

Evonik Magazine

2 | 2009



A Polymorphous Plastic

What is VESTAMID?
It's the first
high-performance
plastic that can
do everything



A Master of Metamorphosis

It's used in everything from sports shoes and underwater oil lines to medical appliances, ski surfaces and



toothbrush bristles—everyone has some contact with Vestamid, the “multitalented” high-performance plastic



TEXT KLAUS JOPP

WHAT DO tiny gear wheels, petroleum pipelines, and modern carving skis have in common? All of these products consist at least in part of VESTAMID from Evonik Industries AG. VESTAMID is a plastic that belongs to the class of polyamides—which also includes the well-known fibers nylon and Perlon, which wrote fashion history during Germany’s “economic miracle” era. Today Evonik is the world’s largest manufacturer of polyamide 12, which is also designated by the chemical abbreviation “PA 12”. The “12” stands for the number of carbon atoms in the initial building block, which is called a “monomer.” In the case of PA 12, this monomer is a compound with the difficult name laurinlactam, which Evonik manufactures itself using a multi-stage process at the Marl Chemistry Park. “We’re profiting from our back-integrated production here,” says Michael Beyer, Vice President Market Development High Performance Polymers (HP) at Evonik.

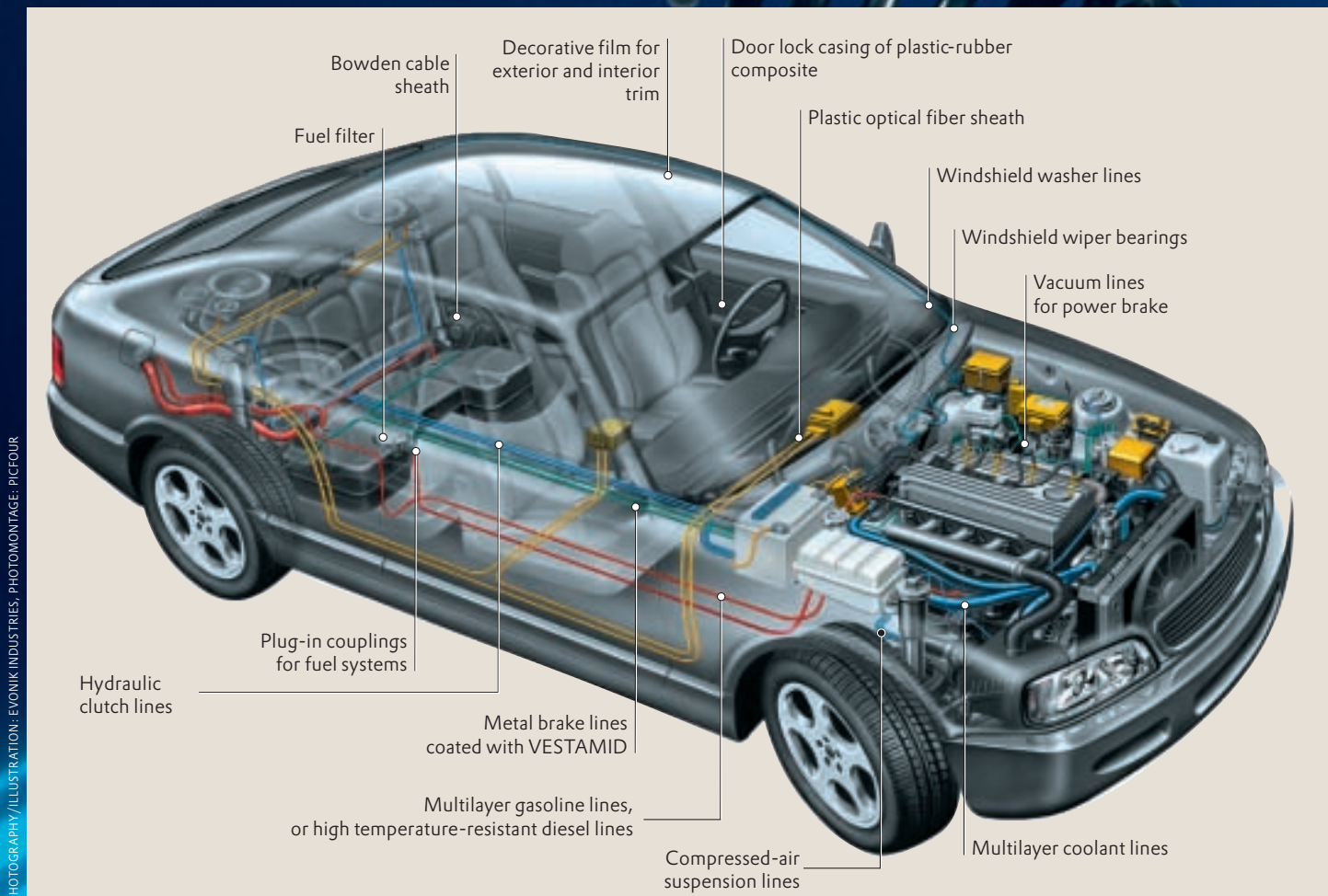
With its special nomenclature, formulas, and symbols, the field of chemistry is for many an unfamiliar world, and for some even inaccessible. And yet it plays a dominant role in our everyday lives: At home or on the road, while enjoying sports and other pastimes, or in medicine and technology, we >

**Michael Beyer is
Vice President
Market Development
High Performance
Polymers at Evonik**



PHOTOGRAPHY: EVONIK INDUSTRIES; PHOTOMONTAGE: PICFOUR

How much VESTAMID is in a car?



PHOTOGRAPHY/ILLUSTRATION: EVONIK INDUSTRIES, PHOTOMONTAGE: PICFOUR

EXTENSIVE USE IN AUTOMOBILES: VESTAMID is used especially in single- and multi-layer cable and pipe systems, such as fuel lines, but also in decorative films and injection-molded products like bearings for windshield washer systems. This and other plastics from the same polyamide family are used extensively in automotive parts. For example, VESTAMELT is used to bond textile parts and seat heaters; the coating powder VESTOSINT helps to ensure safety when used in seat belt brackets; and TROGAMID is used for injection-molded parts that are subjected to mechanical and thermal stresses, such as the red switch of the hazard warning lights.

Pneumatic brake line

Plastic developed for 2,000 meters under water

> are surrounded by materials and solutions that owe their existence to the inventiveness of chemists. This is especially true of polyamide 12 from Evonik, a plastic with a variety of properties that make it suitable for a very broad range of uses. The attributes of the polyamides are determined to a significant degree by the concentration of the amide groups in the macromolecule. The amide group, a special constellation of atoms of the elements carbon, nitrogen, oxygen, and hydrogen, is the linking point at which the monomers are joined together in a long chain. This structure holds the secret of the polyamides, because the chains are linked to one another by special bonds—chemists refer to them as “hydrogen bridges.” These help explain the desired characteristics, which include strength, chemical resistance, and a high melting point.

In PA 12, the concentration of the amide groups is the lowest of all the commercially available polyamides—and this special feature gives the Evonik plastic its very own characteristic set of properties. “And that definitely includes the very high resistance to fats and oils, fuels and hydraulic fluids, solvents—and even solutions of salts such as zinc chloride, which can cause stress cracks in other plastics,” reports Beyer. This is why Evonik is the leader in the global market for plastic systems used in multilayer fuel lines;

the exterior layer of such lines always consists of the tried-and-true material VESTAMID. For the inner layer and the barrier between the layers, there are various solutions—now for biofuels as well, which are known to be particularly demanding. The new types of fuel line systems are tested under the harshest conditions: Gasoline at 80 °Celsius, consisting of up to 85 percent aggressive ethanol, is pumped through them for 5,000 hours. A direct comparison has shown that the condition of fuel lines subjected to these stresses remained unchanged from that of new lines.

IMMUNE TO THE EFFECTS OF OIL AND SALT WATER

Extreme conditions also are prevalent in offshore oil production: The salt water is as corrosive as the oil itself; and the equipment must also contend with factors including pressure and temperature, which play a major role at underwater depths of 2,000 meters and more. The famous Lloyd’s Register has given the modified material (VESTAMID LX9020) its “blessing,” so it is

approved for use in the production of flexible oil transport lines. “Several years of research and development went into achieving this major goal. The new material is based on our VESTAMID polymers for fuel and brake lines, which are both big successes in the automotive sector,” explains Dr. Christian Baron, Vice President Strategic Projects at HP.

These materials are processed in an extruder at 250 °Celsius. At this temperature, however, their viscosity had previously not been high enough for the new application. In the extrusion process, the plastic is melted by applying heat and then pressed through a die to give it the desired shape. Making pipes of a larger diameter therefore requires use of a molding compound that has a much higher melt stiffness. Ultimately it was possible to “grow” a new type of molding compound that gives VESTAMID the requisite melt stiffness, without any loss in mechanical strength. And the strength is absolutely essential. Without it, it would be impossible to lay the lines in one piece from production platforms at the water surface down to a borehole at a depth of 2,000 meters. With these lines, it is necessary to achieve the proper balance between mechanical stability, sufficient flexibility, and long service life. In offshore applications, for example, a service life of over 20 years is required. And >



VESTAMID is used as a material for lines in offshore oil production—where both strength and flexibility are needed

New designs from the chemistry lab

> VESTAMID LX9020 has yet another advantage to offer: The material is very stable when processed and can be extruded right from the package, without further pretreatment and without predrying.

It is also possible to use PA 12 for gas pipes, which in municipal gas mains have to withstand pressures of between ten and 20 bars. At present, all existing gas mains are made of steel. In cooperation with operators of gas distribution networks, Evonik has now demonstrated the suitability of PA 12 for this application in long-term tests. The pipes designed for these purposes have an outside diameter of 110 millimeters and a wall thickness of ten millimeters. "If you consider that stability and flexibility are prominent features of the VESTAMID pipes, they are also very well-suited to 're-lining,' which is a method of refurbishing pipes from the inside," says Baron.

There also are very challenging demands to be satisfied on ski slopes—especially due to the crowded conditions around ski lifts. To ensure that skis and snowboards retain their attractive appearance, their outermost layer consists of a durable VESTAMID decorative film. The material also shows off its "sporty" side in running shoes—in this case, the utmost performance is required of the material used for soles, in particular. Polyamide 12 elastomers have proven ideal

for achieving the required balance between strength and damping—the PA components create the right hardness, while soft polyether elements absorb impacts and protect the joints of the person wearing the shoes. The right degree of resilience also is required in toothbrush bristles, which are made of VESTAMID D (a polyamide 612, which is produced from different starting compounds than those of PA 12). Automakers use a very similar material for hydraulic lines and plug-type connections (quick connectors) for such systems. These product examples illustrate the broad range covered by the polyamides.

RAISING THE MELTING POINT

The creative "designers" at Evonik use two adjustment mechanisms to endow their plastics with the ideal properties for the task in question. Using the chemical modification approach, they can insert other components into the polyamide chains, which by their nature always consist of the same links. For instance, catheters used in medicine consist of a PA 12 in which short-chain

polymers are integrated. "Catheters have to be stiff enough when being inserted, but once they are in the body they have to be very flexible and rather soft, to ensure that they don't injure the blood vessels," explains Beyer. This balancing act is accomplished by achieving a glass transition temperature of about 38 °Celsius, meaning that the change in properties is triggered through body heat. For some tasks, plastics must be made more thermally stable. The "design kit" of chemical building blocks can offer help here too—the melting point rises, for example, as soon as aromatics or short-chain amides are inserted into the chain.

This was the technique used to create VESTAMID HTplus, which will only melt at temperatures above 300 °Celsius. It can therefore be used for parts that are subject to high temperatures in the engine compartments of automobiles, for example. In recent years automotive engineers have improved vehicle features that boost pedestrian safety, while preventing aerodynamic drag from rising. The reduction in available space under the hood caused a significant increase in the temperature around the engine. "We have to respond to this trend with our materials," argues Beyer. And VESTAMID HTplus also is appropriate for applications in which there is direct contact with drinking water and food. Thanks to its high >

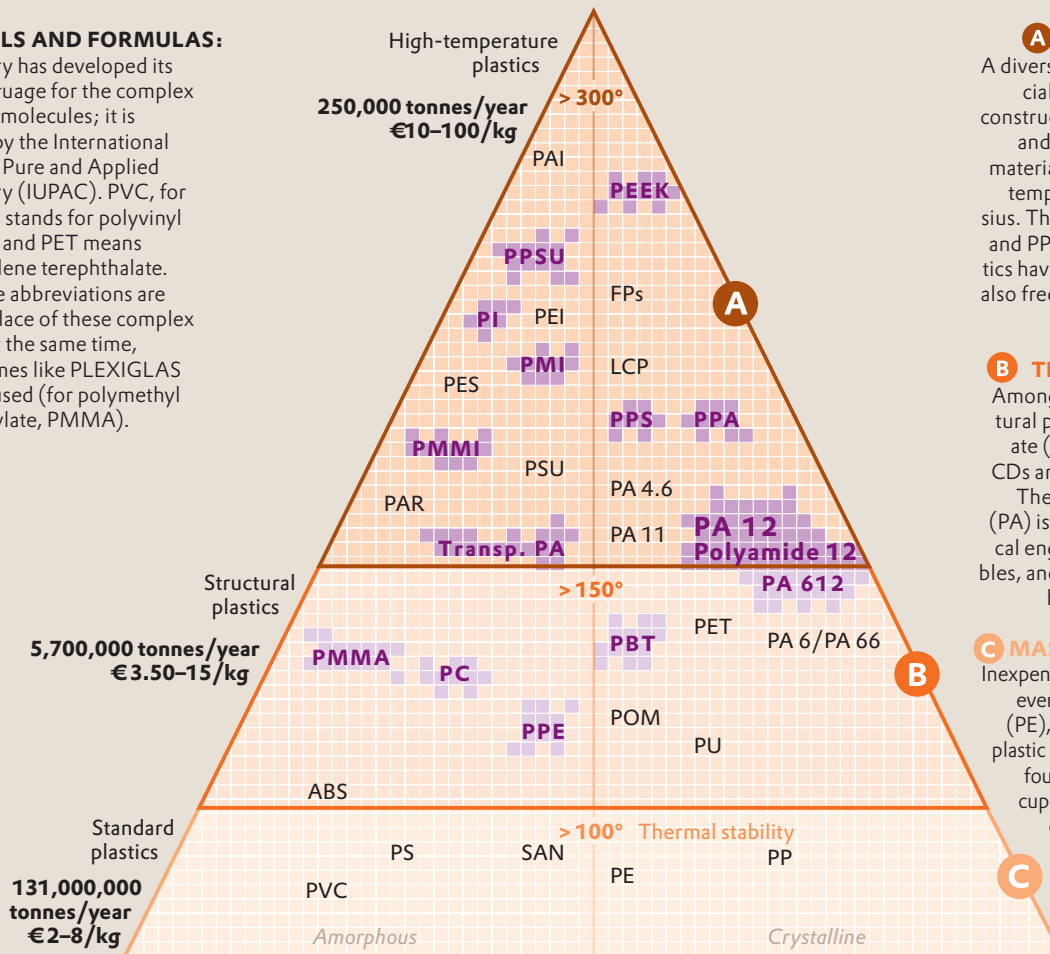


Until now, gas pipes have been made of steel; today engineers can lay flexible VESTAMID pipes that are no less sturdy

The plastics market

SYMBOLS AND FORMULAS:

Chemistry has developed its own language for the complex world of molecules; it is defined by the International Union of Pure and Applied Chemistry (IUPAC). PVC, for example, stands for polyvinyl chloride, and PET means polyethylene terephthalate. Often the abbreviations are used in place of these complex terms. At the same time, trade names like PLEXIGLAS are also used (for polymethyl methacrylate, PMMA).



A PEAK PERFORMANCE

A diverse group of plastics for special applications in automotive construction, aerospace, medicine, and household products, these materials can be used at operating temperatures of over 300 °Celsius. The group also includes PEEK and PPA from Evonik. These plastics have special properties and are also frequently lighter and cheaper than other materials.

B TECHNICAL SOLUTIONS

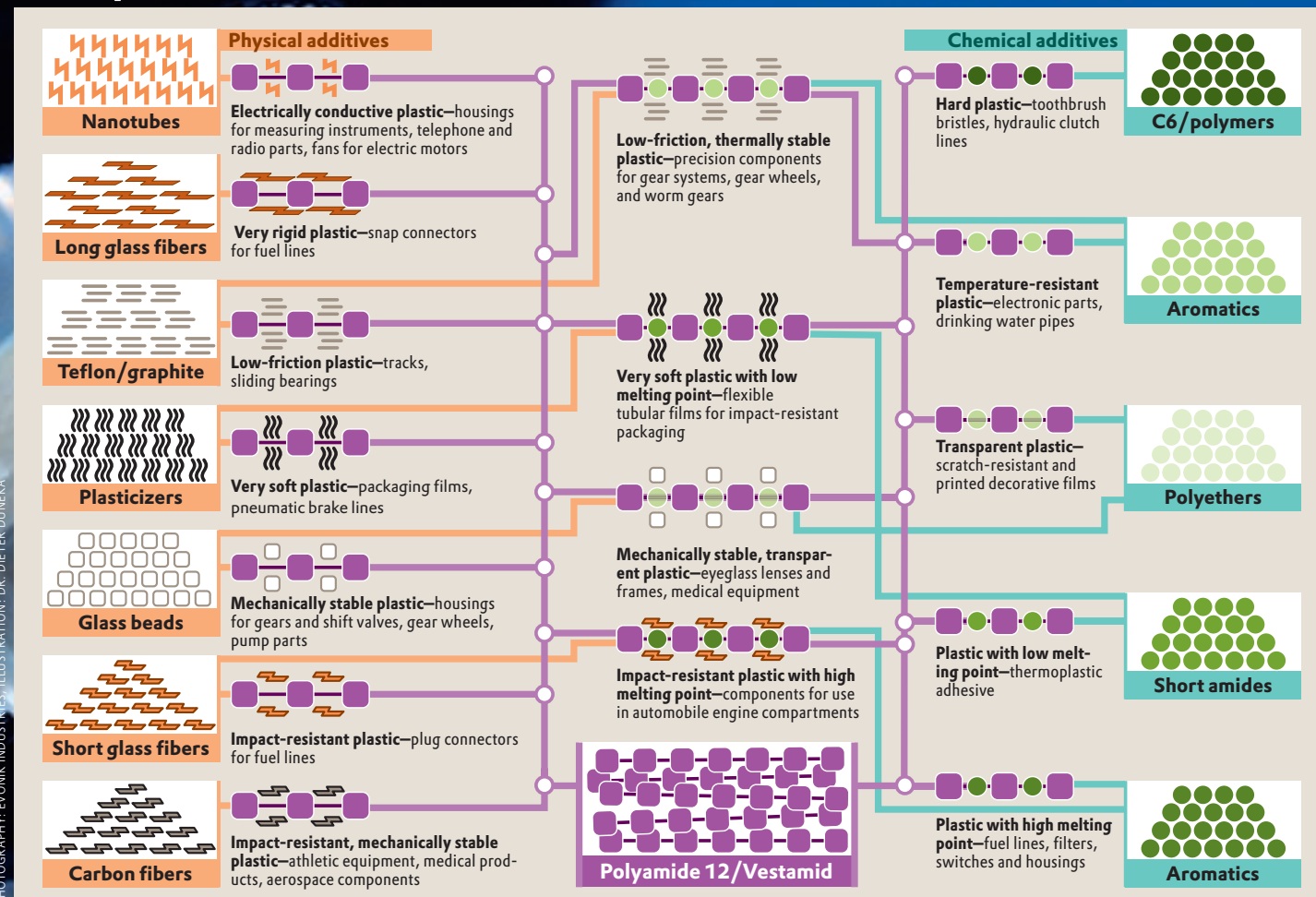
Among other materials, the structural plastics include polycarbonate (PC), which is used to make CDs and other data-storage discs. The large family of polyamides (PA) is used primarily in mechanical engineering and for pipes, cables, and fibers. PET is increasingly being used to make bottles.

C MASS-PRODUCED GOODS

Inexpensive plastics are used in many everyday products. Polyethylene (PE), for example, is used to make plastic bags, and polystyrene (PS) is found in plastic foam or yoghurt cups. There is also a great deal of diversity among the polyurethanes (PU), which are used to make paints as well as mattresses and shoe soles.

THE PLASTICS PYRAMID: There are many varieties of "plastic." They can be sorted according to their capabilities, their price per kilogram, or their internal structure. The molecules of amorphous plastics (left side) are entangled like cooked spaghetti. In contrast to this, however, chain molecules can also sometimes lie parallel in places—like spaghetti in a package. Such plastics are crystalline (right side). Plastics for mass-produced articles, like polyethylene for plastic bags, control over 95 percent of the market. Structural plastics like polyamides account for approximately four percent. The extremely heat-resistant plastics at the top of the pyramid represent less than one percent of the total amount of plastic produced, but their price is by far the highest.

The plastics construction kit



PHOTOGRAPHY: EVONIK INDUSTRIES; ILLUSTRATION: DR. DIETER DUNEKA

ONE BASIC MATERIAL WITH MANY VARIANTS: Chemists at Evonik have developed a whole range of plastics with tailored properties based on the polyamide 12 with the trade name VESTAMID. In general, there are two approaches to creating such new materials: On the one hand, additional polymers can be integrated chemically into the base plastic (right column). On the other hand, the desired attributes of the materials can also be achieved by physical modifications (left column)—e.g., admixture of glass fibers, Teflon, or graphite. For special requirements, it is also possible to use both approaches (compounds in the middle). In this way, Evonik can satisfy almost all customer needs with various VESTAMID types.

Low-noise gears

A pinch of Teflon can do the trick

> dimensional stability and wear resistance, the product also is a first-rate material for the electronics industry, where the ongoing trend toward miniaturization is making ever greater demands on raw materials.

Making use of the available range of polymer building blocks is one possibility; the other option involves physically influencing the properties of a material. Evonik has a wide range of tactics available here also: Glass and carbon fibers in various lengths; glass beads; fillers like Teflon, graphite, and mica; carbon black; emollients, and flame retardants all help to improve mechanical stability, stiffness, or durability. Bearings and screws, for example, should ideally operate without any friction—a “pinch” of Teflon or graphite ensures outstanding antifriction properties. Housings of switches, lamps, and other devices must be electrically conductive to ensure that static charges do not build up. Differences like this have the potential to trigger sparks, and thus even explosions, in chemical systems—which is why the antistatic equipment is so important.

So far, the basis for the various types of VESTAMID has been the use of butadiene, a hydrocarbon produced from petroleum. In the interest of sustainable development, Evonik has augmented its polyamide family with a new group named Terra, which com-

prises materials based partially or entirely on renewable raw materials. The parent compounds required for these materials are made from castor oil. This oil is extracted from the seeds of the flowering plant of the same name, which is mostly native to tropical and subtropical countries. The countries that grow the most castor oil plants are India, Brazil, and China.

THE GAME GOES ON

On the other hand, Evonik is also strengthening its production capacity for laurilactam. As recently as 2006, the facilities at the Marl location were expanded to 26,000 tonnes per year. And work is now underway on another expansion to be completed in mid-2009. Evonik is investing millions of euros in this increased production capacity.

“We’re taking the steps that are necessary to bolster our leading position in the global market for polyamide 12,” says Dr. Klaus Engel, Chairman of the Executive Board of Evonik. The world of polyamides opens up a tremendous range of possibilities, which is why Evonik supports its cus-

tomers with a comprehensive range of services—from the initial design to completion of the product in series production. “That includes state-of-the-art equipment for injection molding, extrusion, plastic-rubber composites, and fiber production,” explains Beyer. The analytical labs of Evonik are likewise open to these customers. The close cooperation between the materials specialists, on the one hand, and the producers, on the other, is indispensable today; this is where new ideas for solutions are born. And we know with certainty that the range of possible uses of VESTAMID has not been exhaustively explored by any stretch. So the “game” with the chemical building blocks goes on. <

SUMMARY

- Evonik is the largest manufacturer of the “polyamide 12” VESTAMID, which is produced in Marl in a multi-stage process.
- VESTAMID has a broad range of properties and is used in everything from sports shoes to offshore oil lines.
- The variety of special-purpose features can be achieved in the lab through chemical and physical modifications—the plastic is thus designed to fit the need in question.



“Achieving major goals”: Dr. Christian Baron is Vice President Strategic Projects in the business unit High Performance Polymers

High-tech for High Performance

Success in sports requires the perfect interplay between physical fitness, athletic technique, and optimal equipment. In the production of athletic shoes, plastics play a major role in ensuring the latter

TEXT ANDREAS BRANNASCH

SPORTS INVOLVE running, jumping, throwing, and scoring goals. Sports also involve high-tech materials, which is why hundreds of biomechanics, sports physicians, and technicians work in the research labs of athletic shoe manufacturers like Adidas, Asics, Nike, and Puma. Together with athletes and coaches, these staff members analyze pressure distribution and flexing action, test new materials, and measure thousands of feet. The goal of all of these activities, which are supported by universities and industry, is to develop equipment that helps professional and amateur athletes all

over the world to become better and more successful in their sports.

Athletic shoes must optimally support the highly complex interaction between 26 bones, 13 joints, numerous muscles, tendons, and ligaments, and a dense network of nerves. Also to be considered when designing such shoes are the approximately 600 sweat glands per square centimeter that each foot contains. Top-of-the-line athletic shoes can absorb rough impacts and stabilize and guide feet. Their soles can also withstand the stresses of constant pounding against surfaces. The development of a well-functioning athletic shoe is a difficult undertaking that results in a work

of art, whereby the artistic achievement lies in perfectly aligning the shoe's many components with the demands of the application in question.

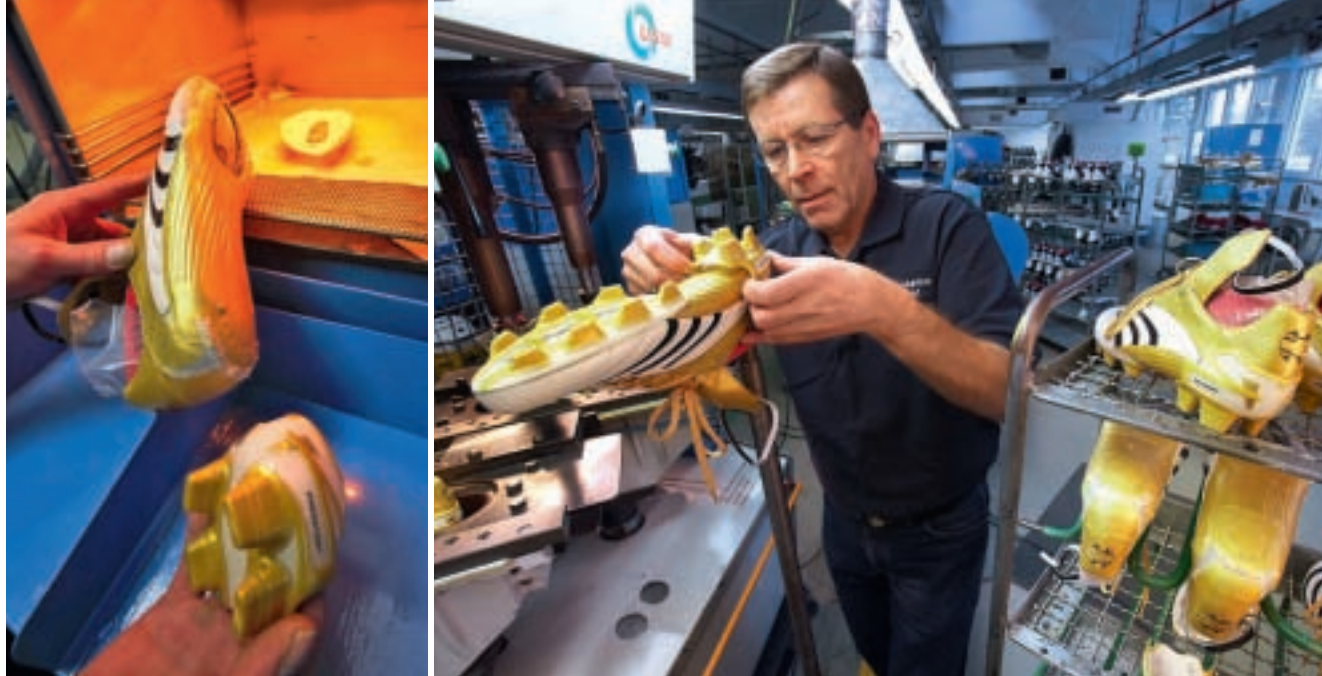
Major advances in this field have been achieved with high-quality plastics and sophisticated technologies, which turn what were formerly mere visions into technical realities. For example, apparent contradictions—such as low weight versus the highest possible stability—have now been resolved through the utilization of state-of-the-art materials. Whereas leather soles fill with water when worn on wet surfaces, polyamides create a long-lasting light shoe sole. Shoe manufacturers put an extraordinarily large amount of effort and expense into the development of running and soccer shoes, the mass markets for which promise the highest sales.

The material used in athletic shoe soles plays a key role in development activities. For running shoes, the most important attributes are shock absorption and flexing qualities, while soccer shoe development focuses on the sole and its varying number of studs and spikes, since a good grip can make the difference between victory and defeat on the field. That's because soccer is a stop-and-go sport in which players have to sprint rapidly, change direction at lightning speed, and get a firm grip when they set up to score a goal. Goalie shoes, on the other



PHOTOGRAPHY: EVONIK INDUSTRIES

Optimal running shoe properties through molding compounds based on polyamide 12



The shoe body, sole, and heel section are brought to the bonding temperature in a heating chamber before being joined together on a last

hand, are equipped with a larger number of studs on the outer part of the sole, which ensures greater stability when jumping.

Given all these facts, it's not surprising that a plastic like VESTAMID (chemical designation: polyamide 12 elastomer) from Evonik Industries AG is extremely popular among athletic shoe manufacturers. Marc Knebel, a key account manager at Evonik's High Performance Polymers Business Unit, has customers that include sports industry companies. Himself an avid jogger, he describes the plastic's benefits as follows: "VESTAMID reconciles seemingly contradictory attributes such as flexibility, low weight, and stability, and is also largely resistant to temperature fluctuations." Such characteristics ensure an extraordinarily high level of stability for products such as high-end soccer shoes like the Adidas Predator TRX FG. A slightly altered mixture of VESTAMID is also used in various types of athletic shoes in order to bring different attributes of this versatile plastic to the fore. One example of this involves achieving a high level of elasticity to ensure that the midsole always returns to its original shape, even after being exposed to major stresses.

Several years ago, Evonik and Framas Kunststofftechnik GmbH (Pirmasens) achieved a quantum leap in soccer shoe development by creating a spring-elastic clip holder for studs. Framas is

now the world market leader for special-application athletic shoe soles, producing five to six million pairs of them each year. The use of a particularly rigid glass fiber-reinforced plastic mixture for the clip holders in the Predator ensures that the shoe's studs can no longer be pressed upward against the player's sole, while the highly firm material also prevents the holders from breaking off. The idea of developing a system for clipping on cleats rather than having to screw them in is actually quite old. However, only after plastics with the required stability were developed did it become possible to implement such a clip system. In this case, cooperation between the raw materials supplier, processing partners, and athletic shoe manufacturers functioned perfectly.

IMPACT SHOCK OF THOUSANDS OF FOOTFALLS

Along with all of its great functional properties, VESTAMID also possesses another important attribute: "VESTAMID is color-neutral and can be dyed easily—and it's also possible to paint it and print on it," Knebel reports. For these reasons, according to Adidas spokesman Oliver Brügggen, "This material is an absolute must for our Predator Powershox TRX FG, as its unmatched stability and robustness make it an irreplaceable component of the shoe."

Various types of VESTAMID compounds can be found in running shoes whose soles are designed to ease the burden on joints. Running shoes are supposed to give the wearer a feeling of lightness on the one hand, while at the same time absorbing the shock of many thousands of footfalls, which, depending on running speed and surface makeup, can equal the equivalent of two to three times the body's weight being brought down upon the feet. The different types of VESTAMID used in midsoles and lower soles can meet all these requirements, as the material absorbs energy during deformation, some of which it gives back to the runner through a spring effect. High-performance plastics from Evonik are also employed in the production of cycling and fencing shoes.

Still, it should also be noted that the 1950 Indian national soccer team opted out of participating in the World Cup in Brazil that year after its players were told they wouldn't be allowed to play barefoot. There's also the South African runner Zola Budd, who in 1984 at the age of 17 caused a sensation by setting a new world record in the women's 5,000-meter race—barefoot. Another barefoot runner was Abebe Bikila from Ethiopia, who set a new marathon record at the 1960 Olympics in Rome. It thus appears that equipment sometimes does not play a role in sports—but only sometimes. <

Milestones in athletic shoe development

From Leather Safety Boot to High-end Soccer Shoe

While many things may have once been better, athletic shoes certainly weren't. The road from the first leather soccer boots to the current Predator model from adidas was a long one.

In the past, the weight of the heavy leather boots doubled in the rain; today

shoe properties are entirely independent of the weather. What at the start of the last century was a handcrafted leather soccer boot intended primarily as a safety shoe—with a steel cap—is now the product of years of development work. Running shoe research is every bit as intense: High sales

volumes beckon here just as they do with that other popular sport, soccer. Until the jogging craze in the early 1970s, the shoes you wore to run through the woods were the same ones you laced up to play volleyball. Since the introduction of running shoes, particular attention has been paid to

various functions, including cushioning, support and guidance. Heel wedges, which for a while were extremely high, have become flatter in recent years for orthopedic reasons. In other words, things have in many ways come back almost full circle to the models from the '70s.



The intelligent shoe

The adidas 1, which hit the market in the year 2004 uses a magnet sensor system in order to automatically adapt to different conditions. A microprocessor calculates whether the cushioning is too hard or too soft for the wearer of the shoe. Roughly 1,000 measurements are performed each second and forwarded to the microcomputer in the shoe. Adjustments are made via a motor-powered cable system that ensures optimal cushioning while the wearer is running.



1925
Adolf "Adi" Dassler applies for a patent for soccer boots. The company he operates together with his brother Rudolf develops soccer boots with studs and track shoes with spikes.



1930
The soccer boot produced in Germany by the Dassler brothers' joint company for the first Soccer World Cup in Uruguay. Nailed leather studs provides secure footing; the high shank protects the ankle.

1949
The first adidas soccer shoe with a sole having a multitude of rubber nubs instead of individual studs or leather strips. The innovation improves comfort to the wearer when playing on hard sand pitches.

1952 / 53
Rudolf Dassler, the brother of Adolf Dassler, begins series production of shoes whose characteristic feature is their screw-in studs. The soccer club Hannover 96 wins the German championship with them in 1954. The brothers decide to go their separate ways in 1948, forming the companies Puma (Rudolf) and adidas (Adolf).

1958
The Puma form strip makes its debut as a distinctive trademark at the Soccer World Cup, which takes place in Sweden. Brazil and a wbecome World Champions in Puma shoes.



1961
The New Balance Trackster is the word's first running shoe that boasts a rippled sole and can be purchased in different widths. The Trackster becomes the most popular running shoe with college students and within the YMCA fitness program in the USA.



1964
adidas introduces the lightest running shoe of all time. The Tokio 64 weighs 135 grams.

1970
One of the first running shoes is the Brütting Roadrunner. It features a cushioning layer in the midsole; the forefoot and rearfoot are located on the same plane. Brütting handmade athletic shoes are still being manufactured in Germany today using the original lasts.



1980
adidas Marathon Trainer: Good cushioning, a grippy sole profile, a very comfortable fit and mesh upper material that provides excellent ventilation make this model a great success story for the manufacturer.

1987
Asics GT II: The first running shoe that comes with gel cushioning. This liquid replaces solid materials in the midsole and inspires a whole new generation of running shoes.



No nails
Rule Number 14, which was published by the English Football Association back in 1863, stated: "No player shall be allowed to wear projecting nails, iron plates or pieces of gutta-percha (rubber-like material produced from the sap of the rubber tree) on the soles or heels of his boots."

1928
The Bahn all-around athletic shoe produced by the Dassler brothers makes its debut at the Olympic Games in Amsterdam (Netherlands), where it is worn by athletes competing on grass, sand and ash.



1948
Shoemaker Albert Bunn submits a patent application for "screw-in soccer studs." Unfortunately, however, he is unable to market them.



1952
Wearing adidas Marathons, Emil Zátopek wins gold medals in the 5,000 meters, 10,000 meters and the marathon at the Olympic Games in Helsinki (Finland). The innovations that make the shoe so special include an absorbent insole, a padded tongue, and a heel strap for a firm fit.



The miracle of Berne



It was a revolution when the German national soccer team took the pitch at the World Championships in Switzerland wearing slim, interchangeable nylon studs. The Sepp Herberger-coached team managed to defeat the Hungarians, who were top favorites, 3-2 on soggy turf in the final game of the 1954 World Championships. The shoes worn by the German team in Berne weighed 360

grams—almost half the weight of the shoes worn by their Hungarian opponents (top shoes today weigh less than 250 grams). The screw-in studs developed by Adolf Dassler gave the German players decisive advantages: a better first step and surer footing. The surprising victory over the Hungarians in their old-fashioned shoes is considered to be the birth of the modern soccer shoe.



PHOTOGRAPHY: PR (20), ULLSTEIN (3), PICTURE-ALLIANCE/DPA, EVONIK INDUSTRIES (2)



1968
adidas Achill: Long before the first jogging craze, the first shoe developed in Germany specifically for running is hitting the streets. It features a cushioned midsole and later also acquires a heel wedge. Runners had previously put their faith in normal athletic shoes.

The athletic shoe turns pro

In 1979, the Nike Tailwind becomes the first running shoe with cushioning provided by a gas mixture in the midsole—a pioneering development from the USA. The first Air models are intended primarily for people interested in road



runs on hard asphalt. They are therefore too soft for the average central European runner, who runs primarily in the woods and in parks. Nike later adapts the shoe for the European market.

Joschka Fischer becomes a state Environmental Minister in 1985—wearing Nike basketball shoes

A Layover on our Journey into the Future

Today's soccer shoe is a high-tech product in which plastics such as VESTAMID play a greater role than ever before

1994 World Cup: Jürgen Klinsmann wears the first Predator model as Germany defeats Belgium 3-2 in the USA.



1991 Puma Disc: The disc system makes it possible for athletes to close their shoes without the need for laces.



1994 adidas Predator: The scale-like upper material made of a special rubber blend has been designed with an eye on improving the player's ball control. Shark skin is later proposed as a material, but never actually makes it to the series production stage. The idea of scale-like ribs on the top of the shoe is pursued further using synthetic materials, however.



1997 Puma Cellerator: The first cushioned soccer shoe offered by Puma. The honey-comb shape of the sole compensates for blunt impacts on uneven surfaces.



2006 Nike Air Max 360: The first running shoe with no conventional cushioning material in the midsole makes its debut. Instead, the sole comprises a completely transparent air element.

1989 adidas Torsion: Splitting the sole allows for a natural rotation between the rearfoot and the forefoot from the heel to the ball when setting down the foot. It also offers light support for the arch.



1993 Nike Air Fuego M: The first soccer shoe with air cushioning. This marks the first transfer of the cushioning technology proven in more than ten years of successful use in running shoes to soccer.



1996 Puma Cell: The cell cushioning technology is based on air chambers in the shoe's sole. Air can flow back and forth within these chambers through narrow ducts, and it is this exchange of air that cushions and stabilizes the foot.



2002 adidas Predator Mania: Snap-in rather than screw-in studs are a revolutionary development and require the use of a material offering the utmost in shatter resistance. VESTAMID, a plastic developed by Evonik, satisfies this criterion.



Final vs. Brazil: The Germans wear the new Predator Mania at the 2002 World Cup held in South Korea and Japan.

2008 adidas Predator PowerSwerve: State of the art—Evonik's VESTAMID remains the material of choice for the stud snaps.

THE HEEL CAP is a plastic shell, with soft plastic on the inside for comfort and a hard component on the outside for stability. The reinforced shank provides additional support. Pressure on the Achilles tendon is greatly reduced.



IN THE SWERVE ZONE on the side of the adidas Predator, fine rubber and silicone strips provide improved swerve when shooting and act like an antislip system to ensure that the ball—which at the professional level is also made of plastic—"sticks" to the foot as long as possible.



ASYMMETRIC LACING on the outside of the shoe. Advantage: Contact between the foot and the ball is more direct when shooting and is not impaired by the shoe laces.

PLASTIC IS ALMOST ALWAYS FOUND in the following parts of professional soccer shoes: sole system, cushioning elements, insole, spray-on shank elements, studs. There are also models made entirely of plastic. Plastic cushioning elements play a lesser role than with running shoes because they require space. A higher stance also adversely affects ball feel. The mechanical properties of the plastic soles are unaffected by cold, heat and moisture; their elasticity provides the cushioning that reduces wear on the joints.

SNAP-IN STUD SYSTEM:

The studs of the adidas Predator exert the least possible pressure against the foot, provide the optimal amount of grip on a grass pitch and are extremely easy to replace when necessary. This technology is made possible by the use of VESTAMID. This polyamide 12 elastomer containing 23 percent glass fiber exhibits extraordinary rigidity.



THE SPLIT PLASTIC OUTSOLE

of the adidas Predator reduces weight significantly and enables a natural set down and rolling of the foot. A removable insole variant of the shoe also includes a PowerPulse element filled with 10 grams of tungsten powder. When shooting, the powder slides forward in a plastic tube and comes to a sudden stop, providing additional energy for the shot.

