and found to be very resistant to the rapeseed oil methyl ester type of biodiesel most commonly used in Europe.

Although the properties of fluoroelastomers make them eminently suitable for use in demanding tasks in the under-the-bonnet environment of motor vehicles, they all suffer from the same disadvantage: their relatively high price. Proven polyacrylate rubber has therefore been developed further to make it an alternative option for certain applications. One example of such an alternative is **Zeo**

Another traditional elastomer has been made fit to meet the new requirements by rubber pioneer **Lanxess.** Hydrogenated nitrile butadiene rubber grades (HNBR) have already acquired an excellent reputation in high-end applications at temperatures around 150°C in hot, oil-vapour-charged, air. The **Therban AT** HNBR grades extend the potential of this high-performance elastomer even further. They are less viscous than conventional HNBR grades and are therefore easier to process. They can be forced through the nozzle of an injection moulding line at lower pressure, blended more easily with other rubber components such as carbon black, and require the admixture of far fewer auxiliary chemicals than have to be added to conventional HNBR grades before they can be processed. Besides the processing advantages, the higher filler tolerance offers a greater degree of freedom for adjusting hardness and compression set. By increasing the proportion of acrylonitrile, Lanxess made the HNBR elastomer suitable for biofuel applications.

Due to the ease with which they can be processed, the relatively young group of materials known as thermoplastic elastomers (TPE) is gaining in popularity for an increasing number of applications in the automotive sector. The uses of these novel elastomers, which can be melted just like thermoplastics, were initially limited to soft-touch applications in car interiors, and interior and exterior profiles. In the meantime, however, they can also be found under the bonnet, where they have displaced traditional rubber for some applications.

The French automotive supplier **MGI Coutier,** for example, uses **Arnitel** thermoplastic copolyester elastomers (TPE-E) from **DSM Engineering Plastics,** Netherlands, to make air ducts for the engine compartment. MGI Coutier claims that the pronounced microcrystallinity of the material ensures superior performance, especially at high temperatures. Moreover, the wall thickness and weight can be reduced by up to 70% relative to components made of rubber. The melting point is also higher, so that temperature peaks of up to 175°C are tolerated. The thermoplastic copolyester can be used at a temperature of 150°C for 800 to 1,000hours and, according to the manufacturer, has an elastic modulus three times higher than its predecessor materials.

Thermoplastic vulcanisates (TPV) are also suitable for applications at the high temperatures in the engine compartment. Japanese rubber manufacturer Zeon's **Zeotherm** product range offers a variety of TPV grades for injection moulding and blow moulding. Their properties include long-term resistance to temperatures of up to 150°C and the ability to withstand temperature peaks of up to 175°C. Moreover they bond to polyamide and are therefore suitable for the production of two-component parts. The material is used for parts such as air guides (intercoolers) and sleeves for steering columns. It ensures excellent seal tightness and insulation under engine compartment conditions. It is also suitable for insulation sleeves in the intake pipes of turbodiesel engines, for which AEM rubber is usually used.

With a temperature resistance of up to 170°C and resistance to motor oil and transmission oil, the properties of **Hipex** TPV from **Kraiburg TPE** are comparable to those of high-performance rubber compounds. The material is based on hydrogenated styrene block copolymers (HSBC) and bonds to all the main hard components (PA, POM and PBT) in the engine compartment. This makes the production of two-component parts easier than when ACM or AEM rubber is used, as no vulcanisation is necessary.

In view of the many options for combining elastic and thermoplastic phases or polymer blocks, TPEs are among the most dynamically developing elastomers and are being used for an increasing number of applications outside the automotive engineering sector. In the medical sector, for example, they have the advantage of easy processability and, above all, reversible crosslinking, so that no vulcanisation residues remain in the product. This is an important criterion for medical applications. Kraiburg TPE recently responded to this trend by launching a completely new product range.

Another trend affecting TPEs is the demand for greater environmental compatibility. Faced with massive demand from processors and their customers, TPE producers are now turning to renewable raw materials and biodegradable polymers. This development is a major challenge for them, as they are expected to offer bio-based materials with at least the same properties as the already existing TPEs, but costing not a single cent more. These bio-materials are mainly used for sport and lifestyle applications, etc., which allow the end user to see and feel them. The currently marketed products include bio-based TPUs from **Bayer MaterialScience** and **Elastogran,** polyether block amides (TPAs) from **Arkema,** made from 100% renewable raw materials, and totally biodegradable material from Italian manufacturer **API.**

Perhaps surprisingly, the oldest bio-plastic of all – natural rubber – can still come up with something new. The geographically very limited cultivation of the plant that is the main source of natural rubber – *Hevea brasiliensis* – has always been a source of frustration to importers of this valuable raw material. In 1867, the British succeeded in breaking the Brazilian monopoly by smuggling out seeds. In the Second World War, German, Russian and US chemists experimented with the dandelion, which also produces natural rubber. But as the sap immediately undergoes uncontrolled polymerisation when it seeps from the plant, their efforts were unsuccessful. Scientists of the **Fraunhofer Institute for Molecular Biology and Applied Ecology** in Aachen have now taken up this old idea again. They hope that genetically modified dandelions will help them to achieve a breakthrough and perhaps reduce the world's current dependency on Asian suppliers.

Turning back to car tyres, it is clear that increasing environmental awareness and the trend in oil prices are forcing a radical rethink of this classical rubber product. It has been shown that 20% of car fuel consumption and 30% of truck fuel consumption are attributable to the rolling resistance of the tyres. The top priority for tyre designers is therefore to achieve a further reduction in these figures. In the early 1990s, **Michelin's** "green tyre" was a milestone on the road towards this goal. The key to this development was the use of silica as a filler. Lanxess has just launched a new Nd-BR rubber grade with a high level of rebound resilience that reduces rolling resistance. However, tyre designers are still faced by a dilemma. This is the conflict between three physical properties of tyres: wet grip, abrasion resistance and rolling resistance – often referred to as the "magic triangle". The problem is that an improvement in one of these three properties has a negative effect on the other two. A solution may now be at hand with the help of nanotechnology. According to Lanxess, a new additive consisting of nanoparticles is able to improve the wet grip, rolling resistance and service life of tyres simultaneously.

The new materials have been accompanied by changes in rubber processing technology. Rising raw material costs and falling prices to buyers are forcing processors to continuously improve the efficiency of their production methods. Many of the new possibilities will be presented at K2010 – the world's biggest trade fair for plastics and rubber – from 27October to 3November in Düsseldorf. In recent years there have been a series of developments in injection moulding processes in particular, which have quickly become standard. In 2006, **Maplan's DKG-**Award-winning self-adjusting injection moulding machine, which controls the processing conditions for short vulcanisation times and maximum product quality in just a few cycles, was a big hit. In the meantime, all manufacturers of injection moulding machines for rubber materials offer heating time reduction techniques – differing widely from each other in some cases – that save time and energy and ensure the constant high quality of the products. Progress has also been made in cold runner injection moulding technology, which can bring about savings in expensive materials because, in contrast to hot runner technology, no sprue wastes are incurred. Depending on requirements, a wide range of systems is available, from standard cold runner to actively controlled nozzle technology. **Desma,** for example, has developed a variable cold runner system with individually adjustable nozzles that can be quickly adapted to the available moulds, making this technology viable even for small series. The latest trend is electrically driven rubber injection moulding machines. Rubber processors can therefore now profit from the energy-efficient technology that used to be the almost exclusive preserve of thermoplastics processors. The possibilities range from an all-electric drive system, such as that offered by **Engel,** to hybrid technology, as already realised by Maplan.

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