



Cardiology: innovative materials make diagnosis and treatment easier

More gently through **the bloodstream**

With cardiovascular diseases, doctors not only examine the engine of life itself, but also the blood vessels surrounding it. Cardiologists navigate their way through the vessels using special probes. To make this procedure as gentle as possible for patients, Bayer MaterialScience researchers have now developed innovative material coatings: with Baymedix® not only do cardiac catheters pass more easily through the blood vessels, but the technical medical coatings carry anti-inflammatory medicines at the same time.

The way to the heart is full of sharp bends. The wire glides slowly through the veins. It winds its way gradually through the patient's bloodstream – carefully guided by the hand of a cardiologist. It is not speed that counts when visualizing the heart or examining the coronary vessels – what is important is a soft, flexible tip and the least possible resistance when navigating the instruments: the smoother the passage of the catheter through the blood vessels, the easier it is for doctors to diagnose and treat cardiovascular disease. Although doctors are able to see where the catheter is on the X-ray (the catheter is usually a plastic tube containing a metal guide wire), the heart specialists also gain important information through their hands, using them to feel bends, branches and resistance on the way through the blood vessels.

Reduced material friction makes treatment easier

The distance that the tiny balloon on the catheter tip has to travel is about a meter – from the insertion

point in the patient's groin to where it is actually going to be used: the blood vessels around the heart – also known as the coronary vessels. "This naturally depends on the size of the patient, but the insertion of a catheter needs a great deal of experience, finger-tip sensitivity and patience in any case. It is as if the doctors are feeling the inner life of the vessels," explains Chris Koppenborg, a medical technology expert and materials researcher at Bayer MaterialScience. His area of expertise is medical coatings – coatings for medical technology products. And his aim is to make treatment easier for patients and doctors alike: together with his team, he has developed exceptionally smooth new materials with the trade name Baymedix®. "With these we can reduce the friction between the guide wire and the catheter in exactly the same way as between the catheter and the tissues of the blood vessels," he explains.

A small demonstration in his office makes the innovation clear: the materials expert places a glass of water on the table. In his hand,

he holds a catheter probe with green plastic sheathing. "Run your finger slowly over the surface of the tube," says the Bayer scientist. You can feel the friction, your finger only moves jerkily forward along the plastic. Koppenborg dips his new development into the glass of water: now the tube moves through his hands with no resistance at all. The exceptional smoothness of the surface coating is due to its hydrophilic property: it absorbs water. This results in a sort of soft soap effect. In technical terms, this is known as lubricious, which means something like "slippery smooth."

The hydrophilic layer is only a few micrometers thick and is especially suitable for thermoplastic materials. The coating, which is applied by dipping, is also characterized by its

Engine of life under the microscope: medical technology expert Chris Koppenborg (photo, right) demonstrates the benefits of the newly developed material on a model of the heart. Thanks to the reduced friction, catheters can slide more smoothly through the coronary vessels (photo, left).





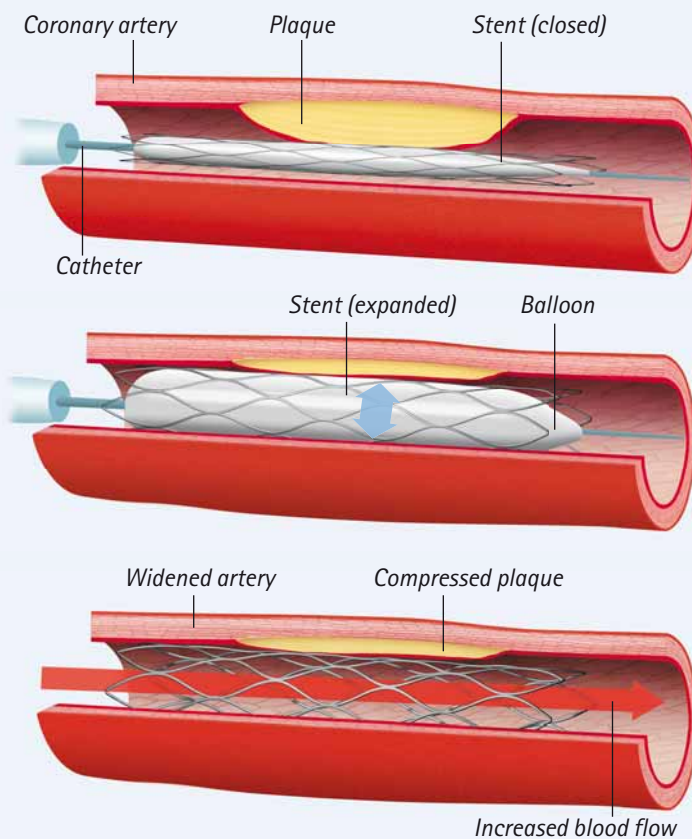
The long road to the heart: implanting an aortal stent – as here at Rostock University Hospital – requires plenty of sensitivity on the part of cardiologists.

high mechanical stability. This is the result of the stable chemical binding of the coating on the catheter: the Bayer scientists attach the coating molecules directly to the surface of the substrate. In addition they graft the slip improver – in the same way as individual branches when grafting trees – directly on to the medical device. "As we bind our material to the activated surface and coat it by dipping, there are no limits to the profiles of the parts which we can treat in this way," explains Koppenborg. Another unique feature is the fact that interiors – known as lumens – can also be coated with the innovative material. This is because the new material hardens purely thermally, drying by itself. Many of the materials which are normally used need UV irradiation for this, which does not penetrate inside.

The extremely high anti-friction properties of Baymedix® CL 100, as the new Bayer material is called, are intended above all to help cardiologists in catheter examinations. But the lubricious material mix is also suitable for other applications: for example for heart pacemakers and defibrillators, as the insertion of these implants using the interventional catheter technique – i.e. minimally invasive from the inside

The support in the blood vessel

If the blood vessel becomes narrow as a result of deposits, danger threatens. Cardiologists use a catheter to place a stent at the danger point. The metal or plastic mesh is then expanded with a sort of bellows. The filigree wire mesh stabilizes and supports the vessel so that the blood can flow through again unimpeded.



and without surgery – is relatively gentle for patients.

Active ingredients in the stent prevent restenosis

Other cardiological treatments could also benefit from this innovative material: doctors use what are known as balloon catheters to dilate constricted – or stenosed – coronary vessels and then keep the vessels open with the aid of supports known as stents. The small metal or plastic mesh then ensures unimpeded blood flow again. Says Koppenborg, "It's similar to mining, where the seams inside the mine are also stabilized with sup-

ports and pillars to keep the transport routes open."

And the materials developers have given the stent-coating material yet another special characteristic: Baymedix® CD is an active substance-releasing coating. This is because the cardiovascular stents lead to a foreign body reaction in the arteries because of the mechanical irritation. "Restenosis occurs in up to 30 percent of patients with coronary heart disease," says Koppenborg. If, however, the stents are also coated with active substances which inhibit the formation of new cells, there is a clear reduction in the rate of restenosis of the coronary vessels – i.e. the risk of



Life-saver: constricted coronary vessels are widened with what is termed a stent. To prevent restenosis, scientists at Bayer coat the metal structure with a polymer that releases a special active ingredient and thus prevents cell formation.

a vessel becoming constricted again. For optimal effect, however, the active substances must be attached very evenly and firmly to the surface of the lattice structure, even after the doctors have considerably increased the diameter of the stents in the arteries with the aid of so-called balloon dilatation. This is because homogenous coating is essential for the even distribution of the medicinal products into the surrounding tissue. Says Koppenborg, "Our coating is elastic and remains intact even after considerable distension. Neither tears nor holes appear."

The active substances on the metal mesh are usually released in a specific concentration over a period of one to three months. The developers achieve this with a tailor-made mixture of hydrophilic and hydrophobic components. "The higher the hydrophilic portions in the carrier substance, the quicker the added medicinal products are released," explains Koppenborg. A greater concentration of hydrophobic particles, on the other hand, slows down the process. In this way, the Bayer scientists can adjust the desired period of release in each case. Although the technology was developed primarily for drug-coated stents, in principle other products made of

metal or polymeric substrates can also be produced to which analgesics or anti-inflammatory drugs have been applied.

Polyurethane facilitates dialysis and transfusions

All polymer-based biomaterials for medical technology offered by the Bayer MaterialScience experts under the Baymedix® trade mark naturally also have to be biocompatible. To ensure that this is so, all materials undergo extensive testing – successfully: apart from catheter coating, these materials are also tested and used in a wide variety of applications with medical technology companies – for example for the insertion of implants into the eye. Baymedix® CH, another member of the innovative material family for medical technology, is characterized by its hydrophilic, hemocompatible and durable surface. The substance – which is available as a water and solvent-based dispersion – is especially suitable for functional surfaces which have to transport liquids, such as filters in dialysis or for transfusions during heart surgery.

Only the long experience of Bayer MaterialScience with polyurethanes made the further development of

The heart at risk

Coronary heart disease (CHD) is a disease of the coronary vessels of the heart. The coronary vessels (Greek: "koronar," meaning "crown") wind round the myocardium like a wreath and supply it with blood, oxygen and vital nutrients. The most common cause of stenosis or obstruction of the coronary arteries is arteriosclerosis, the result of protein and fat deposits in the vessel walls which are then coated with calcium and connective tissue. This impedes the blood flow so that there is impaired perfusion of the myocardium resulting in a reduced oxygen supply to the cells (ischemia). If left untreated, CHD can lead to life-threatening perfusion disorders, heart attack and sudden cardiac death. Established treatment procedures include balloon dilatation – i.e. the dilatation of the blood vessels – and bypass surgery, which involves rerouting the blood supply. According to World Health Organization (WHO) figures, cardiovascular diseases cause about 15 million deaths worldwide every year – about half of these in industrialized countries.

plastics for medical, biocompatible applications a possibility. Since then, however, the material family has been growing apace: for example, with Baymedix® F the researchers have created special foam-based wound dressings. Medical adhesives for wound closure are now also being developed under the name Baymedix® AT. This means that not only will cardiologists benefit in future from innovative, tailor-made medical devices, but also trauma surgeons, plastic surgeons and dermatologists. Says Koppenborg, "With Baymedix we offer a comprehensive platform for a variety of material combinations which we can adapt to the specific requirements and demands of our customers."

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