CHEMICAL INDUSTRIES
ASSOCIATION

Chemistry in Sport

Responsible Care

2012

Chemistry is… sport

In this brochure we explain how chemicals and chemical companies are helping sporting achievement.

It takes years of training if an athlete is to achieve their olympic dream, whatever their sport.

To help realise this dream improvements to new kit can help, too.

Many equipment, stadium and accommodation improvements are only possible thanks to developments in chemistry and the chemists who work hard to create new materials that are stronger, lighter and more resilient.

Chemists also run the drug tests that help ensure a level playing field by catching the cheats.

While there will never be an alternative to hard work and sheer dedication, chemistry can add value to making sport happen.

Chemistry is… light

Bike design can give a cyclist a real speed advantage, and bikes designed for racing on the road or the track are carefully engineered to be as aerodynamic as possible. What they are made out of makes a big difference too – the lighter a bike is, the less weight a cyclist has to drag around, and the faster they will be able to go. Modern carbon fibre racing cycle frames are every bit as stiff and strong as their metal counterparts, but significantly lighter.

Carbon fibres were first made in the 1950s, but it was in the 1960s at the UK's Royal Aircraft Establishment at Farnborough that a practical process was developed, where they started to be used in applications where a strong but light material was an advantage. As well as being extremely light, the fibres are strong and flexible.

The fibres themselves are very fine – at 5 to10 nanometres, they are finer than human hairs.The fibres are wound together to make a yarn, and these can also be woven together to create a fabric. The bike parts themselves are made from composite materials where the carbon fibre is mixed with a plastic resin to form a carbon fibre reinforced polymer. Although the term polymer is sometimes taken to refer to plastics, it actually encompasses a large class comprising both natural and synthetic materials with a wide variety of properties. The fibres are arranged in a mould, the resin is added, and after curing the pieces are removed from the mould.

Many other parts of a bike can also be made from carbon fibre, from wheels and forks to handlebars and seatposts, and smaller components such as brake levers and gear shifters. Even the soles of cycling shoes and the shells of cycling helmets can be made out of carbon fibre reinforced polymer to make them lighter and stiffer.

Chemistry is… strong

Once, canoes were made of wood and bark. Then, they were replaced by wooden frame constructions covered in canvas. Over the years, other materials started to be used – aluminium, plastic, fibreglass. But now, racing canoes and kayaks are commonly made from the polymer Kevlar, which is both strong and light, and thus is ideal for the speed required for flat races, and the turbulence and obstacles encountered in whitewater slalom. Kevlar – or polyparaphenylene terephthalamide, to give it its chemical name – was developed by scientists at *DuPont* in the 1960s. It is made by mixing the two component molecules, or monomers, together, and these react together to form the polymer. These long polymer molecules are then spun out mechanically to form fibres. Because of the way the polymer molecules bond together within the fibres, they are extremely strong – at least five times as strong as steel. They can then be woven to form very strong fabrics.

Kevlar's first commercial use was to replace steel in racing tyres, and it is perhaps most familiar for its use in bullet-proof vests. But its properties make it ideal in sporting products, too. To make a Kevlar canoe, layers of the polymer fabric are combined with a resin on a mould, and then cured to harden the resin. This creates a strong and light hull that does not tear easily, and is resistant to abrasion. However, it does need to be painted with a protective UV-resistant coating because sunlight damages the polymer.

The Kevlar can also be mixed with other materials, such as graphite and fibreglass. A Kevlar canoe is typically 20% lighter than the same design made of fibreglass, but much more resistant to damage.

Chemistry is… stadiums

Modern construction materials have revolutionised the design and performance of sports venues, whether it's a showpiece stadium, a velodrome, an aquatics centre or a multi-purpose sports arena. They can allow venues to be built more quickly, stand the test of time better, and even reduce their energy usage. Concrete, for example, can be formulated with additives that make it set more quickly to speed up building time, or more slowly if it needs to stay liquid for longer to allow it to be pumped further. Admixtures are specially formulated products that are added in small amounts to concrete, mortar or grout during the mixing process in order to modify the concrete properties in the plastic and / or hardened state.These admixtures can make a real difference – for example, the Bird's Nest olympic stadium in Beijing was constructed using *BASF* concrete admixtures that allowed the building process to be completed more quickly. These admixtures were also used to speed up the construction of the Beijing olympic village, tennis centre and aquatics centre. Chemistry also provides the paints and coatings that protect surfaces from the weather and other damage, as well as a decorative finish. Many modern coatings are 'greener' than traditional paints, and yet can still protect just as well – if not better. For example, during the recent renovation of *Bayer Leverkusen's* football stadium in Germany, *Bayer's* polyaspartic coatings were used to protect the metal girders from corrosion. These have a low viscosity so they can contain higher levels of solids. They also dry more quickly and thicker layers can be applied, so fewer coats are needed, and as there is less solvent to be evaporated, they are more environmentally friendly. By painting the girders with this coating, a very tight schedule was met, and only two coats were needed instead of the usual three.

Chemistry is… springy

Athletics track design was revolutionised by the introduction of Tartan by 3M in the 1960s. This polyurethane made its olympic debut in Mexico City in 1968, and since that time these types of synthetic polymers have become the dominant materials used to surface tracks. These all-weather tracks still work well in heavy rain, unlike the grass and cinder tracks they replaced, and since the original Tartan several alternatives that are harder wearing and 'bouncier' have been developed. One of the most common surfaces used for athletics tracks these days is Conipur, made by *Conica*, part of *BASF*. The company has been making liquid plastics for synthetic sports surfaces since the late 1970s, and several major athletics stadiums use this track surface, including the Jawaharlal Nehru stadium in New Delhi that was used for the 2010 Commonwealth Games, and the refurbished olympic stadium in Berlin where the 2009 World Championships were held.

The track surface has three layers. The top layer is hard but elastic, and the liquid polyurethane is poured onto the track in one piece, which makes it waterproof and resistant to both weather and temperature. Beneath this, two softer layers protect the athletes' joints. Typically, an outdoor track lasts for 10 to 15 years, and this can be extended by resurfacing.

Many competition tracks, such as those installed in the stadiums for the Athens, Sydney and Beijing Olympics, are made by the Italian company Mondo, and this style of track is also being used in the London 2012 olympic stadium. The prefabricated synthetic rubber 'mats' are seamed together along the edges of the lanes. The honeycomb backing increases the natural springiness of the rubber material and supports the foot, reducing the amount it rolls when running. Over the years improvements in the design have contributed to some very fast tracks – five World records were set in Beijing alone.

Chemistry is… clothing

Sports clothing has come a long way from the cotton vest and shorts. A whole array of technical fabrics are now available, designed to enhance performance, increase comfort and protect the athlete.

One of the most familiar – and important – fibres used in sports clothing is Lycra, or elastane. This polyurethane–polyurea copolymer was invented more than 50 years ago by scientists at *DuPont* A successor company, Invista, now produces Lycra and other high performance branded textile products. The elastane fibres are combined with other fibres, such as nylon or polyester, and woven into fabrics that stretch and retain their shape, allowing clothes that cling to the skin to be made. It is now used in a wide range of sports clothing, from swimming costumes to cycling kit where a close fit is required, to looser clothing where its elasticity enhances both comfort and fabric performance.

The shape of the fibres can have an effect on a fabric's properties. *Invista's* Coolmax is a great example. These technical fibres are designed to wick moisture away from the skin, as they have four channels running along them to speed up the transport of water along the fibre. This also makes the fabric 'breathable'. A second *Invista* polyester fibre, Thermolite, has hollow fibres, which trap air. Fabrics made with this fibre give good insulating properties, yet are lightweight. They also dry quickly.

Aquafil's Dryarn is another wicking fibre. It's a type of polypropylene based on *LyondellBasell's* Metocene polypropylene resin. This was used to make jerseys for the Italian sailing team for the Beijing olympic, instead of the more usual polyester and polyamide fibres. It expels sweat nearly eight times as fast as polyester, which was particularly important in the very humid conditions in Qingdao, where the olympic competition was held.

By incorporating additives into yarns, the properties of the fabric can be enhanced. *Rhodia's* polyamide Emana is an 'intelligent' yarn, with additives that are claimed to give thermo-regulating properties and improve the microcirculation of the blood when worn for at least six hours. Studies have shown that it can also reduce the build-up of lactic acid that leads to muscle fatigue.

Chemistry is… balls

Where once footballs were made from stitched-together panels of leather, modern footballs are carefully designed using modern polymer technology. They're lighter, don't soak up water and – unlike stitched balls – are perfectly round.

The first unstitched ball to gain official approval was the Adidas Roteiro, which was used at Euro 2004 in Portugal. Rather than being stitched, the pieces are thermally bonded together. Underneath the waterproof polyurethane surface is a layer of foam made from *Bayer's* Impranil polyurethane material. This contains millions of really tiny gas-filled 'bubbles', and gives the ball better elasticity, so when it is kicked more power is transferred from the foot to the ball. As the ball is so waterproof, it still behaves as well in heavy rain.

As air can leak out of balls over time causing them to deflate, the inner bladder of balls such as basketballs and footballs can be made from *Exxon's* butyl rubber, or polyisobutylene. This synthetic rubber is a copolymer of isobutylene with a small amount of isoprene (the building block of natural rubber). It provides a very good barrier to air, making it an ideal material for the bladder in a ball as it helps keep the air inside.

Meanwhile, although tennis balls are usually made of natural rubber, the fluffy felt outer cover is made from a synthetic fibre. This felt improves the way the balls fly through the air by reducing aerodynamic drag. One fibre that is used to make this is *Rhodia's* Noval polyamide, which improves the balls' resistance to both wear and abrasion, so the felt retains its texture better and the balls keep flying well for longer.

Chemistry is… recovery

It's important to drink when exercising – it's easy to become dehydrated as so much water is lost in sweat. But it's not only water that's lost – sweat contains salt and other essential chemicals. And then, of course, the energy that's been burnt up needs to be replaced. Ever since the launch of Gatorade in the 1960s, a steady stream of new sports drinks have appeared on the shelves, and today there are many sophisticated products that contain chemicals designed to aid recovery.

A sports drink contains these three essential components – water, electrolytes and carbohydrates. Water on its own isn't enough – it quenches the thirst too quickly and there is a danger that the athlete will remain dehydrated. Even if they do drink sufficient plain water, there is a risk that the level of salt in the blood will fall to dangerous levels. Electrolytes, including sodium and potassium salts, replace those lost in the sweat. The carbohydrates are also important, as they replace the 'fuel' that has been burnt by the muscles. These might be glucose, fructose, maltodextrin or even sucrose.

A number of sports recovery drinks also contain proteins. The aim here is to increase the levels of glycogen and protein in the muscles, and help muscle repair and growth. Some of these drinks also contain amino acids, the chemical building blocks that make up proteins. There are also claims that if products containing whey protein are drunk after exercise, it can reduce muscle soreness.

Chemistry is… fair

Bringing Science to the London 2012 Olympic and Paralympic Games

The London 2012 Olympic and Paralympic Games will be the major event of 2012 watched by over 4 billion people around the world. GlaxoSmithKline is using the excitement generated by the Games as an opportunity to advance scientific progress, inspire a new generation of young scientists and improve the health and wellbeing of communities and employees. Some of this will be achieved through our official London 2012 partnership, but we are also going beyond this commitment to ensure we create a positive and lasting legacy.

Promoting fair play and advancing scientific progress

As the Official Laboratory Services Provider of the London 2012 Games, GSK are contributing expertise in research and development to support the integrity of the Games and health of athletes. Scientists from King's College London (KCL) will use the new World Anti Doping Agency (WADA) accredited laboratory, established by GSK, to test for use of performance-enhancing drugs during the Games. GSK are helping to recruit over 100 PhD students, who will support KCL anti-doping experts to analyse over 6000 samples - more than any tested during previous Games. GSK is currently working to secure a sustainable future for the laboratory in the hope that it could operate as a standalone business beyond the Games. GSK has also selected 10 employees who will manage Anti-Doping Control Centres at Olympic and Paralympic venues where athletes will provide their samples.

GSK will continue to help in the fight against doping after the Games and have committed to supply WADA with confidential information about medicines in early stage development that have the potential to be abused by athletes. This will allow them to develop testing techniques before these medicines are even marketed.

Inspiring young scientists

London 2012 has inspired GSK to create 'Scientists in Sport', a school outreach programme. Jointly developed with KCL and UK Anti-Doping (UKAD), this helps 11-14 year old students understand the role science will play in the Games and excites them about potential science careers. The children visit a university to participate in activities and hear about how science is used in sport.

At the same time GSK are running a UK-wide challenge for schools, endorsed by the British Science Association, where teams are asked to design a portable anti-doping kit to test for new substances. GSK have developed kits for GSK Science Ambassadors to use in our outreach programme and a range of free resources for teachers and students available at www.scientistsinsport.com.

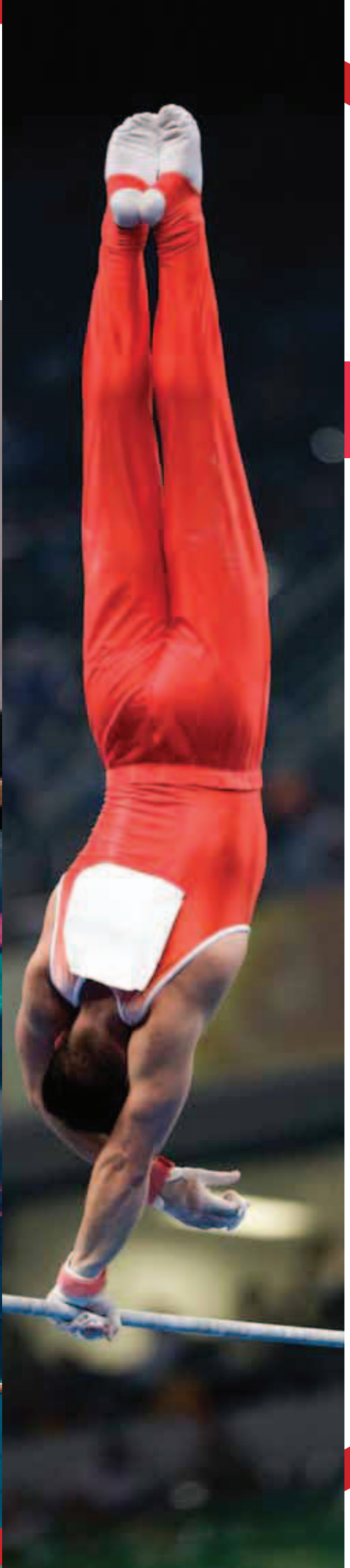
The ambition is to reach every secondary school in the UK and encourage thousands of school children to participate in the programme.

Improving health and wellbeing in the community

GSK has a long heritage of contributing to local communities by supporting employees and being involved in wider partnerships. They are using London 2012 as an opportunity to improve health and wellbeing through community initiatives such as 'Your Personal Best' (www.yourpersonalbestcampaign.co.uk). This initiative with NHS London will help to deliver a health legacy for London 2012 by inspiring the 7.78 million people aged over 55 with long-term health conditions to lead a more active lifestyle.

Motivating our employees

GSK have used their London 2012 partnership to recognise GSK employees who make a positive difference. They are using 100 per cent of their ticket allocation for the Olympic and Paralympic Games to reward employees who are demonstrably living the joint GSK and Olympic / Paralympic ideals of integrity, equality, friendship and excellence.



WORLDWIDE PARTNER

WINNING SOLUTIONS

DOW AT THE LONDON 2012 OLYMPIC GAMES AND BEYOND

Working to deliver solutions for a more sustainable Olympic Games and a more sustainable world

OLYMPIC STADIUM – LONDON

Dow solutions: Roofing and stadium wrap

London's Olympic Stadium is "wrapped" with fabric panels produced by Dow and made with Dow resins. Roofing insulation materials from Dow offer moisture resistance and structural strength.

OLYMPIC VILLAGE – LONDON

Dow solution: Roofing

Insulation from Dow is used in the Olympic Village apartments to protect 17,000 athletes and officials from the elements.

WESTFIELD SHOPPING CENTRE AND PARKING DECK – LONDON

Dow solutions: Roofing and flooring

Insulation materials from Dow are helping to ensure long-term moisture resistance and durability of the Shopping Centre's roof. Below, Dow insulation materials help ensure strength, durability and moisture resistance for a safer parking deck.

ETON MANOR SPORTS COMPLEX – LONDON

Dow solution: Flooring

Low-VOC resin flooring from Dow is designed to be tough, durable and slip-resistant for athletes using this aquatics and Paralympic training facility.

COPPER BOX – LONDON

Dow Solutions: Roofing and flooring

High-strength insulation materials from Dow help meet high structural and energy efficiency demands for the handball structure's inverted roof.

The Facts:

Where science and sport are the winning team...

Chemistry makes a surprisingly large contribution to sports. Recycled engineering plastics are rapidly finding their way into sports equipment such as lacing systems, fishing reels, components for fitness machines and mountain sports gears.

Higher-end outdoor segments are expected to be the most demanding sport markets for high-quality recycled and renewable-based materials.

We hope this brochure shows you that without chemistry, sport would not exist and that when they come together they produce a winning team.

Steve Elliott, CIA CEO

The industry that delivers UK growth...

Innovation drives growth. Chemical and pharmaceutical businesses spend more on research and development than anyone else – over **£5 billion each year** which is one third of the total UK amount. This generates growth. Chemistry facilitates other research in – new materials, adhesives, paints for aerospace and automotive, and key components of electronics and communications.

Every working day our **companies contribute £70 million** to the UK economy, equivalent to **£17 billion** a year.

We are major investors in capital equipment, helping to sustain UK activity in construction. Even during the worst recession in a generation, we are still investing well over **£1 billion a year** in capital expenditure.

The products and technologies of our companies are at the heart of the **green economy.** The energy saved by society in the lifetime of these products is twice that used in making them.

We provide employment for **over half a million people.** Our highly skilled workforce perform quality jobs that **pay 40% more** than the average for the manufacturing industry. We develop workforce skills and encourage academic studies which reinforce the UK position as a competitive industrialised nation.

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Richard Davies, Essar Oil (UK) LTD, Leader of Chemical Industry Future Forum

"I joined the chemical industry as an apprentice and I am now training to asses new apprentices that join us at the Stanlow Refinery. The chemical industry has a big role to play in making the products that you and professional athletes use for sport. It is great to think that basic chemicals that come from a plant I help to keep running might end up running the olympics in London. But it is not just sport that our products help, chemicals are also helping cut the carbon emissions of things you do every day, for instance when you switch on a light or get to school by car. To find out how you can be part of the solution too, you can learn about careers in the chemical industry at www.cia.org.uk"